Seizure Detection for Single-Channel EEG with SVM

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Abstract

Seizure is a period of symptoms due to abnormal neuronal activity in the brain. An epileptic seizure is one of the most serious neurological disorders. Approximately 50 million people have suffered from a seizure. Electroencephalogram (EEG) is the measurement and recording of electrical activity in the brain for diagnosis purpose. Detection of epileptic seizures could be very useful for patient safety. The various method has been proposed to detect the seizure. The main objective is to analyze and detection of the seizure using a single-channel, i.e. F4-C4 (Frontal-central). In the proposed algorithm analysis of EEG signals using single-channel frontal- central (F4-C4) are formed by extracting the alpha-beta gamma delta and theta bands from the EEG signals using a bandpass filter, then the classifiers using neural network and support vector machine is used separately to detect the seizure. The experimental result shows that the proposed method effectively detects the seizure in the EEG signal using the F4-C4 Channel and also showed a reasonable accuracy in detection.

***Keywords:** - Electroencephalography (EEG), Seizure, Discrete Wavelet transform (DWT) Artificial neural network (ANN) Support vector machine (SVM).*

INTRODUCTION

The EEG signal is normally recording the electrical activity of the brain. The recording of EEG signals using 10-20 system. Epilepsy is a chronic neurological disorder of the brain that affects people of all ages. The group of neurons in the brain is sometimes abnormal. Hence the normal pattern of neuronal activity may be disturbed, causing strange sensations, sometimes convulsions, and loss of consciousness. Nearly 80% of the people with epilepsy living in low and middle-income countries do not get the treatment they need. Most seizures involve twitching or shaking, but some seizures only involve staring spells etc. There are two main types of seizures are partial seizures and generalized seizures, depending upon the brain is involved. Partial or focal seizures begin in a limited part of the brain, involving the face or arm. Partial seizures can be either simple or complex. A simple partial seizure doesn't affect memory, while a complex partial seizure may affect behavior, as well as awareness and memory before and after the seizure. Generalized seizures affect both cerebral. Hemispheres from the beginning of the seizure, sub-categorized into several major types: In the Absence of seizure, a person may blink their eyes rapidly, smack their lips, pick at clothing or swallow frequently. EEG signal from patients with seizure-like partial, generalized in Tonic-clonic, myoclonic, absence seizure etc.

Various methods are used for the detection of seizures in the EEG using time-domain analysis, frequency domain analysis, time-frequency domain analysis. The EEG is a non-stationary signal most appropriate to use wavelet transform (time–frequency-based) to get the time as well as the frequency information of the signal simultaneously [1], [2], [5]. It also helps to accurately capture and localize transient features of the epileptic signal on the EEG. The DWT is used for time-frequency analysis giving a quantitative evaluation of different 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 the seizure, divide them into five frequency range such as α, β, γ, δ and θ related to the total range, and eliminate frequency. The EEG signal is highly non-linear and non-stationary, and hence, it is difficult to analyze and interpret it, so SVM is used for the analysis of the EEG signal. Support vector machine is a popular machine learning method; it constructs a separating hyperplane that maximizes the margin between n number of inputs. Two parallel hyperplanes, one on each side of the separating hyperplane, are constructed to calculate the margin from training data, and the feature can be extracted from discrete wavelet transform (DWT). The decomposition of DWT is calculated by a low frequency and high-frequency component using an Artificial neural network (ANN) able to capture and represent complex input and output relationship. A neural network can be used for different purposes like function approximation, classifier, time series prediction, data mining and processing.

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 characteristics is done in automated detection of epileptic activity proposed by ***Katerina D Tzimourta et al. (2017)*** with the help of DWT. A classifier of the support vector machine (SVM) is 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.

