A REVIEW ON SEIZURAL EEG SIGNAL CLASSIFICATION METHODS

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Abstract: Electroencephalography (EEG) is a technique which records variations in the electrical potential between two electrodes placed on the scalp. Due to its powerful temporal resolution, they are more effective in diagnosis of brain activities or brain abnormalities. Seizure is a brain abnormality where the electrical disturbance in the brain is caused by the firing of the brain cells. Seizures may also be described as either motor or non-motor, depending on whether muscle movement is involved or not. EEG, being a highly non-stationary signal, feature extraction and classification techniques applied should have high accuracy, sensitivity and specificity. This review compares the available classification techniques and suggests the better classification method to achieve high accuracy.

IndexTerms **– EEG, Seizure, Feature Extraction, Signal Classification**

I. INTRODUCTION

Noninvasive neuroimaging techniques including functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy, and electroencephalogram (EEG) are emerging as key tools which help to explore and understand the functionality and dynamics of the brain. Electroencephalogram (EEG), boasting the advantages of portability, low cost, and high temporal resolution, is a non-invasive brain-imaging modality that can be used to measure different brain states although invasive electrodes are used in case of electrocorticography. EEG measures potential changes resulting from ionic current within the neurons of the brain. Despite limited spatial resolution, EEG continues to be a valuable tool for diagnosis and research.

A seizure is an electrical disturbance in the brain caused by the firing of the brain cells. The kind of seizure a person has depends on which part and how much of the brain is affected by the electrical disturbance. Seizures may also be described as either motor or non-motor, depending on whether muscle movement is involved or not. A seizure may take many different forms, including a blank stare, uncontrolled movements, altered awareness, odd sensations, or convulsions. According to an estimation of the World Health Organization, more than 50 million of the world population is affected by epilepsy [1].

The usual detection procedure is based on visual analysis of multi-dimensional EEG signals, performed by experts in neurophysiology, manually, which is a tedious and highly time consuming process. If a system can effectively predict the pre-seizural (inter-ictal) phase, it would be a warning alarm to the physicians for diagnosis. The signal processing methods contains mathematical algorithms, where the features and information are extracted and classified, for better decision making. Through this review, available classification methods are compared, to conclude the best method for EEG seizure signal classification.

II. CLASSIFICATION TECHNIQUES

1. In this paper author investigated on whether Simple Random Sampling (SRS) technique combined with Sequential Feature Selection (SFS) gave the best features for epileptic EEG signals classification. The author selected random samples from their datasets and used 9 statistical features in SRS. The SFS is used to generate less number of uncorrelated variables and to decrease the feature space, which can be used as features for better classifications. The extracted features from SRS were used in two different ways, where firstly the statistical features directly fed to the LS_SVM classifier and results were obtained. Secondly, the SFS based on the criterion was employed to select the key features. They presented a classification with 99.90%, 99.80% and 100% of accuracy, sensitivity and specificity respectively. And their method is faster than the SRS technique [1].

2. In this paper, a novel method for classification of ictal EEG signals, based on wavelet has been proposed. The author used ‘db4’ mother wavelet SWT and employed the same on the trials, on which the Hilbert transform was employed on wavelet coefficients, such that the phase and amplitude of each wavelet was calculated, based on which the Phase to Phase Coupling(PPC), Phase to Amplitude Coupling(PAC) and Amplitude to Amplitude Coupling(AAC) were calculated. The obtained features were ranked using t-test and the further classification was performed with Quadratic Discriminate Analysis (QDA). The proposed model gave 100% accuracy in the method of classification [2].

3. Different supervised (SVM) and unsupervised (k-MC) learning algorithms for classifying the epileptic seizure phases have been employed by the author in this paper. Different techniques to combine binary SVMs, namely One vs One(OvO), One

vs All(OvA) and Binary Decision Tree(BDT) were employed for multiclass classification. Comparisons were made with two traditional methods, namely K-Nearest Neighbor (KNN) and Naïve Bayes classifier were used and it was evaluated that SVM outperform the traditional methods in terms of accuracy. The SVM classifier was intern tested with the ANN, where ANN classified the signals even in the presence of noise [3].

