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# Diagnosis and Analysis of Epileptic Seizure Neurological Disorder Using Electroencephalography

Mr. Sanjay S. Pawar[1], Dr. Sangeeta R. Chougule[2]
[1](*Ph.D. Scholar,Shivaji University, Kolhapur, Asst. Professor, Electronics and Telecommunication Engineering, BharatiVidyapeeth's College of Engineering, Kolhapur, , India)*
[2](*Professor, Electronics and Telecommunication Engineering, KIT's College of Engineering, Kolhapur, India)*
*Corresponding Author: Mr. Sanjay S. Pawar*

***Abstract:*** *Epileptic seizure is neurological disorder which can be diagnosed by using Electroencephalography, in this paper online database is used which is preprocessed and artifact removal of EEG signal is carried out. The primary features and secondary features such as mean, standard deviation, variance, skewness, kurtosis are found, which are given for a linear classifier which is Support Vector Machine for classification as seizure or non-seizure. Performance analysis of algorithm is also carried out by calculation of sensitivity, specificity and accuracy.*

***Keywords–****Artifact, Electroencephalogram, Independent Component Analysis, Kurtosis, Seizure, Support Vector Machine.*

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## I. Introduction

Epileptic seizure is a neurological disorder, which is fourth common neurological disorder in the United States after migraine, stroke and Alzheimer disease affecting about approximately 2.2 million people worldwide [1]. An Electroencephalogram (EEG) is the medical test that detects electrical activity in brain using small electrodes, necessary system and international 10-20 electrode placing standards. Any variations in EEG patterns for certain state of the subject indicate abnormality. The brain cells communicate with each other via electrical impulses and are active. A proper identification of Epileptic seizure is necessary for appropriate treatment [2]. The EEG signals are subjected to internal and external noise, which are called as artifacts. External Artifacts are minimized by precautionary measurement during recording of EEG, internal artifacts are removed by implementation of notch filer for power noise and extracting required signal by implementation of band pass filter. The other type of artifacts such as ocular movements and ECG artifact is removed by Independent Component Analysis (ICA). In this paper the detection of seizure is done with the help to statistical first order and second order features and then classifying by using linear classifier.

## II. Methodology

Detecting or identifying seizure in EEG signal with accuracy is very important appropriate treatment. Figure 1 shows block diagram of Automatic seizure detection system which consist of EEG signals from online database, which are preprocessed and required signal is extracted ,internal artifacts are removed, primary and secondary features are extracted which are further given to linear classifier to classify as seizure and non-seizure and then the performance of system is evaluated.

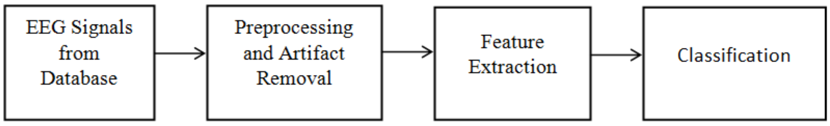


**Figure1:** Block Diagram of Automatic Seizure Detection System

### 2.1 EEG SIGNAL AND DATABASE

The EEG is the brain electrical activity measured by putting electrodes on the scalp. The joint activity of millions of cortical neurons, at the depth of several millimeters, produces an electrical field which is sufficiently strong to be measured from the human scalp [4]. Typically, the amplitude of an EEG signal is approximately from 40 to 100 mV with the frequency range from 0 to 100 Hz [5] on the cellular level bioelectrical signals are related to ionic processes which arise as a result of electrochemical activity of cells having ability to conduct an electrical current. A potential arises when membrane channels of cells open so that ion may diffuse across the membrane, which creates an increase in positive electrical charge. The axon and dendrite are connected with a synapse, which transmits the signal from a presynaptic neuron to a postsynaptic neuron. When some stimulus evokes a nerve impulse to travel across the brain, the signal is moving from a neuron to another. On the brain cortex, the parallel nerve cells becomes synchronously positively and negatively charged, thus these dipoles generate an electrical field [4]. The electrical activity of the cerebral cortex is often called as rhythm, there are five brain waves characterized by their frequency bands. These frequency ranges are called alpha (α), theta (θ), beta (β), delta (δ), and gamma (γ) and their frequencies range from low to high frequencies respectively.

