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Epilepsy Detection Based on EEG Signals

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Abstract

Epilepsy is a brain neurological disorder in which the brain activity becomes abnormal causing unusual behavior, uncontrollable jerking movements, sensation and sometimes loss of awareness, affecting 71 million people world-wide. ElectroEncephaloGram (EEG) is used to measure the electro-neurological activity of the brain. When the Signal to Noise Ratio (SNR) of the noisy data is lower than 0dB the current seizure detection method can't maintain a strong performance. The SNR of the noise data is below 0dB or negative means that EEG data is corrupted with serious levels of noise..

Index Terms: *Electroencephalogram (EEG), Neural Network, specificity, accuracy, sensitivity, Epileptic seizure, SNR*

INTRODUCTION

Epilepsy is a common brain disorder after migraine. In worldwide around 72 million people have epilepsy, it makes epilepsy the second common electro-neurological disorder after migraine [22]. It is a brain disorder that occurs in mammalian species, in both genders at all ages, especially in neonates and in aging population. In this case probably more frequently the brain become more complex, it can cause a variety of temporary changes in perception and behavior such as the brain activity becomes abnormal, causing unusual behavior, sensation, sometimes loss of awareness stare blankly, and uncontrollable jerking movements of the arms and legs. Epilepsy can be ordered into two, fractional/general Partial seizures: - they are delivered by and large from a restricted limited locale of the cerebrum, and some of the time it might radiate to other new regions. Based on the epilepsy patient's response during the seizure period, partial epileptic seizure is again divided into simple and complex [14]. Epilepsy detection plays a very important role in improving the quality of life of epileptic patients. Electroencephalogram (EEG), the prime and more complex signal widely used for the diagnosis of epilepsy. It represents neuro-physiologic activity of the brain measured electrographically using electrode placed on the Scalp. Electroencephalographic records, is a relevant and most relevant tool/medium for the detection of neural disorders like head injury, tumor and epilepsy. Human EEG they are reflected by numerous ictal patterns, epileptic seizures can typically become evident as characteristic. Usually rhythmic brain signals frequently coinciding with or precedent the earliest observable changes in the behavior. Their diagnosis at the beginning of ictal patterns in the EEG can be used to begin detailed detection process during seizures and to discriminate epileptic seizures from other conditions with seizure-like symptoms [23]. Around 90% of the previous work has aim on developing sufficient and important feature extraction method that can find the most important EEG features

for epileptic seizure diagnosis. Majority of the techniques use hand made features extraction method in time-domain, frequency domain, wavelet-domain, and multiple domain representation of the EEG signals. Domain-based method experience two severe complications. The non-stationary nature of EEG signals makes more difficult to have only one seizure pattern, it makes features small practical in clinical application [4]. Second, the EEG data contain artifacts like eye-blinking, muscle activities & white noise. Noise and artifacts intervene with EEG data, causing serious deterioration that adversely affect the epileptic seizure detection performance [19]. So when the EEG signals corrupted with a medium level noise it results in a drop of 10% in the seizure detection accuracy [24]. In other words if the noisy data SNR is less than zero dB will cause serious distortion in performance [19].So to overcome these problems, a powerful seizure detection system based on deep neural network is adapted, this can accurately and automatically recognize seizures even from the noisy EEG data. Similar to other method feature extraction and classification are the important steps necessary to form automatic seizure detection system. First divide the time-series EEGs into short-length segments. Then feed these EEG segments into a deep neural network for feature extraction. The learned features are then given into a classifier, which calculates the cross-entropy between true labels and predicted labels for the data.

DATA ACQUISITION

Ammama Furrukh Gill et al., use CHB - MIT EEG data base [1]. This database is collected from Boston Children's hospital. The EEG signal were recorded and monitored for several days by the removal of anti-seizure medication to represent their seizures. Osman Salem et al. Hashem Kalbkhaniet, &Ramy Hussein et, use Bonn University, Dr. R. Andrzejak, Germany data base [2]. The recording method uses ten to twenty electrode systems.

Khurram I.Qazi et al. use Peking University People's Hospital, China [3], EEG data set. For Bonn University and Peking University, the data sets are divided into five subsets labeled as A, B, C, D and E. Each subset consists of 100 segment of duration 23.6 sec and each one is sampled at a frequency of 173.61 Hz. To select desired band EEG signal use band-pass (BP) filter with a cutoff frequency 0.53–40 Hz. Sets A consists of EEG signal of a healthy person with their eyes open and B from a healthy person with their eyes closed. Sets C, D and E were recorded from epilepsy patients. Sets C and sets D consists of EEG recordings during the seizure free period, where set C was recorded from the formation of the hippo campal opposite to the hemisphere of the brain and sets D from the epileptogenic zone. And sets E obtained during seizure.