4. The author has performed the classification method on Infants, where the performance of proposed 2D-DWT based scheme represented a set of eight extended Time Frequency based features which were flux, flatness, Renyi entropy, mean, variance, skewness, kurtosis and coefficient of variation in the first set and again eight set of features, which include mean of Instantaneous Frequency(IF), deviation of IF, complexity measure, maximum of singular values of TFD matrix, features based on non-negative matrix factorization of the TFD in this paper. The computational complexity of an EEG sample classification is near real time. The classification of the signals was done using SVM classifier and the seizural and non-seizural activity was validated using Leave-one-out cross validation [4].

5. In this paper, the author has used wavelet decomposition and extracted time and frequency domain, obtained new feature space suing ANOVA, classified using KNN, SVM, Naïve Bayes, SVM. 99% of accuracy was obtained. They proposed classification framework based on multi-domain feature and nonlinear analysis is capable of distinguishing the seizure signals, with the overall average classification accuracy of 100-times 10-fold cross-validation reaching 99.25%, where the 10-fold cross-validation is used to achieve the best classification accuracy compared to the 5-fold cross-validation method [5].

6. The author proposed a novel feature extraction algorithm, a slope of counting wavelet coefficients over various thresholds (SCOT) method with hidden markov model (HMM), to solve long-term EEG monitoring problems. The proposed method had a robust detection accuracy, with result of a good performance of the novel feature extraction method, SCOT with HMM The average detection accuracies are 96.5% and 98.4% using the HMM in seizure and non-seizure, respectively [6].

7. In this work, the ability of high frequency oscillations to discriminate ictal and inter-ictal EEG signals of epileptic seizure patients have been investigated and received satisfactory outcome on it. The DWT and EMD are two strategic methods applied here to develop feature space using r.m.s value of dominant four IMFs. Dominant Intrinsic Mode Functions (IMFs) resulting from wavelet-EMD operation are utilized to propose higher order statistics, entropy and root mean square (r.m.s) based features. One way ANOVA test has been performed for selecting RMS value as the most efficient feature. The latter performance was evaluated using the K- Nearest Neighbor(KNN) and the outcome was satisfactory [7].

8. This author proposed an algorithm for the classification of epileptic seizures of EEG signals. The proposed algorithm was developed in separate modules and later combined to implement epileptic seizure detection and classification of EEG data. In the first stage, analysis of EEG signal was carried out using discrete wavelet transform further in the second stage, using combination of discrete wavelet transform and fast fourier transform, feature extraction was done using twelve cohen class functions in the time-frequency domain and fed to ANN classifier for classification of epileptic seizures [8].

9. In this work, author has proposed a method that was based on application dependent feature selection and HFD calculation stages. The feature set is created by calculating mean values of m number of FD feature series. For the proposed naive method, each signal was divided to the m number of series. Applying HFD algorithm to the features extracted from EEG signals, they have proved that it is possible to gain intuitive information related to signal characteristics [9].

10. The author investigated the problem of classification between epileptic and non-epileptic events from multi-channel EEG data using a large number of time-domain and frequency domain features in this paper. The proposed methodology was evaluated in EEG data from 11subjects. Examination of several classification algorithms showed that the best accuracy is achieved by Bayes Net. The use of the most discriminative features (N¼10) increased significantly the performance of Bayes Net classification at 95%accuracy. The method has been evaluated using cross-validation across subjects and showed that it can generalize satisfactorily providing the means for diagnosis [10].

III. CONCLUSION

From the above techniques that have been compared, few methods gave satisfactory accuracy of classification and few could give the maximum accuracy of 99-100%. The classification methods such as LS-SVM with Sequential Feature Selection, Quadratic Discriminate Analysis and SVM with 10 fold classification have given maximum classification accuracy between 99-100% whereas other methods could give lesser classification accuracies. Thus from the above review, it is suggested that to classify seizural phases using EEG signal should have multidimensional features using combined feature extraction methods such as SRS-SFS and classification techniques such as Quadratic Discriminate Analysis or SVM classifier to achieve maximum accuracy.

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