Mohammad Sohaib et al. (2018) Proposed dimensionality of the data, using Dynamic mode decomposition (DMD) based epileptic seizure detection is proposed by. CHB-MIT dataset, as well as the 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, and 0.99 of specificity is provided for the datasets. Various kinds of 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 ***Shitanshu Kusmaker et al. (2019)***. With the help of a nonlinear technique, the extraction of the time-domain feature is done efficiently, and a classifier of support vector data description (SVDD) is trained. 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).***

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. 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 ***Shitanshu Kusmaker 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) trained is proposed by ***Satarupa Chakrabarti et al. (2019).***

METHODOLOGY

A seizure, in turn, is a "transient of signs or symptoms due to abnormal activity in the brain. The EEG signals recorded from a patient with epilepsy is to receive and analyze a set of signals and transform the information to indicate that of whether the patient is in a state of seizure or not.

The objectives of the proposed research:

1. Preprocessing of (F4-C4) EEG signal.
2. Decomposition of EEG signals into its prime frequency components using discrete wavelet transforms (DWT).
3. Feature extractions of EEG signal using approximate entropy concept.
4. Classification of seizure using neural/ SVM technique.

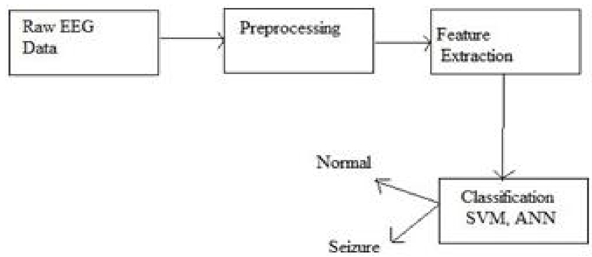

Figure 1: Block diagram of EEG Signal analysis

The block diagram of analysis of EEG signal for seizure detection. The raw EEG data will be given for preprocessing and is filtered to remove noise.

Preprocessing: Preprocessing stage attempts to eliminate these artifacts without losing relevant information, which are related to the type of EEG. The brain activity of an epileptic patient has four major stages:

1. ***Preictal stage:*** the time before the seizure.
2. ***Ictal stage:*** the actual seizure,
3. ***Postictal stage:*** the period after the seizure, lasting usually between 5 and 60 minutes.
4. ***Interictal stage*** characterised by normal brain activity, is the time between seizures (postictal to preictal stage). Seizures can occur

anywhere in the brain, but in children, they frequently occur in the temporal and frontal central lobe.

A. Feature Exaction: For the preprocessed data, the features in the time domain and time-frequency domain are extracted; DWT provides information in both frequency and time domain. DWT is the feature extraction process and analysis of non-stationary signals with transient's occurrences like EEG recordings.

The following features are extracted from the EEG waves

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

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

Where the total number of samples is represented by n and every single data sample is represented by where, 'i' ranges from 0 to N-1

2. Standard Deviation (σ):. The average distance of every single data sample in addition to the mean is measured in this method. The square root of the sample variance is equal to the following equation.

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

Where the discrete sample value of EEG signal in each sub-bands is represented by Xn and denotes the entire samples in the signal is denoted by N.

3. Energy: It refers to the addition to the square of absolute sample value of continuous signals. The calculation of the energy of sub-bands like gamma, beta, alpha, theta and delta are given in equation [11].

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

Where the discrete sample value of EEG signal in each sub-bands is represented by Xn and denotes the entire samples in the signal is denoted by N.

4. Entropy: 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.

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

Where N represents the length of the input signal.

CLASSIFICATION

Several classification methods have been used for EEG classification where the most widely used are Artificial neural network (ANN), SVM [15].

a. Support vector Machine (SVM)

EEG signals are non-stationary it's very difficult to interpret high dimensional feature sets and analyse the characteristics of brain patterns. Machine learning, which is a part of artificial intelligence techniques for pattern recognition of different signals.

SVM is a popular machine learning algorithm that gives better classification accuracy. SVM reduces the complexity of the learning model. Hence it has the ability to successfully generalize in classification problems. This method uses the separation of two different classes; this SVM aims to maximize the margin in order to avoid the risk of overfitting data and minimizes the misclassification error.