LITERATURE REVIEW

AmmamaFurrukh Gill et al use the Dataset of CHBMIT[1].The proposed method consist of following steps that are preprocessing, feature selection, classification. The data sets are organized in an orderly manner and unwanted signal (noise) is removed in the preprocessing step, is then followed by dissimilar time - domain features from the EEG data recordings from large - range of epileptic patients, in random intervals. This step de-noise and suitably arrange the complete data. The noise removed data is divided into segments of 3.9 seconds and is sampled at frequency 256 Hz. Then feature selection is performed to extract the most excellent features, they are finally used for classification of signals as abnormal or normal. The system is tested from a publicly available dataset and it achieved a typical accuracy of 82.5%.The proposed method consists of a different and

dissimilar time domain features.

1) From thousands of collected samples from a particular portion of the brain entropy (f1) is calculated.

2) From a sets of collected data Mean (f2) [5] is obtained by Multiplying every point with the probability and then adding them together.

3) By adding the inverse of individual signals and then again computing its inverse (reciprocal) to obtain Harmonic Mean (f3) [6]

4) Range (f4) for the signal data is obtained from every channel, is computed to understand the domain.

5) Inter Quartile Range (f5) [7] is obtained by finding the difference between the 75th and the 25th quartile of the data collected from a single channel.

6) The average distance is obtained from a EEG channel is used to calculates Mean Absolute Deviation (f6) [8].

7) Moment (f7) decides central moment of the signals.

8) The third central moment, Skewness (f8) [9] it determines the lopsidedness.

9) Kurtosis (f9) [10] understand is the data is short & squat tall &thin.

10) Percentile (f10) represents the value below which a given percentage of values in a group fall.

Two kind of tests are performed to achieve the goal,: Ansari- Bradley test [11] - [12]. Wilcoxon signed - rank test [13]. From the complete feature set the five features based on the ranks are selected. The selected features mean, entropy, mean absolute deviation, inter quartile range, & moment. Gaussian mixture models (GMM) which is used for the classification is performed based on Bayesian decision rule. The training data consists of around 71 percentages of whole data labeled as X1 as abnormal and X2 as normal. GMM parameters are optimized by using Expectation Maximization. Expectation maximization is an iterative method and choose optimal parameters from the local maximum value of GMM. Then performance is analyzed using Specificity, Sensitivity and Accuracy. This method achieved an average values of specificity, sensitivity and accuracy as82.3%, 82.7%, and 82.5% respectively [26].But this process is liable to human computational errors and erroneous judgment may prove lethal in few cases. This method achieves specificity, sensitivity and accuracy of 82.3%, 82.7%, and 82.5%. [4].

Osman Salem et al. utilize Bonn University informational collection [2]. Rather than breaking down the EEG flags straightforwardly itself this technique depends on extraction and examination of the highlights from EEG. Here receive Discrete Wavelet Transform (DWT) and Ant Colony (AC) Classifier. First concentrate factual highlights from EEG information and after that deteriorated them into four levels and from the wavelet coefficients removing the vitality proportion. What's more, these highlights are the contribution to the AC calculation for determining grouping rules, these standards are utilized for the seizure identification. This strategy gives abnormal state of recognition exactness under genuine condition. The WT look at the EEG motion for various recurrence band and at various goals [15]. This is achieved by high pass filtering and low pass filtering action of the signal in time domain. Each stage consists of two down samplers by 2 and two digital filters. High Pass filter is the first filter and Low Pass (LP) filter is the second filter. The coefficients details and approximation coefficients are the HP filters outputs in the primary stage. The approximation coefficient is again decomposed and is extended up to the desired decomposition stage/level. This wavelet decomposition produces wavelet coefficients of five groups. The frequency bands are D1 is in range of 43.4Hz to 86.8 Hz, D2 is 21.7 Hz to 43.4 Hz, D3 is 10.8 Hz to 21.7 Hz, D4 is 5.4 Hz to 10.8 Hz, and A4 is between 0

to 5.4 Hz, it correlates with EEG to coming within the four frequency bands. They are delta, theta, alpha and beta. Delta is between 1 Hz to 4 Hz, theta: is 4 Hz to8 Hz, alpha is 8 Hz to 13 Hz and the beta takes 13 Hz to 22 Hz [14]. AC classifier, which is a machine learning algorithm, it is similar to the food collecting nature of the ants they communicates each other in an indirect form by the deposition of pheromone [16]. If ants go out from their colony (taking as starting point) looking for food, and stop point is their destination. First the ant's starts inspect for their food in an order less fashion, and there must have some obstruction it makes them to take a final judgment for searching another alternative paths. And there will be a difference in the path lengths. Ant Classifier is applied to the labeled training sets for developing classification rule.

