Review of Different Techniques to Detect Epilepsy

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Abstract— Epilepsy seizures are the assumed abnormal brain activities which interrupt the common activity of the brain. These abnormal activities arise because of unpredicted electrical activity in the brain. Brain controls the different parts and different functions of the body. Brain cells are communicated by sending the electrical signals in a proper format. Epilepsy is a neurological disorder caused by malfunctioning nerve cell activity in the brain. These malfunctions cause episodes called seizures. In this paper we will evaluated and validated on the basis of the statistical parameters like accuracy, sensitivity and specificity and by comparing it with other art of techniques. The purposed method will emphasize the novel parameters which may more efficiently define the spikes as they are the main characteristics find in the EEG signals with seizure activities. The decomposition techniques the choice of classification model will also be considered otherwise.

Key words: Electroencephalogram (EEG) Signal, Epilepsy, Empirical Mode Decomposition, EEG Signal Analysis

I. INTRODUCTION

Epilepsy seizures are the unprovoked abnormal brain activities which disturb the common activity of the brain. These abnormal activities occur due to extra electrical charge produced in brain cells or neurons [2]. Total 1% of the world population is suffering from the disease [1]. The manual detection of an EEG is most likely to false detection due to large amount of data and difference in views of different neurologist [4]. Epilepsy is a neurological disorder caused by malfunctioning nerve cell activity in the brain. These malfunctions cause episodes called seizures. Electroencephalogram (EEG) is used to analyze the brain activity for neurological purposes. EEG signal are the measures of electrical potential of brain on different locations on the scalp of a person. The EEG signals are composed of different bands which referred to as Alpha, Beta, Gamma, Delta and Theta. The ranges of these bands are shown in table 1.

Name of band	Range
Alpha	(8-12)Hz
Beta	(13-30)Hz
Gamma	(30-60)Hz
Delta	(0-4)Hz
Theta	(4-8)Hz

Table 1: The ranges of these bands

EEG signal is mixture of these complex waveforms which make its analysis difficult for the doctors. The manual analysis of EEG signal is also time consuming and need experienced doctors which are few in numbers. So the various computational methods have been proposed for the automatic analysis of the seizures.

Seizures (from the Latin satire, "to take profession of '') is a paroxysmal event due to abnormal excessive neuronal activity in the brain. Seizures: two or more unprovoked seizures.

- Provoked seizures: presence of a precipitin factor: head injury, fever, infection, hypoglycemia, CVA, CNS tumor withdrawal from medication.
- Unprovoked seizures: Absence of an identifiable acute alteration of systemic metabolic function or acute insult to the structural integrity of the brain.

II. REVIEW OF LITERATURE

A lot of work has been done on the automation of the detection of epilepsy seizures from the EEG signal. Most of the system use decomposition and then extracting the features which gives them uniqueness. After that training with classification network with extracted features to identify the seizure prone and seizure free EEG signal.

Each EEG signal was decomposed into Intrinsic Mode Function and first three functions were considered for the experimentation purpose. Energy is measured from an EEG signal and detection is done on the basis of energy threshold and a minimum duration decision. EEG records were provided and validated by the Epilepsy Centre of the University Hospital of Freiburg. Before employing the Empirical Mode Decomposition, EEG records were initially filtered with a second order, bidirectional, Butterworth, 50 Hz notch filter in order to remove the line frequency interference. In 90 segments analyzed (39 with epileptic seizures) the sensitivity and specificity obtained with the method were of 56.41% and 75.86% respectively [3].

N. Sivasankari et al. proposed another method in which Linear prediction error filter (LPF) to estimate the signal. LPF is used to measure the spikes in the signal. Difference between actual and predicted value is used as modeling error. On basis of this error, decision of presence of seizure is made. It is observed by the author that energy of the predicted error is much higher in seizures signal than seizures free signals. The performance is measured by ROC (Receiver Operating Curve) curve. The results prove that LPF is very promising technique in seizure detection.

Alam, SM Sheffield, and M. I. H. Bhuiyan et al. proposed Combination of statistical and chaotic features along with the Artificial Neural Network. They proposed to discriminate electroencephalogram (EEG) signals for seizure detection. The EEG signals are subjected to empirical mode decomposition, generating intrinsic mode functions. Skewness, kurtosis, variance, and largest Lyapunov exponent, correlation dimension and approximate entropy are measures as chaotic features from these modes and fed to the ANN to classify the EEG signals. It is shown that the proposed method can achieve up to 100% accuracy as compared to several state-of-the-art techniques in discriminating the seizure signals from the non-seizure ones.

V. Bajaj and R. B. Pachori et al. proposed a method Hilbert-Huang Transformation (HHT) is used for rhythm decomposition [7]. The HHT consist of two steps, first is decomposition of signal by Empirical Mode Decomposition (EMD) and second HHT for the frequency estimation. The frequency estimation of IMF (Intrinsic Mode Decomposition) is used as parameters. The second order difference plot is made to represent variability. Central Tendency Measure (CTM) is used to quantify the variability. It has been observed that best results are shown by the alpha rhythm out of all other bands.