Alpha waves are over the occipital region of the brain and appear in the posterior half ofthe head. The normal range for the frequency of the occipital alpha rhythm in adults isusually given as 8 to 13 Hz, and commonly appears as a sinusoidal shaped signal. Delta waves lie within the range of 0.5-4 Hz. These waves appear during deep sleep and havelarge amplitude.Theta waves are the electrical activity of the brain varying the range of 4-7.5 Hz. The theta rhythm occurs duringdrowsiness and in certain stages of sleep or consciousness slips towards drowsiness. Beta waves are within the range of 14-26 Hz and consist in a fast rhythm with low amplitude,associated with an activated cortex and observed during certain sleep stages. This rhythm ismainly present in the frontal and central regions of the scalp.Gamma waves are those frequencies above 30 Hz related to a state of active information processing of the cortex [8].

The database used for experiment purpose is used from online which is freely available. This database, collected at the Children's Hospital Boston, consists of EEG recordings from pediatric subjects with intractable seizures. Subjects were monitored for up to several days following withdrawal of anti-seizure medication in order to characterize their seizures and assess their candidacy for surgical intervention. The signals were sampled at 256 samples per second with 16-bit resolution. The International 10-20 system of EEG electrode positions and nomenclature was used for these recordings [3]. In this experimental work, we have used bipolar EEG recordings insteadof referential recordings to reduce the effects of common noise/artifacts as well as to eliminate the influence of contaminated references.In case of bipolar EEG recording an EEG channel is formed by taking the difference between potentials measured at two electrodes, and captures the summed potential of millions of neurons. In this experiment both the genders are considered and the age of subjects varies from 11 years to 22 years.

### 2.2 PREPROCESSING OF EEG SIGNALS

Biomedical signals which are in our case more particularly EEG signals, are subject to noise, and noises in EEG signals are termed as artifacts, these artifacts may affect the outcome of the EEG recording. An artifact is considered a disturbance in a measured brain signal not originating from the brains. The artifacts are classified according to their source of introduction in EEG signal either through internal or external influences. External artifacts are caused by outer actions and internal artifacts are associated with the actions made by subject itself. These undesired signals may affect the outcome of the recording procedure, being necessary a method that appropriately eliminates then without altering original brain waves. Most frequently EEG signals contain neuronal information below 60 Hz, so it is possible to remove frequency components above this value simply using low pass filters. In the cases where the EEG data acquisition system is unable to remove electrical noise as 50Hz line frequency, it is necessary to use a notch filter to remove power line noise in it.EOG artifacts have mainly high amplitude and low frequency components and their effects appear usually in the low frequency band of EEG spectrum. Since clean EEG is essential for efficient signal processing and feature extraction, it is necessary to remove EOG artifacts from EEG [10].

Signals from eye movements and blinks called as electrooclugrams (EOG) affect the EEG signals and can be orders of magnitude larger than brain-generated electrical potentials and are one of the main sources of artifacts in electroencephalographic (EEG) data. A movement of eyeballs or eyelids causes a change in the electrical held that will be picked up by electrodes nearby. The human eye can be considered a dipole that is positively charged in front and negatively behind. Movement of eyeballs and eyelids produce different kind of artifacts. These artifacts are somewhat easy to detect because of their typical shape and there are algorithms developed to detect these sorts of artifacts automatically from EEG signal [7],[11].

The Eye blink artifacts are removed by implementing of Independent Component Analysis (ICA), which belongs to a class of blind source separation (BSS) methods for estimating or separating data into underlying informational components. ICA is used in separating and denoising the signals, ICA is applied to only those EEG signals where there is probability of introduction of Eye blink artifacts. The channel 1, channel 5, channel 9 and channel 13 are passed through ICA as the FP1 and FP2 electrodes are used in these channels. The FP1 and FP2 electrodes placements are near the eyes and can be the source of Eye blink artifacts.

