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Wavelet Based Classification And Analysis Of Seizures In EEG Signal

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Abstract

Epilepsy is a spontaneous or provoked synchronized cortical activity in cerebral neurons that leads to epileptic seizures which affect the person in motorized dispositions and sensory or psychological sensations. The Detection of epilepsy is achieved using the electroencephalogram (EEG). The EEG is a continuous, irregular signal in which any section is never repeated exactly at any other time. The EEG can therefore not be exactly described by certain parameters (such as amplitude or frequency) It is only available for statistical estimation. With the properties mentioned, the EEG virtually challenges signal analysis. Frequency analysis (spectral analysis) is an essential component of electronic signal processing in many devices in EEG diagnostics. In general, the digital representation and processing of the EEG is becoming increasingly important. This paper presents a procedure to detect seizures in EEG signal using EEG wave component frequency analysis. Depending on the level of alertness, a distinction is made between different patterns in the electroencephalogram, namely Alpha, Beta, Theta and Delta waves. The statistical parameters are extracted after wavelet transform is applied on the EEG signal. These parameters are trained with SVM classifier to detect the seizure. The proposed method performs better than the existing algorithms.

Keywords: Electroencephalograph (EEG),Epilesy, Wavelet, SVM.

1. INTRODUCTION

A process of measuring electrical activity neurophysiologic ally within the brain by incorporating the electrodes that are placed upon the surface of the scalp within the cerebral cortex is referred as Electroencephalograph (EEG). The malfunctioning human brain is accompanied by different types of disorders and diseases. A natural electric signal stream is expressed in a human brain by a healthy individual[1]. Moreover, an unhealthy person is signified by an abnormal electrical signal flow. Therefore, numerous neurological disordered diseases are solved by analyzing and recording the given signs. Placing the electrodes on the scalp for 20-40 minutes, evaluating possible changes in the brain to establish the transcript of electrical activity. This paper is primarily concerned with the exponentially rising volume of biological and clinical documents. Various complications that must be resolved are present in the data analysis for extracting the data from the information that are assumed as medical applications [2]. In order to resolve the issues regarding the data analysis, various analytical equipment depending upon Machine Learning (ML)methods. A neurological disease named as epilepsy has impacted about 1% of total population in world. Numerous diseases with neurological disorders are resolved through examining EEG signals carefully.

The people of age groups are affected by a chronic neurological disorder of the brain named as Epilepsy. In some cases, a set of neurons present within the brain are abnormal and therefore a disturbance is caused in the usual pattern of neuronal activity that causes sensations like convulsions and unconsciousness[3] [4].

- **Preictal stage:** during the seizure of assets,,
- **Ictal stage**: actual seizure, Formatter will need to create these components, incorporating the applicable criteria that follow.
- **Postictal stage**: Duration between 5 and 60 minutes after the seizure;
- **Interictal stage**: Times between seizures are characterized by regular brain activity.

The EEG signals are in general noisy and non-stationary that are recorded with the scalp electrodes. Unwanted signals, artifacts, noise from electrical system and environmental noise are included in this [5-6]. Therefore, the highly noisy information is realized in order to implement powerful preprocessing. By considering Epilepsy as the more popular neurological diseases, it is seen in around 50 million people around the world. Around 80% of the people who are suffering due to epilepsy come short of the essential treatment those who live in low and middle income nations [7].

Twitching or shaking is involved in maximum seizures and staring spells are involved in few seizures .Based on the brain that is present, partial seizures and generalized seizures are the2 major kinds of seizures that are present. By including the face or arm are involved in the Partial or focal seizures that are initiated within the small portion of the brain. Simple or complex Partial seizures can be implemented. The memory is unaffected by the simple partial seizure whereas the performance, awareness and memory before and after the seizure is affected by the compound partial seizure[8-9].

The cerebral hemispheres out of the seizure beginning are affected by the generalized seizures. Unconsciousness is produced by it for an extended duration and it is divided within various main kinds, for example, a person may blink their eyes rapidly In the Absence seizure while picking up the clothes and smacking their lips. The duration of these seizures is usually up to3 to 20 seconds and therefore it occurs hundreds of times daily [10]. These kinds of seizure are commonly started during the age of 4 to 12.The loss of muscle activity is involved by the Tonic seizures for more than 1 second. On the either sides of the body, it can be occurred usually. In both of the regions involved in the Myoclonic seizures. Partial, generalized in Tonic-clonic, myoclonic, absence seizure and so on are the seizures observed from the EEG signal of the patients.