U. Orhan, M. Hekim, and M. Ozer et al. proposed a method of Probability distribution, which is based on equal frequency discretization, is used to detect epileptic seizures [11]. The EEG signal is discredited by Equal Frequency Discretization (EFD) method, and then probability density is calculated. Two different functions are calculated, one for EEG without epilepsy seizures and other for EEG with epilepsy seizure. The MLPNN (multilayer Perceptron Neural Network) is used for classification which gives 99.23% success rate.

M. S. Mercy et al. proposed the comparison the two methods, DWT (Discrete Wavelet Transformation) and ICA (Independent Component Analysis) for the classification of seizures and non seizures EEG signal shows DWT perform better [17]. The dataset is obtained from Rubi Hall, Pune. The performance of both methods has been accessed on the basis Accuracy, Specificity and Sensitivity. Wavelet decomposition at level 4, using Daubechies wavelet of order 2 is used for the decomposition. Mean, Maximum, Minimum and Standard deviation at each level is computed which are used as parameters. As EEG is non stationary signal so DWT gives better results so it outperforms the ICA with great margin.

S. Patidar et al. proposed Empirical mode decomposition method that has also been used to decompose the EEG signal and the resultant sub bands are referred to as Intrinsic Mode Functions (IMF). The SODP (Second Order difference plot) provide their elliptic structure. The 95% confidence ellipse area measured by SODP is used as a feature. The Multilayer Perceptron Neural Network (MLPNN) is used for classification. It is shown that feature space formed using first and second IMF given best results [10].The method based on radial base function neural network by differential evolution (DE-RBNF) is used in [14] for classification. Dataset [16] is used for implementation. The signal is decomposed by wavelet transformation. The parameters used for classification are maximum of wavelet coefficient in each sub band, minimum of wavelet coefficient in each sub band, mean of wavelet coefficient in each sub band and standard deviation of wavelet coefficient in each sub band. DE-RBNF is used for classification. Sensitivity and Specificity are used for performance measure.

Varun et al. have employed Fractional Linear Prediction (FLP) for seizure detection. The dataset [16] is used. The raw EEG signal is passed through the FLP filter, FLP coefficient is used to model the signal. The difference between actual signal and modeled signal is known prediction error. Then energy of the prediction error is estimated and signal energy is also estimated. These two parameters are given to Support Vector Machine (SVM) as training. SVM with different kernel is used and the best results are shown with Radial basis function (RBF).

Empirical mode decomposition has been used by Varun et al. To compute intrinsic mode functions (IMFs). The Hilbert transformation is used for analytic representation of IMF's. Amplitude and frequency modulation bandwidth computed from these IMF's is used as parameters. The dataset is taken from [16]. For the classification Least Square- Support Vector Machine (LS-SVM) is used with morlet kernel which shows better result [9], Accuracy is used for performance measure.

The discrete wavelet is used to separate the different bands of the EEG signal that are alpha, beta, gamma, theta and delta in. The features of gamma band are extracted as it carries maximum information [6]. The dataset is taken from [18]. Least square support vector machine (LS-SVM) is used for classification. The 6th minimum frequency and 6th maximum amplitude is used as feature for preictal and 6th maximum frequency and 6th minimum amplitude is used for incital seizure signal. The specificity, sensitivity and sensitivity are calculated for performance measure.

In the above mentioned work, researchers have employed either pre-processing technique or decomposition of signal into different bands for pre-processing of EEG signals. After the pre-processing or decomposition, some parameters or features (such as amplitude, frequency estimation [7], energy of signal [9], Second Order Difference Plot (SODP) [11], probability density [10]) are extracted for the classification of seizures. Since EEG signals are composed of five bands Alpha, Beta, Delta, Gamma and Theta each of them fall under some specific bandwidth and all the decomposition techniques does not give the signals of exact bandwidth to which alpha, beta, delta, gamma and theta belongs to. So in the proposed methodology, five bandpass filters are designed to decompose the signals into the exact bands and then parameters from these bands are extracted for epileptic seizure classification.

III. CONCLUSION

EEG signals can be used effectively to study the mental states of the brain. Each EEG signal was decomposed into Intrinsic Mode Function and first three functions were considered for the experimentation purpose. For the automation detection of the epilepsy seizures from the EEG signals a lot of work had been done in this. We have presented various signal analysis techniques such as linear production error filter(LPF), combination of statistical and chaotic features along with the artificial neural network, Hilbert-Huang Transformation(HHT) for rhythm decomposition, probability distribution which is based on the equal frequency discretization to detect epilepsy seizures, Discrete wavelet transformation(DWT), Independent component analysis(ICA), Fractional linear prediction(FLP). These techniques give us the accuracy approximation upto 96%. But through our technique we give accuracy up to 99%.

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