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Identification of Seizures in EEG Waves using Determinant Analysis

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Abstract: **Electroencephalogram (EEG) signals are electrical signals that are recorded from the scalp. They can be used to carry out the analysis and identification of brain disorders. EEG signal are non-stationary. Feature extraction of EEG always remains as a major because of the non stationary behavior along with their accurate classification. Support vector machines are supervised learning models used for classification & regression analysis. LDA classifiers are also used for classification. The main objective of the proposed work is to identify the seizures in the EEG waves. Real time databases are collected and filtered to remove the noise. Each EEG channel is normalized & trained using Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) classifiers to locate the seizures. Their results are compared based on their performance.**

Keywords **– Electroencephalogram, Seizures, Classification, Support Vector Machine, Linear Discriminant Analysis**

I. INTRODUCTION

Brain-Computer Interface (BCI) is a communication system in which commands are not dependent on the brain's normal output pathways of peripheral nerves. It is used to help the patients suffering from damaged motor functions (example: completely paralyzed patient). BCIs are also widely used in the area of biometric identification. It is interesting and highly interdisciplinary area of research that will bridge medicine, neurology, psychology, signal processing and machine learning. The main objective of BCI is to convert brain activities into commands. To achieve this goal, initially signals from the brain are recorded using electrodes (example: amplitudes of evoked potentials). These features are later classified and translated into commands.

EEG is a measure of the electrical activity of the brain which represents summation of post-synaptic potentials obtained from a number of neurons. The temporal resolution of EEG is higher and it is a direct measure of the brain's electrical activity. EEG is an useful clinical tool in the field of epileptology. It also has its application in neurology and psychiatry.

There is wide range of problems associated with EEG analysis and interpretation, which has reduced the application of EEG. Visual analysis of EEG activity is the most popular method which used strip charts. This is time consuming job and skilled interpreters are required, who can do subjective judgment and error. Manual analysis of temporal EEG sometimes fails to detect the features of EEG that contain significant information, and hence many researchers are working on development of an automated tool that makes analysis of the EEG signal easy and extract the hidden important information in the signal. Some contribution already exist that are used in detection of epilepsy& seizure in EEG signal using different methods such as template matching, Neural Network based approaches, etc.

The proposed work deals with identification of seizure areas in the given EEG waves using two classifiers namely Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) classifiers to locate the stimuli The results of both the classifiers are compared.

II. LITERATURE SURVEY

Classification approaches for Seizure detection is a wide research area in computer vision. Researchers have used a number of different algorithms to detect the seizure. Papers on both classification and seizure identification for BCI have been studied and described below in this section.

By studying an adaptive feature extraction and classification methods[1] and their performance, we conclude that adaptive feature extraction and adaptive classification methods are given higher preference over non-adaptive methods because adaptive methods perform better on EEG signal variation during the process.

In another detection algorithm [2] which was proposed using a bio-medical processor, a newly proposed architecture had a programmable MSP430 CPU, and had 16kb of program memory and data memory each. It had SVM accelerator that can provide operand and model data. Also it had active learning data selection accelerator (ALDS) which is the main reason for sensing data continuously. Arithmetic operations are required for both modules. It showed a great reduction in field of energy.

The statistical features [3] were calculated on the feature basis, which was allowed to follow with two feature extraction methods, PCA and ICA along with ANN. The results were compared which showed excellent classification. Two layered neural network classifier was trained supported with feed forward algorithm. Using a non-linear feature extraction increased the performance of classifier.

Quantitative analysis [4] of different types of coherence measures were carried out with the technological tools being available such as Phase synchronization and amplitude correlation. But this work failed to develop automatic seizure monitoring techniques, since an automatic monitoring system should be implemented on a single patient with multiple techniques employed simultaneously.

The EEG signals data for Upper Limb Motion [5] were publicly available. To reduce the dimension of the data, PCA was used and to classify ANN, LDA and decision tree methods were implemented. The accuracy was 81.6% for ANN classifier method, far better compared to LDA and Decision Tree.

To identify and predict partial seizure from epileptic data, fuzzy logic [6] was used. The results for Normal state, pre-seizure state and seizure state for a subject's brain signal data were documented. For the detection of these states, a system was developed to overcome few limitations. Fuzzy interface system proposed in this work consists of 2 descriptors-membership as input, along with three descriptors-membership and a set of 5 rules will represent the combinational model of the membership functions. The main limitation of the algorithm is its restriction for specific type of seizure disabilities.