2. Literature Review

The recordings of the EEG within the various sub-bands are decomposed and the extraction of the 5 characteristics out of the creation of the wavelet coefficients with a group of ww``characteristics is done in an automated detection of epileptic activity proposed by ***Katerina D Tzimourta et al (2017)*** with the help of DWT [11]. The classifier of support vector machine (SVM) was implemented for training a feature vector that is extracted. The addressing of 5 issues of classifications is done in this method by reaching the higher stages of the entire precision with the range of 87% to 100%. Moreover, the statistical resulting approaches are enhanced in this method [12].

The pre-ictal, inter-ictal EEG segments are classified by designing a binary SVM classifier with the Multirate filter bank characteristics like Hurst component and Auto regressive moving average (ARMA) and depending upon the high-degree fractional noise procedures in addition tothe rhythms extractions through the multilevel Discrete Cosine Transform (DCT), an

Automatic seizure detection using EEG signal modeling is presented by Anubha Gupta Pushpendra Singh (2018).Using the public dataset classifier, the testing and validation of the classifier is performed and moreover, 97%of total accuracy is provided upon the two dataset on behalf of the classification of the ictal as well as interictal EEG sets [13-14].

Detecting a scalp EEG data within the various frequencies in reducing the dimensionality of the data, Dynamic mode decomposition (DMD) based epileptic seizure detection is proposed by ***Mohammad sohaib et al (2018)***. CHB-MIT dataset as well as KU Leuven dataset are the 2 datasets out of which the testing of data is performed through the hours of EEG data.0.87& 0.88 of sensitivity is provided by it and0.99 of specificity is provided for the datasets [15].

Various kinds of convulsive epileptic seizure by short duration(>10sec) are detected and depending upon a single wrist-worn accelerometer sensor, a wireless remote monitoring system is presented by ***ShitanshuKusmaker et al (2019***).With the help of a nonlinear technique, the extraction of time domain feature is done efficiently and a classifier of support vector data description (SVDD)is trained [16-17]. By the implementation of principal component analysis (PCA)in selecting the channels, the artificial neural network (ANN)efficiency upon the EEG signals (CHB-MIT database)is proposed by ***Satarupa Chakrabarti et al (2019)***.

3. Proposed method

The work proposed in this paper consists of the following steps

Step 1: Pre-processing the EEG signals.

Step 2: Decomposing the EEG signals within the components of prime frequency with the help of discrete wavelet transforms (DWT).

Step 3: Extracting the EEG signal features with the help of the concept of approximate entropy.

Step 4: Classifying the seizure by SVM or neural network.

The electrical activity of the brain is performed by EEG, and scalp EEG as well as intracranial EEG are the types of it. this method adopts international 10-20 placement system, the collection of the real EEG data is done using the epileptic seizures in From Basaveshwer hospital Kalaburagi, 30mm/sec of speed is recorded by EEGs for 30 minutes125 samples per second of sampling rate are digitized. FPl, FP2, F3, F4, F7, F8, FZ, AI, A2, T3, T4, T6, C3, PZ, P4 and 02 are various scalp electrodes

Preprocessing:

The noise and artifacts within the raw signals are determined by a method called as Preprocessing toward decrease effect of feature extraction phase. Cut off frequencies of high-pass and low-pass filters, notch filter features and sampling speeds [12] are eliminated by the efforts of the preprocessing stage and abroad range of the artifacts in the recordings of EEG.

4. Feature Extraction

The following features are extracted from the EEG waves

- **Mean (μ)**: The arithmetic average of the data values.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (1)$$

Where, n is the total number of samples and every single data sample is represented by $\mathrm{x_i}$. Where, ‘i’ Ranges from 0 to N-1.

- **Standard Deviation (σ):** a well-known dispersion measurement is known as sample standard deviation. The average distance a mid every single data sample in addition to the mean is measured in this method. The following equation has to be equal to the square root of the sample variance.

$$\boldsymbol{\sigma} = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}} \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}} \quad (2)$$

- **Energy**: It implies the addition of continuous signals to the square of absolute value for the sample. Equation [11] provides the measurement of energy from different sub-bands is given by

$$E = \sum_{n=0}^{N-1} |X_n|^2 \quad (3)$$

Where, X_n is discrete sample value of EEG signal, N is the number of samples.

