Spike based Epilepsy Detection Algorithm from an EEG Signal

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Abstract: ***Epilepsy seizures are the assumed brain activities which interrupt the common brain activity of the brain. To detect the epilepsy we use the EEG signals. This paper shows new spike based component as it is one of principle qualities of epilepsy inclined EEG. The IMFs (Intrinsic Mode Decomposition) of the EEG is computed by utilizing EMD (Empirical Mode Decomposition) and initial five IMFs are utilized as a part of proposed study. Since the nearness of spikes builds the adequacy of sign, greatest estimation of each IMF is utilized as highlight to prepare the classifier. The characterization of EEG sign into seizure or no-seizure is finished by utilizing ANN. The consequences of the every IMF is recorded exclusively and finished up the third IMF demonstrates the best nearness of spikes. The after effects of proposed technique are moreover contrast and other existing strategies for the approval.***

Keywords: Epilepsy,Seizures,Spikes,Electroencephalogram(EEG),Empirical Mode Decomposition,

1. Introduction

The neurological exercises of the human characterize the status of the cerebrum and also body. These exercises are recorded as signs and investigation of which requires instruments relating the computerized signal preparing. One of the confusion for which cerebrum exercises are examined is for the identification of epileptic seizure. It is ridiculous anomalous exercises of the cerebrum which aggravate the every day life of individual in which individual experience seizure which likewise come about into the passing now and again [1]. The exercises are for the most part created due to the era of additional electrical charge by the neurons in mind [2]. Absolute 1% of the world populace is enduring from this sickness [3]. Electroencephalogram (EEG) signal is estimation of the mind exercises as electrical sign which cover the extensive variety of data of the mind movement. The patient is put under the investigation for long time which results into huge information of EEGs and the EEG is concentrated on by the prepared specialists for variation from the norm. The entire procedure is costly and tedious [4]. The examination of an EEG is finished by the disintegration or preprocessing of a sign which is trailed by the parametric extraction. Segregation of ECG sign into seizure or no-seizure by utilizing regulated learning instrument. Diverse creators have utilized the diverse methodologies for each step.In [5, 6] an EEG sign is considered as stationary sign, time and recurrence related parts are removed from a sign for recognition of epileptic EEG signal. The sign is moreover considered as non-stationary sign in which strategies in view of time-recurrence is utilized for EEG signal examination [7, 8]. Alternate studies in which sign is considered as non stationary utilized multiwavelet [1519] what's more, wavelet [3,9-14] for epilepsy classification.The diverse parameters removed identified with the epilepsy are recurrence based, abundancy based, mean and standard deviation subsequent to utilizing wavelet change on the sign and free part examination [16-18]. The coefficients of sub-groups, normal of coefficients, entropy of the sub-groups after wavelet disintegration are additionally utilized as parameters for epilepsy grouping [19, 20]. The displaying and expectation blunder in the wake of utilizing Linear Forecast Filter, Equal Frequency Discretization and Fragmentary Linear Prediction is additionally utilized as parameters for epilepsy grouping [21-23]

2. Material and Method

A. EEG Data Set

The proposed method is implemented on the publically available dataset by Bonn University, Germany [9]. The whole dataset consist five sets; A, B, C, D and E where each set contains 100 single channel EEG signals of duration 23.6 second. The dataset is recorded by placing the electrodes according to 10-20 international system with 128 channel amplifier system at 173.61 Hz sampling frequency. The first two set A and B contains the signal of five healthy volunteers by using surface EEG recording system with their eyes open and closed. The set C and D contains the signal from the five patients suffering from epileptic seizure during seizure free stage. The set C contains the signal from epileptogenic zone and set D contains the signal from hippocampus formation of the brain which is opposite to the hemisphere. The last set E contains the signal during the active seizure stage from all the recording sites. To verify the proposed algorithm for seizure detection, two set A and E is considered where set A belong to seizure free class and set E belong to seizure class. The Fig. 1 and 2 shows the signal from Set A and E.

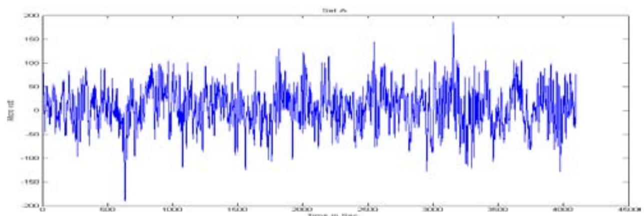

Figure 1: Signal from set A (Non-Seizure)