Phase synchronization [7] is one of the most effective tools to measure task specific ensemble activities. It can be used for different brain regions, which is specialized for specific functions. An ensemble synchronization measure is proposed across all EEG channel pairs for a cluster, based on Frobenius norm of the phase synchronization matrix. The quantitative methods such as Hilbert Phase Synchronization, Statistical Significance of Phase Synchronization, Ensemble Synchronization Measure and Logistic Regression are used in this method. This experiment was carried out on only few data samples.

Since locating the seizure region manually in the recorded EEG is quiet difficult and time consuming, an automatic detection method was very much needed. Seizure detection was carried out using prediction methods [8] such as Time Domain, Wavelet Domain, Frequency Domain, PCA and ICA Domain, Empirical Mode Decomposition, And SVD. EMD gave best overall results.

The technology which is highly growing regarding BCI application fields such as medical, organizational, transportation, games and entertainment, and security and authentication fields, it is necessary to demonstrates the various devices, which are used for capturing brain signals. These recording devices are divided into two main categories [9]: invasive and non-invasive, in which non-invasive category has many applications.

Detailed information regarding Support vector machines [10] was provided and along with that, pattern recognition problems were also discussed. The recent applications and extensions of SVM are summarized.

III. DESIGN METHODOLOGY

The proposed method uses Support Vector Machine and Linear Discriminant Analysis algorithms to identify seizure. The figure below shows the basic block diagram for the proposed work.

A prerecorded EEG wave of a patient who suffers seizures in his brain is loaded to Matlab from stored memory.

It is filtered in couple of stages to remove the unwanted noise from the EEG waves. The EEG signal read need to be filtered to extract the individual components. Applying Band pass filters according to their frequency band for each category will individually extract the corresponding waveform. By this higher frequencies will be filtered out and then the filtered signal will be devoid of undesired frequency components.

Normalization is also one of the preprocessing options which make mean zero and unity standard deviation. Each EEG channel which is nothing but the potential differences between the pair of electrodes under consideration are normalized.

The EEG waves recorded from each channel are trained using Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) classifiers. Support Vector Machine Classifier, it is one of the most popular classifiers for development of BCI. LDA explicitly attempts to model the difference between the classes of data.

After training phase is done, the same classifiers are used to locate the stimuli on the EEG Test wave. Seizure area is identified using both the classifiers & their results are compared.

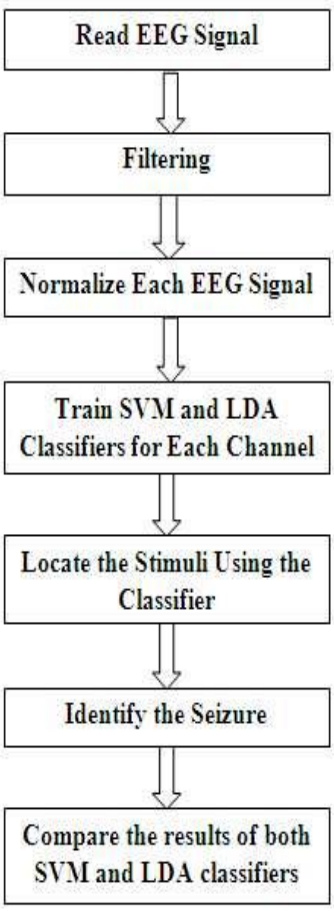

Fig. 1: Block diagram of proposed method

IV. IMPLEMENTATION AND RESULTS

The implementation is done using Matlab 2014. The following images show the obtained results till date.

A pre recorded EEG data of a patient suffering from seizure is collected from Neurologist. It is stored in the memory of the computer before beginning with the execution of the code. An EEG lab GUI is created upon the execution of the code, which is shown in Fig 2.

An existing EEG data is loaded EEG lab database. If EEG data does not exist, a new data should be loaded, which is demonstrated in Fig 3.