### 2.3 FEATURES VECTOR OF EEG SIGNAL

Feature extraction is a crucial step of seizure detection in which features of the data are investigated that is able to differentiate between the seizure and normal EEG data. Feature extraction helps to extract the most relevant features from the EEG signal and thus giving a more precise description and hence making it suitable for further EEG processing. Feature extraction consist in finding a set of measurements or a block of information with the objective of describing in a clear way the data or an event presents in a signal. These measurements or features are the fundamental basis for detection, classification or regression tasks in biomedical signal processing and is one of the key steps in the data analysis process [9]. The change in the distribution of the signal segments can be measured in terms of both the parameters of a Gaussian process and the deviation of the distribution from Gaussian. The non-Gaussianity of the signals can be checked by measuring or estimating some higher-order moments such as mean, standard deviation, variance, skewness and kurtosis [6],[12].

**2.3.1** Mean attempts to describe a set of data by identifying the central position within that set of data.
**2.3.2** Standard deviation it is a statistical feature which indicates the distribution of the data with respective to the mean.
**2.3.3** Coefficient of variationis a normalized measure of thevariance of a series of data.
**2.3.4** Skewness is a measure of symmetry or, more precisely, the lack of symmetry of the distribution. A distribution, or data set, is symmetric if it looks the same to the left and right of the Centre point. If the distribution is more to the right of the mean point the skewness is negative, and vice versa. For a symmetric distribution such as Gaussian, the skewness is zero.
**2.3.5** Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution; i.e. data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak.

### 2.4 CLASSIFICATION

In this paper, EEG signals were classified by using linear classifier such as support vector machinesto detect whether a subject has a seizure or not.Support Vector Machine (SVM) is a primarily supervised machine learning algorithm which can be used for both classification and regression challenges. However, it is mostly used in classification problems. SVM performs classification tasks by constructing hyperplanes in a multidimensional space that separates cases of different class labels. For two dimensional data, single hyper plane is enough to separate the data into two groups such as +1 or -1. In this paper, the value of the SVM output was defined as 1 or -1, which 1 represents the normal/non-seizure EEG and -1 represents the seizure EEG.

## III. Performance Evaluation

The automatic seizure detection systems is tested by using the EEG signal acquired from online database of 4 patients namely subject1, subject2, subject3 and subject4 in which two are male and two are female with age 11 years, 11 years, 14 years respectively. The data is collected by 23 electrode placement by using international 10-20 standard system a bipolar montages are used.A total of 100 EEG signals are used of four patients, out of which 79 signals are of non-seizure and 21 signals are of seizure, A training set of 51 signals are used out of which 40 signals are on non-seizure and 11 signals are of seizure, a testing set of totally different 49 signals are used out of which 39 signals are on non-seizure and 10 signals are of seizure.The signals are preprocessed by removing power noise of 50Hz by notch filter and Eye blink artifact by Independent component analysis and required signal between 3Hz to 60Hz is extracted using band pass filter. The statistical features such as mean, standard deviation, variance, skewness and kurtosis are found out and given to linear classifier SVM for classification between the normal and seizure EEG signal.

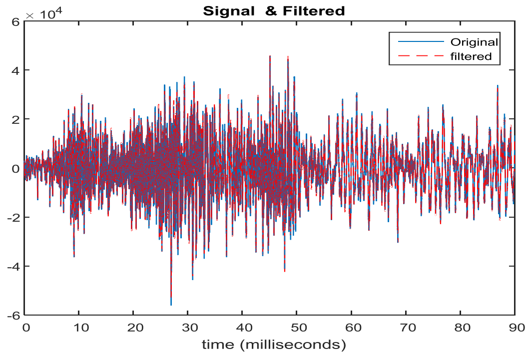

**Figure2:** Original signal and filtered signal

Figure 2 shows the original signal and the filtered signal plot, the signal is filtered by notch filter to remove power noise of 50 Hz.