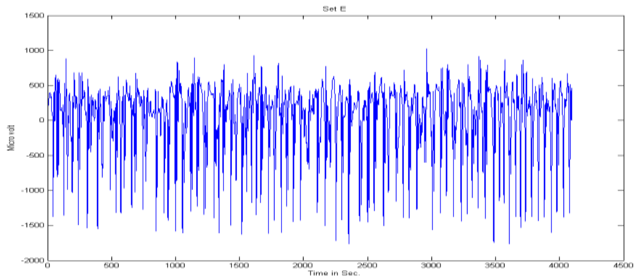

Figure 2: Signal from set E (Seizure)

B. Decomposition

a) Discrete wavelet decomoposition: Wavelet Transformations provides the representation of a signal into the time and frequency domain and is widely used in the area of biomedical signal for different kind of problems. In the wavelet transformation two windows are used; one of which is used get high frequency information and second is used for low frequency information of a signal which helps to separate out different related data from intermixes of irregular data. In DWT the signal is passed through low pass and high pass filters on the basis of some cut off frequency which is one fourth of the sampling frequency. The outputs after the passage of filters are considered as approximate coefficient and detail coefficient where output having half of the bandwidth of original signal is decomposed into the two sub-bands again. The same procedure is used to calculate approximate and detail coefficient at each level. At each step frequency resolution is double and time resolution is halved through down sampling and frequency resolution*[10.11]*.

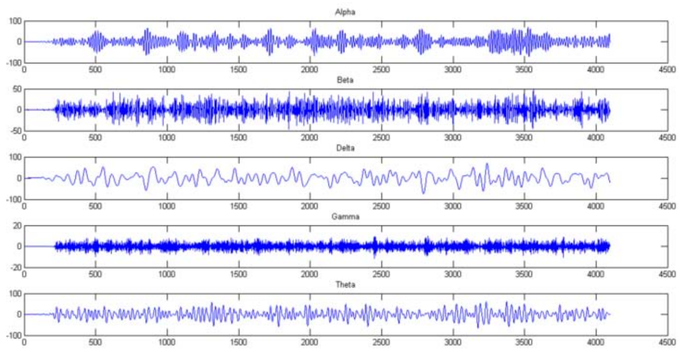

Figure 3: The decomposed sub-bands of the Set A (non-seizure)

b) Empirical mode decomposition: The EMD decomposed the signal into the different Intrinsic Mode Functions with being provided by any conditions where each IMF satisfies the two conditions; one is number of zero crossing by signal and value of extreme must be same or differ by two and second is at any time mean value of maxima and minima defined by envelope must be same[12]. Each IMF is derived by subtracting the preceding IMF from the original signal, the process continue until the residue is come out be a signal from which no more IMF's can be calculated.

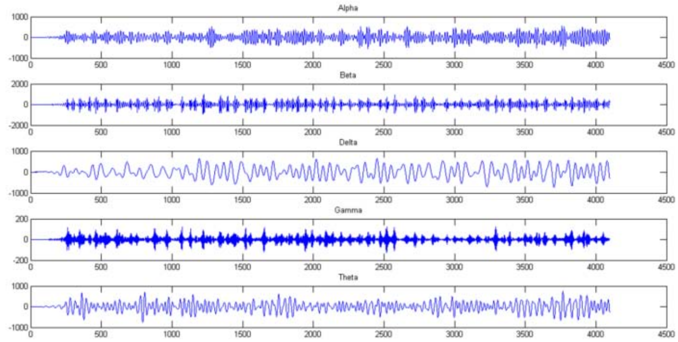

Figure 4: The decomposed sub-bands of the Set E (Seizure)

C. Parameters Extraction

After decomposition or pre-processing of an EEG signal, some parameters related to the epilepsy is extracted which discriminate seizure and non-seizure EEG signals are used to train classifier. These parameters are chosen so according to abnormal behavior that is find in seizure prone EEG signal as compare to seizure free EEG signals.

EEG signals with seizure activities are found be to more regular than normal EEG signals so the entropy values and probability distribution values are used as discriminating feature to train classifiers. On the spectral parameters the amplitude and frequency behaviors of the seizure prone EEG signals are very much different as compare to normal EEG signal so amplitude bandwidth, frequency bandwidth, zero crossing, frequency estimation are used seizure classification. In some studies, modeling errors are also calculated after pre-processing the raw EEG signal after applying some filter which is further used for training classifiers and gives promising and acceptable results in seizure classification.

D. Classification

The parameters extracting from an EEG signals of all classes are used to train classifiers which make the decision while testing the method with testing data. The commonly used classifiers in epilepsy detection from an EEG signal are Artificial Neural Network, Support Vector Machine and Neural fuzzy network all of which gives good results with one or other parameters relating to epilepsy

E. Evaluation Parameters

After the training and testing of the classifiers for the epilepsy detection, the performance of purposed method is measured on basis of three evaluating parameters. These parameters are Sensitivity, Specificity and Classification Accuracy.