Entropy: Depending upon the values of the earlier amplitude values quantification measure where a plenty of data regarding the complexity and regularity of time series details provided by a statistical parameter called as Entropy (En)in which the predictability of the physiological signal's current amplitude values are measured. X= {x(i+1), x(i+2), x(i+3),…..,x(i+m-1)} for 'm' points subsequences of EEG signal and X= {x(1), x(2), x(3),…..,x(N)}for a given N point time series data.

$$x = \frac{1}{m}\sum_{i=1}^{N-M+1}\sum_{j=0}^{m-1} X(i+j) \quad (4)$$

Anywhere, N represents length of input signal.

- **Kurtosis**: The kurtosis or curvature is a description of the distribution form. It indicates how sharp the curve is. Distributions that are rather wide at the edges but flatter in the middle have a high kurtosis.

Discrete wavelet transforms (DWT): The method of extracting a feature in which a time series data is converted into the frequency domain is referred as Discrete Wavelet Transform (DWT) and moreover, the non-stationary signals are analyzed, Using the transient occurrences such as EEG recordings, the electrical activity is recorded essentially. The electrical activities of the brain signal which are raised usually within the human beings are recorded by using the EEG signal. The voltage fluctuations within the brain are measured by the placement of the electrodes by recording the electrical activity. Interictal or seizure free and ictal are the two states of abnormal activities that are exhibited by the EEG signal of epileptic patients.
Wavelet transform is an effective analytical method, such as the EEG, for study of non-stationary signals. The statistical parameter such as electricity, entropy and standard deviation have been determined to derive the characteristic seats for the system to be used to train the regular and epileptic signal with a vector machine supporters classifier.

Classification: Depending upon earlier observations, the identification issue of a data that belongs to a category is done by the Classification. Various classification techniques are implemented by EEG in which artificial neural network (ANN), SVM [15] are the extensively employed methods.

Support vector Machine (SVM): A portion of artificial intelligence techniques in which various signals are recognized is referred as Machine learning improved accuracy in classification is provided by a well-known machine learning procedure called as SVM. An artificial neural network (ANN) is an integrated artificial neural network that uses an information processing mathematical model. ANN consists primarily of an ANN architecture learning mechanism that adapts to the inputs under the learning rule.

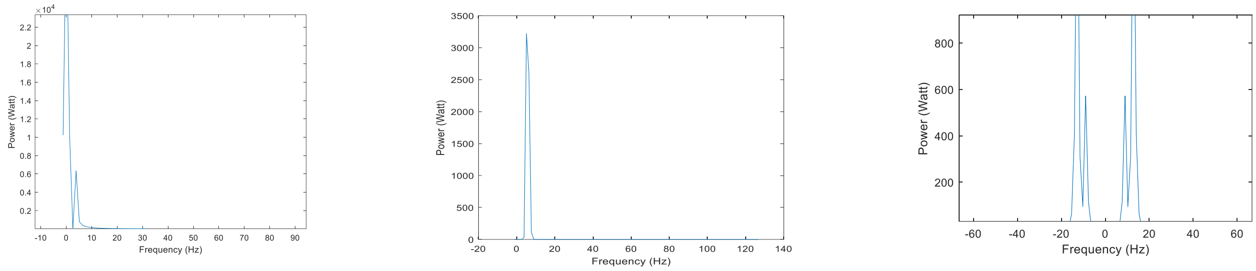
5. Results and Discussion

The seizure and classification system based on the learning machine algorithm with EEG signals from different brain locations, sex , age, and seizure types is presented. After this paper the A classifier is used for classifying interictal and preictal / ictal signals on the basis of the features extracted. In the current work we train the extracted features of the signal to achieve optimum accuracy. We find that epilepsy can be diagnosed using an SVM classification and various features including energy, entropy and standard deviation in different configurations.The meaning of our whole combination, as illustrated in Table 1, can be defined as the meaning of mean and standard deviation, signal frequency distribution and frequency distribution variability. As shown abnormal EEG signal.

