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Seizure Detection using SVM Classifier on EEG Signal

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Abstract: Brain is the essential organ for human being because it performs the co-ordination of different specialized function of the body through neural and chemical communication. Seizures are symptoms of a brain difficulty. It happens because of sudden abnormal electrical activity in the brain. Human brain emits the electric field in waves that can be precise by the device called an electroencephalography (EEG). As done in the previous study, Gray level Cooccurrence matrix (GLCM) is used for extracting essential features from the EEG signal. Selected features are classified using the support vector machine (SVM) method. This proposed system brings forth the achievement of sensitivity, specificity and classification accuracy which are 90, 90 and 90%, respectively with simple preprocessing. According to the previous study Artificial Neural Network (ANN) was analyzed. The most important objective of this analysis is to compare the performance of classifiers such as ANN and SVM for seizure detection.

Key words: Seizure, EEG signal, GLCM, SVM, neural network, accuracy

INTRODUCTION

The record of electroencephalography (EEG) is closely related to the record of epilepsy. Human brain is a focal point and takes part important functions related to nervous system. The system is divided into three separate areas. They are the cerebrum, the cerebellum and the brain stems which are circulated by the electrical field of nerve fibers are found in the cerebrum. A device that measures this electrical action in the brain is called EEG. Seizure is a paroxysmal event due to irregular excessive hypersynchronous neuronal discharge (Misra and Kalita, 2009). Epilepsy is also identified by seizure disorder because the tendency has recurrent seizures. Classification of seizures is important for aetiology, using the suitable method for providing information regarding epilepsy. The main characteristics distinguishing different groups of seizures are partial or generalized. The partial seizure identifies by affecting partial area of brain where the seizure activity is restricted to the part of the cerebral area whereas generalized seizures affects diffused regions of brain by bilaterally symmetrical fusion (Subasi and Ercelebi, 2005; Ubeyli, 2009). Special sensors (electrodes) are attached on the scalp to diagnose epilepsy and see what types of seizures are occurring. A system of electrode placement is necessary for maintaining a constant relationship between the electrodes and underlying cerebral structures. The 10-20 system of electrode placement has been approved by International Federation of Societies for EEG and Clinical Neuro-physiology (Misra and Kalita, 2009). For recording the amplifying voltage differences between the electrodes placed on the scalp or cerebral cortex or brain, EEG helps in this study and analysis of electrical activity of the brain. The scalp EEG is studied by recording the electrodes which are placed on the scalp is known as the scalp EEG. If it placed in depth it is electrocorticography or depth EEG recording. The EEG recording based on earlier experience and normative data is classified into normal and abnormal and abnormality is again classified into epileptiform or non-epileptiform activity. Lastly, the significance of EEG finding is determined in the background of clinical and radiological investigations. EEG comprises the variety of waveforms of diverse frequency, amplitude, spatial distribution and reactivity to different stimuli. The types of EEG waves are identified according to their frequency range and they are as follows (Ubeyli and Guler, 2007; Orhan *et al*., 2011):

- Delta: Below 3.5Hz (0.1-3.5 Hz)
- Theta: 4-7.5 Hz
- Alpha: 8-13Hz
- Beta: 14-40 Hz
- Gamma: Above 40 Hz

The diagnosis of epilepsy is clinical since the scalp EEG is the generally accepted test for the diagnosis for epilepsy (Subasi, 2005, 2007). Quantitative EEG analysis and brain mapping, though have been around several years, are yet to be integrated into routine clinical practice. For identification of electroencephalographic changes includes feature extraction, feature selection and

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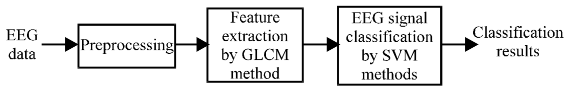

Fig. 1: Block diagram of the proposed system for EEG classification

classification is the general pattern recognition approach on EEG signals (Fig. 1). In this study, by using the raw EEG data the GLCM method is used for feature extraction. SVM classifier is detected the features such as contrast, correlation, energy and homogeneity for seizure classification. The proposed method has been tested on both normal and abnormal EEG data. We compare the results with our previous study where the method was tested using neural network as classifier.