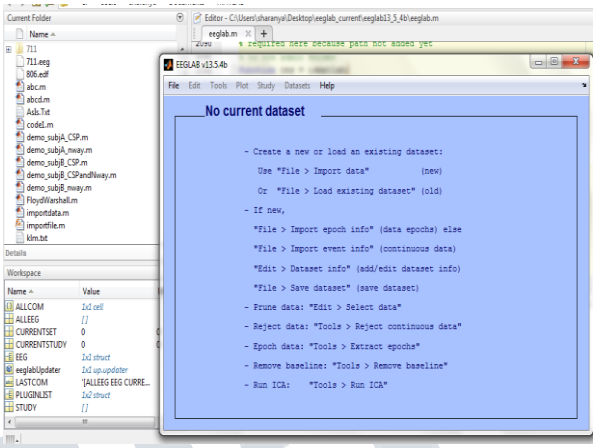

Fig. 2: EEG lab GUI

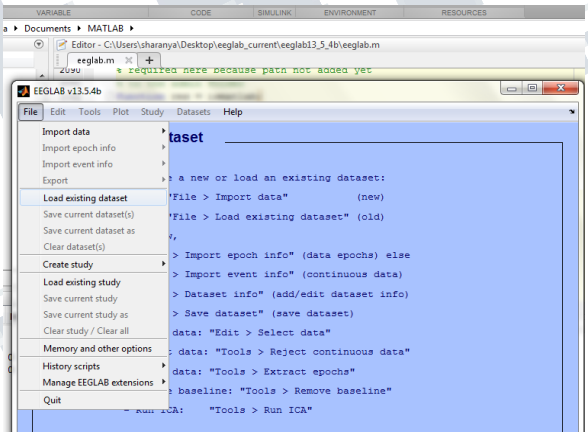

Fig. 3: Loading existing/Importing new data

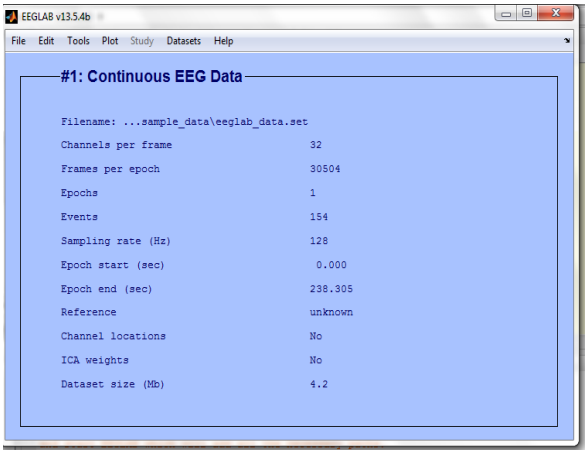

Fig. 4: EEG data features

Fig 4 displays the detailed information of the loaded EEG data set, which is loaded into the EEG lab from the EEG database.

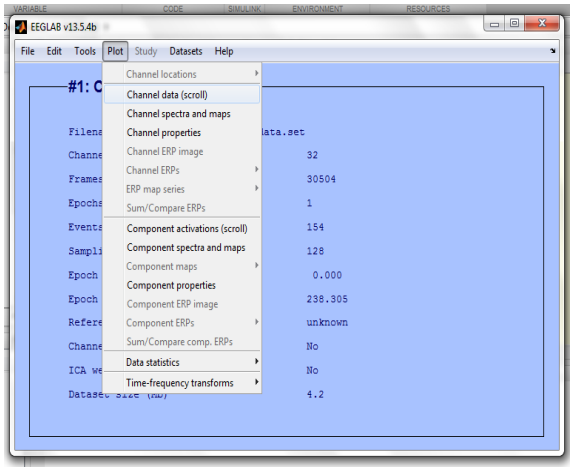

Fig. 5: Selecting the channel data to Plot

The channel data option is selected to plot the EEG waves as shown in Fig 5.

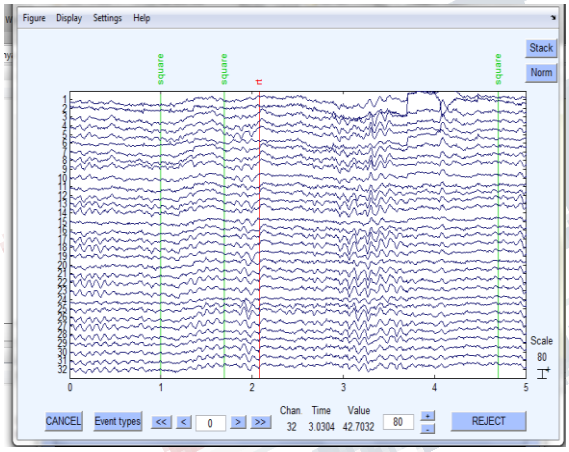

Fig. 6: Seizures identified using SVM

Fig 6 shows the plot of time varying EEG wave with Seizure area marked successfully using SVM classification. The Red line indicated the beginning of Seizure area and Green line indicates the existence of normal EEG wave, which is free from Seizure.

IV. CONCLUSION AND FUTURE SCOPE

The proposed work makes an attempt to provide a classification algorithm for the identification of Seizure areas in EEG data collected from the Neurologist. The demonstration of the proposed work resulted in better performance for SVM classification compared to LDA classification. This work can be extended to develop an automated online system that receives EEG waves recorded from scalp of a patient suffering from Seizure problems, and provide real time results for seizure identification, which can be a big contribution towards BCI applications.

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