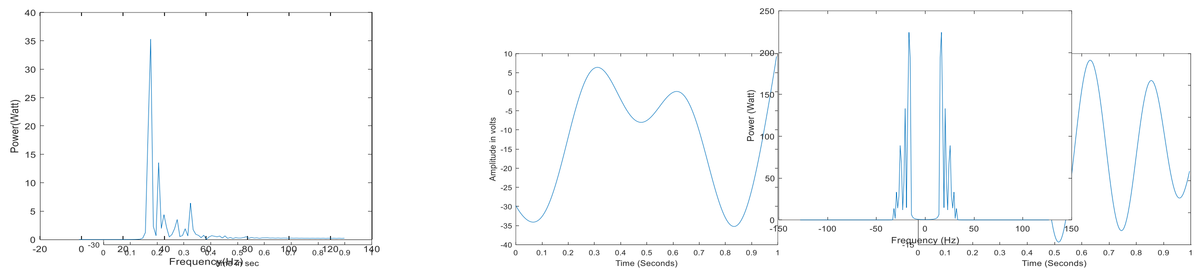
23 pediatric patients in Boston Children's Hospital registered this data set.And Compared physionet database and real database from BH kalaburgi. The system performace is tested by using 100 non-seizures EEG signal.

The set of data used for our detector is 916 hours of EEG, sampled at 256 Hz. The data set used is used. The data were collected in 23 pediatric hospitals and in one adult patient at the Children's Hospital Boston. Compared physionet database and real database from BH kalaburagi. The table 2 is represents CHB- MIT Database Average of 23 Channel. The resulting output class for the test signal is given by the position value. Table 3 gives the accurateness for the normal and seizure signal which is achieved using the classifier. With regards to the accuracy, the system performance can be computed. The accuracy is expressed as:

$$Accuracy = \frac{correctlydetectedpatterns/signals}{totalnumberofpatterns/signals} \quad (5)$$



a. Delta (0-4Hz) Band bTheta(4-8Hz) Band b. Alpha (8-13Hz) Band



c. Beta(13-30Hz) a. Input EEG b. Delta Band d. Gamma(>30Hz) c. Theta Band

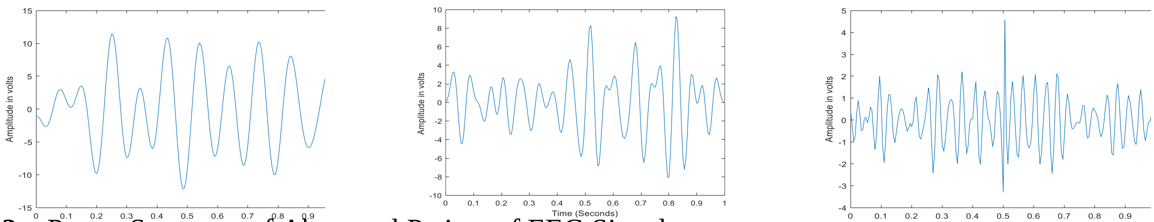


Figure 2: Power Spectrum of Abnormal Patient of EEG Signal.

d. Alpha Band e. Beta Band f. Gamma Band

Figure 1: Input EEG of all Abnormal Patient from Basveshwer Hospital Kalaburagi

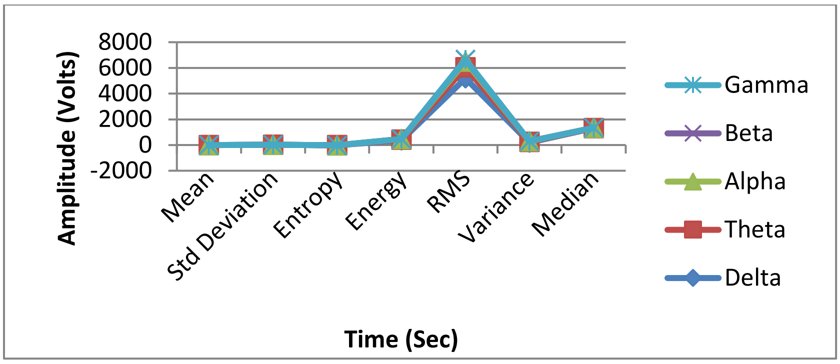


Figure 4: Real time Database from BasvesveshwerHospitalKlb overall average of Abnormal Patient 1 of 18 Channel