- **Sensitivity**
  Sensitivity is the measure of the correct classification of the positive patterns.
- **Specificity**
  Specificity is the measure of the correct classification of the negative patterns
- **Classification Accuracy**
  Classification is the measure of the overall accurate classification of the method

3. Results and Discussions

The proposed method is implemented in MATLAB® 2010b on Core 2 Duo (2.93 GHz) with 2.00 GB memory. The proposed method for epilepsy detection from an EEG signal is tested on the publically available dataset which have five sets each containing 100 single channel EEG signal from different location of scalp from normal and epileptic patients. The whole dataset is divided into total five cases where each case contain one or more set having non epileptic EEG signal as one class and epilepsy prone EEG signal as another class as non epilepsy. The method is tested on each case with two classifiers artificial neural network (ANN) and support vector machine (SVM) and performance is evaluated with three parameters Accuracy, Sensitivity and Specificity. The proposed methodology is analyzed by individual sub-bands and their performances are recorded in the form of same parameters as used in detection with all bands. The validation of the method is given by the comparison of it with other state of art techniques for epilepsy detection from an EEG signal.

The analysis of the results of the proposed method with ANN and SVM shows that spike based parameters shows better results with ANN as compare to SVM. The best results are given in some cases but both ANN and SVM but in overall performance ANN shows better results as compare to SVM in all cases.

Readings with zero crossing (Wavelet): This table shows the values of accuracy, sensitivity, specificity and having five dataset i.e. A, B, C, D, E.

The proposed method is approached with the help of parameters and by the technique zero crossing(Wavelet) with the help of Artificial neural network(ANN). This method gives thebest result in two cases. But the Support vector machine(SVM) gives the better result in all the cases which is shown in the fig the graph diagram shows that the accuracy,senstivity,specificity are validated with the help of ANN

Table 1: Readings with zero crossing (wavelet)

S. No	*Set name*	*Accuracy*	*Sensitivity*	*Specificity*
1	A,B,C,D Vs E	86	45	96.3
2	A Vs E	85	81	89
3	B Vs E	88.5	89	88
4	C Vs E	96.5	95	98
5	D Vs E	93.5	95	92

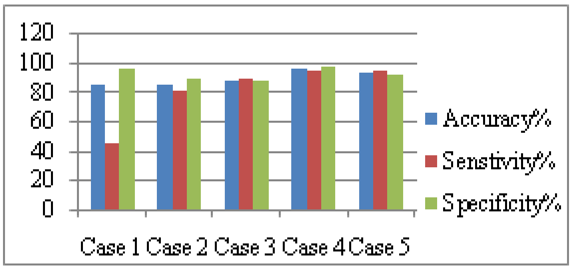

Figure 5: Result with SVM

Table-2 Readings with Zero crossing and Max, Min (Wavelet): This table shows the values of accuracy, sensitivity, specificity by the help of SVM.

The results with the help of SVM I three cases are good. By the help of zero crossing technique we show that the ANN gives the best results.

S.no	Set name	Accuracy	Sensitivity	Specificity
1	Z,N,O,F Vs S	98.8	96	99.5
2	Z Vs S	100	100	100
3	O Vs S	100	100	100
4	N Vs S	100	100	100
5	F Vs S	98	98	98

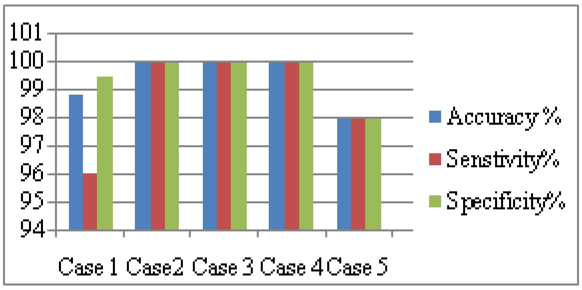

Figure 6: Results with ANN

Table 3: Comparison of proposed method

S.no	Reference	Year	Accuracy (%)
1	13	2004	97.2
2	14	2005	92.22
3	5	2005	99.6
4	17	2007	95
5	6	2007	98.72
6	18	2010	95.2
7	19	2011	(PCA+Neural network) 96.75 (ICA with Neural Network) 93.63
8	16	2012	100
9	20	2014	93.55
10	15	2015	99
11	Proposed	2016	100

4. Conclusion

The implementation of the proposed method for the epilepsy detection and its evaluation in term of classification accuracy, sensitivity and specificity. The method is also compared with the other state of art techniques for the validation and its is observed from comparison that the proposed method gives better results as compare to most of the state of art techniques for epileptic seizure detection from an EEG signal.

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