SVM tries to find out the maximum margin between two different classes; the optimum dataset is linearly separable means that there exists a hyperplane working as a decision surface we can write

$$WTXi + b \geq 0, \text{ then } di = +1$$

$$WTXi + b \geq 0, \text{ then } di = -1 \quad (5)$$

Where $WTX + b$, is the output function. X_i is the i^{th} input vector W is the weight of the vector, which is perpendicular to the hyperplane, and b is the bias.

Marginal function $WTXi + b$ the dataset is linearly separable we can write as

$$WTXi + b = +1$$

$$WTXi + b = -1 \quad (6)$$

The Neural Network can also be used for different purposes like Function approximation, Classifier, Time series Prediction, Data mining and processing.

RESULTS AND DISCUSSION

In this paper, seizure detection and classification algorithm is proposed based on the Machine learning algorithm. The EEG signals were collected from different brain locations and includes patients having different sex, age and seizure types.

Table I: F4-C4 EEG dataset of seizure patient

Parameter	*Delta*	*Theta*	*Alpha*	*Beta*	*Gamma*
Mean	35.45	0.94	0.3002	0.16	0.01
Std Deviation	47.91	10.27	4.42	3.78	4.49
Entropy	42.97	0.79	0.1	0.12	0.445
Energy	3541.25	105.92	19.53	14.3	20.08