LITERATURE REVIEWS

Guo *et al.* (2009) projected feature classification by using the method of relative wavelet energy. The artificial neural network was used for EEG signal classification. Implemented of their method on the epileptic EEG database by using eyes open healthy volunteers and for epileptic seizure activity patients attains 95% classification accuracy. Siuly and Wen (2011) experimented and obtained 94.92, 93.44 and 94.18% of the average sensitivity, specificity and classification accuracy, respectively by using Clustering Technique (CT) approach for the feature extraction and by using the Least Square Support Vector Machine (LS-SVM) as classifier with RBF kernel function for the EEG signal classification. Subasi (2007) reached overall accuracy of 94.5% by using wavelet transform for feature extraction and double loop Expectation-Maximization (EM) algorithm for detecting the epileptic seizures. The method proposed by Ubeyli (2008) achieved 99.56% total classification accuracy by using the method of coefficients of three model-based to extract the features. The author implemented the method of LS-SVM as classifier for detecting the epileptic seizures (Subasi, 2006). Evaluated and reported the performance of the Dynamic Fuzzy Neural Networks (DFNN) for epileptic seizure detection. In their method features were extracted using Discrete Wavelet Transform (DWT). Ubeyli (2008) moulded EEG signals by describing the time-frequency representations and discrete wavelet transform (DWT). The statistical features were calculated and the mixture of experts (ME) classifies the EEG signals.

MATERIALS AND METHODS

Data collection: In this study, the online available EEG database was experimented and the study of Andrzejak *et al.* (2001) was referred for further details. In our previous study (Nanthini and Santhi, 2012) we had been utilized this same database for Artificial Neural Network (ANN) classifier and concluded that ANN gives good performance classification results. In this proposed system, Support Vector Machine (SVM) classifier for the same set of database is used. Five healthy volunteers were selected by using the standardized electrode placement scheme. EEG recording were carried out using sets A and B. Set A explains those relaxed subjects in an awaken state while eyes open. Set B explains those relaxed subjects in an awaken state while eyes closed. Set C and D showed the measured activity during seizure free intervals. Set E explains the seizure activity only. Dataset (A and E) were used in this study. EEG recordings taken from set A and E are characterised in the following facts. The Fig. 2 shows the periodogram of normal subjects. The Fig. 3 shows the periodogram of abnormal subjects. The periodogram is an approximation of the spectral density of a signal. Here the smoothed version of the periodogram is identified by the help of spectral plot. Smoothing takes part an important role to reduce the effect of measurement noise.

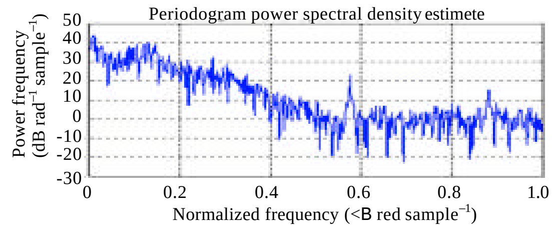

Fig. 2: Periodogram for normal subject

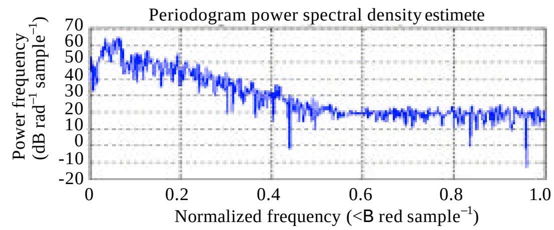

Fig. 3: Periodogram for abnormal subject

EEG feature extraction: GLCM (Gray level Cooccurrence matrix) is used for EEG signal features are extraction. A cooccurrence matrix C is described over n*m and image I limited by an offset (ΔyΔx) as:

$$C\Delta x\Delta y(i,j)=\sum_{p=1}^{n}\sum_{q=1}^{m}\begin{cases}1, \text{if } I(p,q)=i \text{ and } I(p+\Delta x, q+\Delta y)=j\\ 0 \text{otherwise}\end{cases}$$

In this study, each signal wave is considered as an image. The grayscale values of the specified pixels are identified by the value of the image. The texture of an image with cooccurrence matrix can be used to generated

Table 1: GLCM features for normal and abnormal subjects

Features	Subject	Contrast	Correlation	Energy	Homogeneity
Normal	s1	22.0816	0.0165	0.2944	0.6057
	s2	24.1962	-0.0977	0.3002	0.5679
	s3	25.8003	-0.0813	0.2637	0.5393
Abnormal	s1	19.7969	0.1338	0.2928	0.6465
	s2	24.7066	-0.0113	0.2514	0.5588
	s3	24.1233	-0.0151	0.2651	0.5692

by using any matrix or pair of matrices (Nanthini and Santhi, 2012). The sample GLCM features for normal and abnormal subjects are shown in the following Table 1.