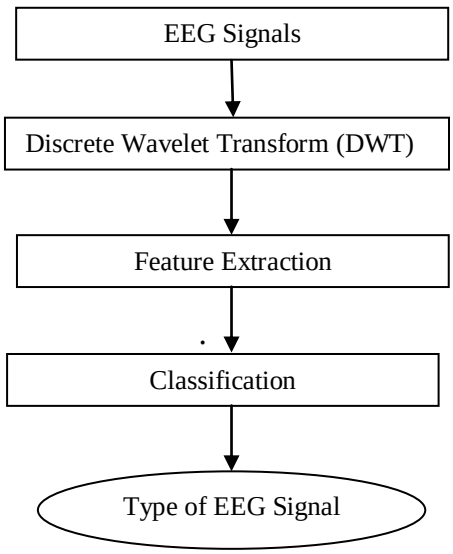

Fig: 1. *Flow chart*

In the first stage record the brain signal by attaching electrodes. In second stage features are extracted, from the original signal extract features such as MIN, MAX, MEAN and STD. Then extract energy ratio and approximation coefficients. At last extracted features are given as the input to the AC classifier for deriving classification rules. These rules are used to detect seizure. The performance of this approach is analyzed based on the Receiver Operating Characteristic (ROC) curve, this can achieves a Detection Ratio (DR) of 100% with a false alarm(FA) = 9% [14].

Khurram I. Qazi et al. use Peking University People's Hospital, China [3]. In feature extraction eliminate the redundancy by selecting the discriminative features. It also helps to reduce the input size of the feature vector. From the EEG data signals first extracting features. By utilizing windowing technique separate neighborhood includes and dependent on the entire flag length worldwide highlights are removed. Discrete Wavelet Transform (DWT) at that point deteriorated the flag into various sub - levels then the flag after every disintegration is gone through a HPF pursued by a LPF. At that point yield of each level is tested by a rate of two. After deterioration extricate highlights, for example, Sum of Absolute Values (SAV), Energy (E), Mean Absolute Values (MAV), go (R), fluctuation (Var) and standard deviation (SD), Average Amplitude Change (AAC) Waveform Length (WL), and Difference Absolute Standard Deviation in time area. At that point consolidate every one of the highlights to shape huge element vector .These element vectors are taken as the contribution to the clever systems to takes in the example. Arrangement depends on prepared classifier. Here utilize managed strategy incorporate SVM, ANN and unsupervised technique k-MC to think about the execution. The execution SVM, ANN and k-MC strategy have been contrasted and the customary classifier, for example, NBC and k-NN technique. SVM and NN have great acknowledgment and arrangement exactness contrasted with k-MC, indeed, even within the sight of commotion [17].

Hashem Kalbkhani et.al, use Bonn

University data set. At First EEG signals are transformed into frequency and time domain using stock well transform (ST).Then computes the amplitudes of five sub bands alpha, beta, gamma delta and theta. Feature extraction is obtained by using Kernel Principal Component Analysis (KPCA). It reduces their relevant information in the feature vector. Then find out the distance measurement, between the training and test samples. The feature vectors are created from the amplitude of the sub-bands. Then normalize each amplitude corresponds to each sub-band is considered as one feature. Highlights are then connected to Nearest Neighbor classifier, the execution depends on the most extreme comparability separate between the test informational collection and preparing information. The test tests be a piece of the preparation test class, it has the most extreme likeness separation of the test information test. The distances includes city block, Euclidean, correlation and Chebychev to measure the test and training sample distance. It achieves higher efficiency. The performance for city block, Euclidean, correlation and Chebychev dissimilarity measures is 99.39%, 99.43%, 98.97%,and 99.54% obtained for 300, 700, 950 and 450 respectively. Optimization algorithms similar to Genetic algorithm can be used to find efficient weight & functions to merge the distance in different sub-bands [18].