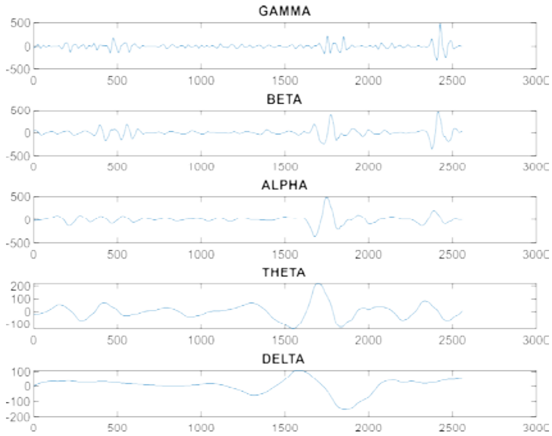

Figure 2: Decomposition of EEG signal of seizure patient

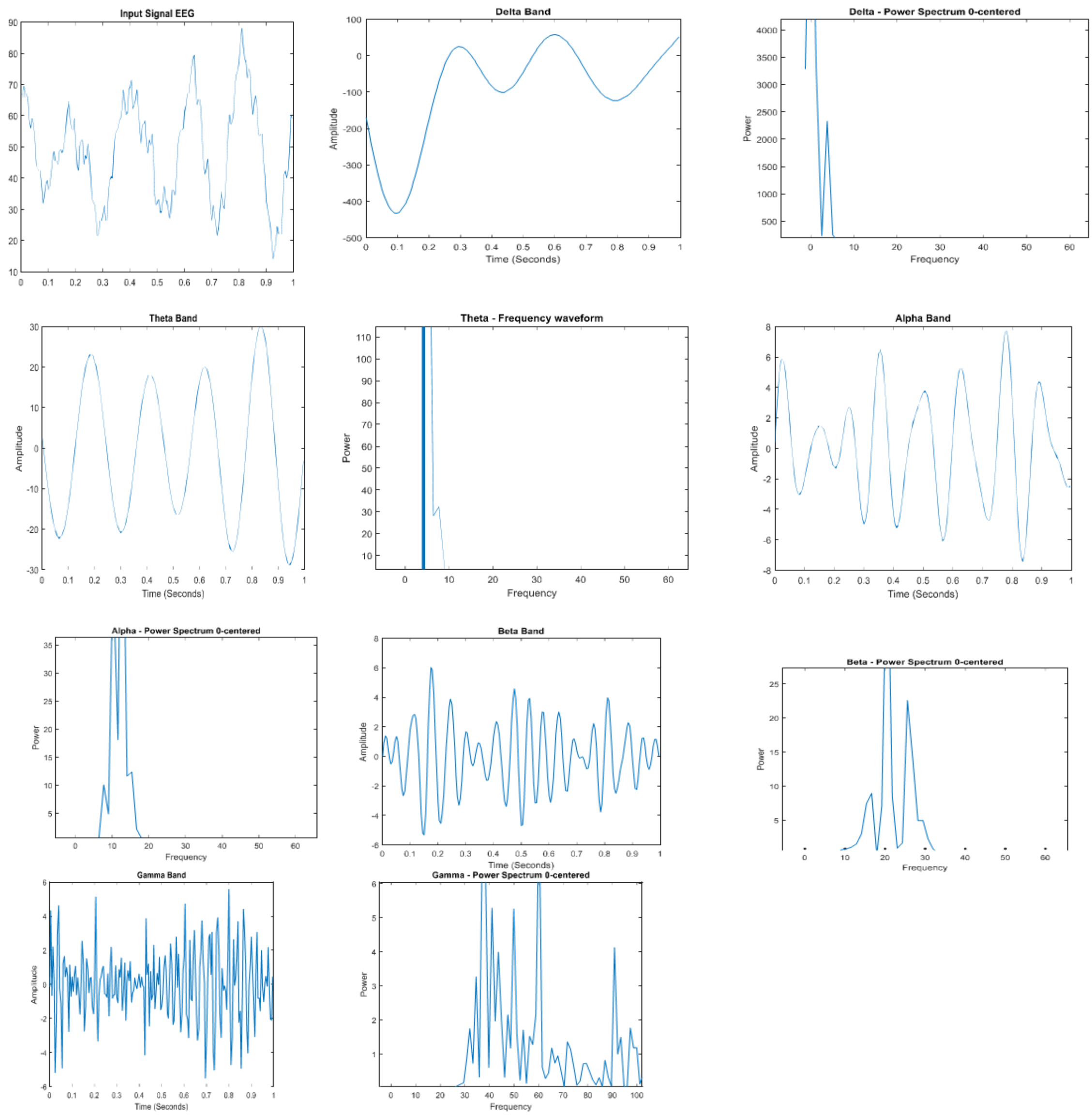

Figure 3: Patient 1, Input signal of Frequency band and Frequency spectrum a. Delta band b. Theta band c. Alpha band d. Beta band e. Gamma band

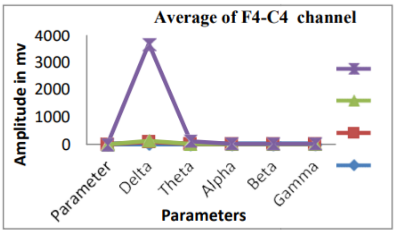

Figure 4: Seizure patient, Average of F4-C4 channel frequency band

The resulting output class for the test signal is given by the position value. Table 2 gives the accurateness for the seizure patient signal, which is achieved using the classifier. With regards to the accuracy, the system performance can be computed. The accuracy is expressed as:

$$Accuracy = \frac{correctlydetectedpatterns/signals}{totalnumberofpatterns/signals}$$

Table 2: Accuracy of EEG signal

Methods used	Accuracy
Support vector machine(SVM)	98.5

CONCLUSIONS

In this paper proposed an efficient SVM classifier based on a few simple features for epileptic seizure detection in EEG signals, Using single-channel F4-C4 (Frontal- Central). The DWT is used for decomposing the EEG recording in 6 frequency subbands and extract several features. The EEG signals are formed by extracting the alpha-beta gamma delta and theta bands from the EEG signals, as shown in the experimental outcomes. Subsequently, these features are given as input to train an SVM classifier. To achieve 98.5% accuracy of F4-C4 Channel.

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