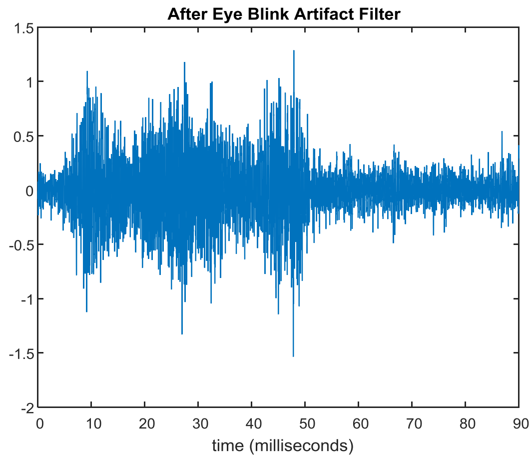


**Figure3:** Signal after removal of Eye blink artifact

Figure3 shows the signal after removal of Eye blink artifact by implementation of Independent Component analysis (ICA).

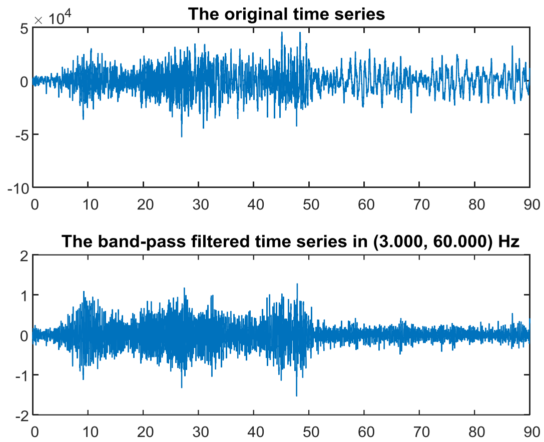


**Figure3:** Band pass filter signal

Figure3 shows the signal after passing through band pass filter with lower cutoff frequency 3 Hz and upper cutoff frequency 60Hz to extract the desired signal.

Out of total 50 tested signal (39 non-seizure and 10 seizure) 9 signals are found to be True Positive (TP), 38 signals are found to be True Negative (TN), 01 signal is found to be False Positive (FP) and 01 signal found to be False Negative (FN).

## IV. Result And Discussion

We have characterized the performance of our seizure detector algorithm in terms of statistical measures such as sensitivity, specificity and accuracy.

Sensitivity: Number of true positives/the total number of seizure segments labeled by the EEG experts. True positive represents a detected seizure segment by the algorithm was also identified as seizure by the EEG experts. Sensitivity = TP/ (TP + FN) = (Number of true positive assessment)/ (Number of all positive assessment), sensitivity of seizure detection algorithm comes to be equal to 90.00%

Specificity: Number of true negatives/the total number of nonseizure segments labeled by the EEG experts. True negative represents a segment labeled as nonseizure both by the algorithm and by the EEG experts. Specificity = TN/ (TN + FP) = (Number of true negative assessment)/ (Number of all negative assessment),specificity of seizure detection algorithm comes to be equal to 97.44%

Accuracy: Number of correctly identified segments/ total number of segments.Accuracy = (TN + TP)/ (TN+TP+FN+FP) = (Number of correct assessments)/Number of all assessments),accuracy of seizure detection algorithm comes to be equal to 95.92%

## V. Conclusion

Automatic seizure detection is significant in both diagnosis of epileptic seizure and relieving heavy working load of inspecting prolonged EEG.In this paper, we proposed a novel method for the automatic seizure detectionin which statistical features of first order and second order such as mean, standard deviation, variance, skewness, and kurtosis which wereextracted and given to SVM classifier to detect the seizures. Experimental results on online EEG datasets show that our proposed method achieved a sensitivity of 90.00 %,specificity of 97.44 % with accuracy of 95.92 %. In future additional feature vectors can be derived and classifier such ask-nearest neighbor algorithm (KNN) and Probabilistic Neural Network (PNN) can be implemented to improve the results.

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