EEG signal classification: SVM has been used in current years as an alternative to ANN. Due to Structural Risk Minimization (SRM), SVM achieves the enhanced generalization. SVM can be used for non linear data by using kernel function even though SVM is linear. Basic SVM detects the pattern into two class classifier, with some modification, multiclass classifier can be obtained. Classifying data is an important job in machine learning (Ubeyli, 2010). In EEG classification problems, n experiments as follows $\{(x_1, y_1)... (x_n,y_n)\}$ This is called the training set. Where x_i is a vector and y_i is a binary class label ±1. For this given data points each data pointed belong to one of the two classes. The main aim of the SVM algorithm is to choose which category a new data position will be in. The SVM classifier was trained using MATLAB. Using the information in SVM classifier structure svmstruct and svmtrain function, the function svmclassify classifies each row of data in sample. In this study, the SVM is applied to the problem of EEG signal classification. The classifier was trained using 50 datasets and tested using a new set 20 epileptic and non epileptic data.

EVALUATION OF PERFORMANCE

A value of "-1" is utilised for detecting the normal EEG pattern and "+1" for epileptic seizure. Confusion matrix method is used for examine the prediction success of the classifier. TPR (true positive ratio) and TNR (true negative ratio) are calculated by using confusion matrix method for analysing the output data. In order to analyse the output data obtained from the application, Sensitivity, specificity and total classification accuracy are evaluated by the following equation:

$$\text{Sensitivity} = \text{TPR} = \frac{\text{TP}}{\text{TP}+\text{FN}} \times 100\%$$

$$\text{Specificity} = \text{TNR} = \frac{\text{TN}}{\text{TN}+\text{FP}} \times 100\%$$

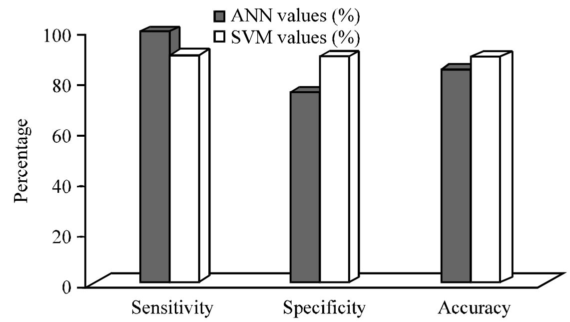

Fig. 4: Performance measurement of ANN and SVM

Table 2: Performance measurement for ANN classifier

	Predicted	
Actual	Normal (Negative)	Abnormal (Positive)
Normal (Negative)	10 (TN)	0 (FN)
Abnormal (Positive)	3 (FP)	7 (TP)

Table 3: Performance measurement for SVM classifier

	Predicted	
Actual	Normal (Negative)	Abnormal (Positive)
Normal (Negative)	9 (TN)	1 (FN)
Abnormal (Positive)	1 (FP)	9 (TP)

Table 4: Valuesof performance measures

Measures	ANN values (%)	SVM values (%)
Sensitivity	100	90
Specificity	76	90
Accuracy	85	90

$$\text{Accuracy} = \frac{(\text{TP}+\text{TN})}{(\text{TP}+\text{FP}+\text{TN}+\text{FN})} \times 100\%$$

EEG classification using ANN has showed in Table 2 and 3 shows the confusion matrix of the EEG classification using SVM. The SVM classified the normal and abnormal subjects with the accuracy of 90%. ANN and SVM models are compared for EEG signal classification are given in Table 4.

The performance measures of ANN and SVM are calculated for three independent features such as sensitivity, specificity and accuracy are shown in the Fig. 4.

CONCLUSION

Seizure detection is a complex task. Based on GLCM, an automated seizure detection method was developed. To improve classification accuracy of the EEG signals various methods are suggested, this study is presented the use of SVM for EEG signal classification. The extracted features like contrast, correlation, energy and homogeneity are suggested for the classification of EEG signals which are trained and tested. Our proposed system has achieved sensitivity, specificity and classification accuracy which are 90, 90 and 90%, respectively. The same small set of database has been utilized in this present study which had analyzed in the previous study. In future this limitation will be overcome by further points of data. In this analysis, the comparison of classifier based on performance accuracy has been furnished. The accuracy rate achieved by the SVM classifier is offered for the classification of the EEG signals which are found to be higher than ANN trained with the back propagation algorithm.

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