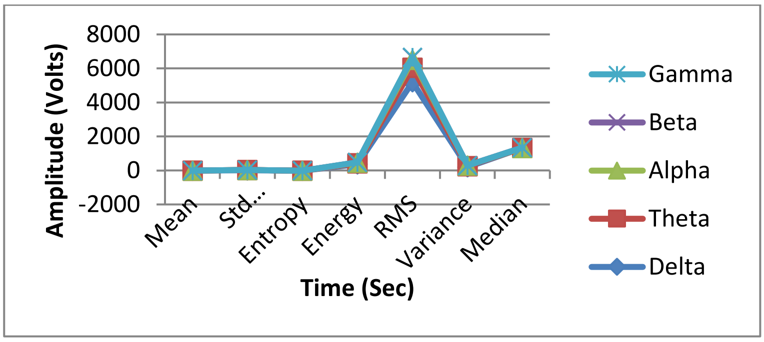


Figure 5: CHB-MIT Database overall average of 23 channel

Table I: EEG Dataset of seizure patients from Basveshwer Hospital Kalaburagi

Table 1: EEG Dataset of seizure patient from Basveshwer hospital Kalaburagi						
Patients	**Statistical Parameter**	**Delta**	**Theta**	**Alpha**	**Beta**	**Gamma**
Patient 1 9Y Male	(Mean± std)	13.89±13.94	19.86±24.07	65.5±89.5	29.77±32.53	13.4 ±15.21
	Entropy	-17.84	25.25	85.9	43.58	17.66
	Energy	367.2	964.32	12273	1939.9	409.9
	RMS	5193.23	13637.65	173567.7	27435.6	5798.03
Patient 2 11Y Male	(Mean± std)	0.00±7.74	0.164±3.38	2.26±19.9	0.39±4.84	-0.51 ± 4.83
	Entropy	1.73	0.63	3.51	-0.074	-0.22
	Energy	59.75	11.45	400.2	23.48	23.51
	RMS	845.1	161.96	574.2	332.13	332.5

						1
Patient 3 Female **4Y**	(Mean± std)	0.13±5.75	-0.02±1.95	0.31±6.38	-0.204±8.2	0.24 ± 4.87
	Entropy	-0.94	0.531	0.88	-0.411	0.67
	Energy	33.02	3.81	40.6	66.97	23.69
	RMS	466.97	53.95	574.2	947.11	335.02
Patient 4 29Y Male	(Mean± std)	0.04±3.19	0.05±3.17	0.15±5.77	5.98± 0.046	0.026 ±2.69
	Entropy	0.01	0.09	0.106	0.05	0.056
	Energy	10.16	10.01	33.24	35.58	7.21
	RMS	143.74	141.56	470.2	503.31	102.03
Patient 5 25Y Male	(Mean± std)	0.00±1.08	-0.00±0.91	0.023± 1.54	0.046± 9.58	0.0013± 1.009
	Entropy	-0.25	0.07	0.565	-1771.38	-4.59
	Energy	1.167	83	2.37	0.056	0.012
	RMS	16.5	11.8	33.53	1292.22	14.33

Table II: CHB- MIT Database Average of 23 Channel

CHB-MIT DATABASE VERAGE OF 23 CHANNEL								
Frequency Band	Mean	Std Deviation	Entropy	Energy	RMS	Variance	Median	Kurtosis
Delta	393.9	141.08	-302.25	174203.8	835452.3	19039.11	4529.44	22.52
Theta	9.37	5.19	7.22	113.7	545.29	24.8	108.3	16.74
Alpha	9.75	99.25	23.19	918.02	45646.8	9421.8	112.6	12.55
Beta	-14.8	97.25	14.79	9268.99	44452.54	9046.67	170.58	9.14
Gamma	4.72	248.67	4.72	59172.9	283783.45	59149.62	54.82	6.25

Table III: methods and Accuracy

Methods used	**Accuracy**
K Nearest Neighbour	93.86
Feed forward Neural Network	95.39
Support vector machine(SVM)	98.5

6. CONCLUSION

From the input EEG signals, the alpha beta gamma delta and theta bands are extracted as shown in the experimental outcomes. A band pass filter is used for performing the extraction upon the signal. Depending upon the band's properties that are presented within the outcomes is fixed by the frequency ranges. The recording of the Mean, Standard deviation, energy, Entropy extracted properties is done during the extraction of the bands. The EEG signals including and excluding the seizures are analyzed by using these features.

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