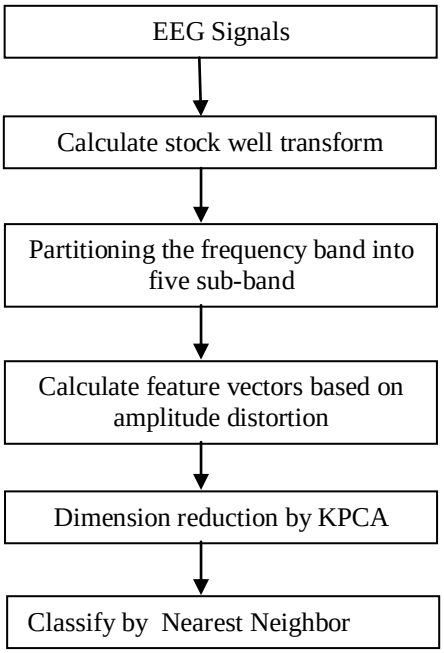

Fig:2. *Stock well Transform-based seizures detection method*

Ramy Hussein et.al, use Bonn University data set. In the presence of noisy data most of the existing method can't maintain strong performance in real life condition. This method maintain a strong epilepsy seizure detection it can accurately identify epilepsy under ideal conditions as well as real life conditions. The feature extraction method is based on L1-penalized robust regression (L1PRR), it extract the important informative seizure-associated feature. These spectral features are the input to the Random Forest (RF) classifier for classification and to train the data sets. When the data is completely free from noise and artifacts this method provide highest epileptic seizure detection rates of specificity, sensitivity and accuracy [19].At first the features are extracted from the frequency spectra using L1-penalized robust regression (L1PRR), it extract most relevant spectral features. These extracted feature is given as the input to the RF (random forest) classifier, it achieves optimum performance in detection rate

&computational cost. The Random Forest classifier merge a set of self-reliant decision tree [20]. A prediction function is characterized based on each tree & the final classification is build based on the majority votes of trees. RF classifier of 100 trees are used. For classification and decision making the data sets are divided for training and testing sets. Disadvantage of using this method is that when EEG data immersed with serious noise, will cause serious distortion. The benefit of this paper is that it achieves higher detection results compared to state-of-the-art method also it keep up high epileptic seizure detection accuracy even in the presence of artifacts and white noise. And this method is computationally simple even though it adopt block coordinate descent (BCD)algorithm to identify most representative features. Random selection of the coordinate is updated using block coordinate descent. Seizure detection in ideal conditions: Under ideal conditions, noisy EEG data of SNR > 0dB, this method achieves high classification accuracy ie; greater than 97.00%. In two class problem presence of any artifacts this system achieves higher sensitivity, 99.00%, DR of 100.0%specificity 99.50%. In three-class classification achieves specificity of 99.67%, sensitivity of 99.67%, & classification accuracy of 99.67%. In five-class classification obtained99.99% sensitivity, 99.99% specificity, and 99.99%classification accuracy. Under white noise accuracies down to76.67% [19].

CONCLUSION

Ammama Furrukh Gill et al, is a four phase framework in which initial step is Pre - preparing, second component extraction, third step as highlight choice and last arrangement step. The grouping depends on Gaussian blend models (GMM). This system achieves an average rate of specificity, sensitivity and accuracy as 82.3% 82.7%, and 82.5%. Human errors and may affect the performance and sometimes it may results wrong judgment.

Osman Salem et al is based on discrete wavelet transform and Ant colony classifier. First the signal is decomposed into 4 sub band levels using discrete Wavelet transform and extract and energy coefficients ratio. Then extracted features are given as the input to the AC classifier for deriving the classification rules. These tenets used to distinguish seizure. This approach can achieve a high DR with low false classification ratio.

Khurram I. Qazi et al in this extract some features and combine them as single set, then classification is based on SVM, ANN and k-MC.

HashemKalbkhani et.al, first calculate stock well transform, then partitioning the signal into five sub-bands to calculate vector based on amplitude distortion, then KPCA is used for dimension reduction, and neighborhood is used for classification.

Ramy Hussein et.al, is based on strong feature extraction method based L1PRR. It can deeply learn the features, this method achieves highest seizure DR ie; 100% specificity, sensitivity and classification accuracy. The disadvantage of this method is that the serious distortion in performance when EEG data merged with high level noise.

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