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EEG signal classification using artificial immune system

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***Abstract*— The processing and analysis of electroencephalogram can be done using artificial immune system which involves decomposition of signals into its frequency sub bands amd a set of features was extracted from its subbands. Reduction of dimensions of data can be done with the help of principal component analysis and Independent Component Analysis. Then these features were used as an input to the neural network classifier by means of which EEG signal can be classified as normal, seizure and seizure free. The performance can be measured in terms of accuracy, speficity and sensitivity. The Artificial Neural Network (ANN) is trained by incorporating Levenberg Marquardt (LM) training algorithm into the back propagation algorithm that results in high classification accuracy. Experimental results reveal that the methodology will improve the clinical service of the EEG recording and also provide better decision making in epileptic seizure detection than the existing techniques.**

***Index Terms*— ANN, Artificial Immune system (AIS), Electroencephalogram(EEG), Feature Extraction, Feature Extraction.**

I. INTRODUCTION

Now a days, 1% of people suffer from epilepsy and 30% of epileptics are not helped by medication. Several researches are needed to take care for mechanisms in case of epileptic disorders. So valuable records can provide valuable insight into this widespread brain disorder. Here Artificial Immune System is an effective pre processing tool for analysing the given signals which involves the following steps namely initialisation, cloning, mutation and selection. Careful analyses of the electroencephalograph (EEG) records can provide valuable insight into this widespread brain disorder. Absence seizure is one of the main types of generalized seizures and the underlying path physiology is not completely understood.Neurologists make the absence seizure epileptic diagnosis primarily through visual identification of the so-called 3-Hz spike and wave complex. Epileptic seizure is an abnormality in EEG recordings and is characterized by brief and episodic neuronal synchronous discharges with dramatically increased amplitude. This anomalous synchrony may occur in the brain locally (partial seizures), which is seen only in a few channels of the EEG signal, or involving the whole brain (generalized seizures), which is seen in every channel of the EEG signal. Electroencephalograms (EEGs) are recordings of the electrical potentials produced by the brain. In 1924, Hans Berger reported the recording of rhythmic electrical activity from the human scalp. In the past, interpretation of the EEG was limited to visual inspection to qualitatively distinguish normal EEG activity from localized or generalized abnormalities contained within relatively long EEG records. This approach left clinicians and researchers alike buried in a sea of EEG paper records. The advent of computers and the technologies associated with them has made it possible to effectively apply a host of methods to quantify EEG changes. The EEG spectrum contains some characteristic waveforms that fall primarily within four frequency bands: delta (<4 Hz), theta (4-8 Hz), alpha (8-13 Hz) and beta (13-30 Hz). Since the EEG signals are non-stationary, the parametric methods are not suitable for frequency decomposition of these signals. A powerful method was proposed in the late 1980s to perform time-scale analysis of signals: the wavelet transforms (WT). This method provides a unified framework for different techniques that have been developed for various applications. Since the WT is appropriate for analysis of non-stationary signals and this represents a major advantage over spectral analysis, it is well suited to locating transient events, which may occur during epileptic seizures. Wavelet‘s feature extraction and representation properties can be used to analyze various transient events in biological signals. Adeli et al. [2] gave an overview of the discrete wavelet transform (DWT) developed for recognizing and quantifying spikes, sharp waves and spike-waves. They used wavelet transform to analyze and characterize epileptic form discharges in the form of 3-Hz spike and wave complex in patients with absence seizure. The techniques have been used to address this problem such as the analysis of EEG signals for epileptic seizure detection using the autocorrelation function, frequency domain features, time–frequency analysis, and wavelet transform (WT). The results of the studies in the literature have demonstrated that the WT is the most promising method to extract features from the EEG signals. In this respect, in the present study for epileptic seizure detection in patients with absence seizures (petit mal), the WT was used for feature extraction from the EEG signals belonging to the normal and the patient with absence seizure.[17]. In this paper, the input signal used is EEG signal which consists of five data sets namely Z,O,N,F,S. It is then passed through the feature extraction by means of which some of the features can be extracted from the given signals. The feature extraction used is mean, standard deviation and variance. Then the extracted features are then fed to the classifier by means of which the signals can be classified as normal, seizure and seizure free. Here the classifier used is Feed Forward Back Propagation in which LM algorithm is used for training the given classifier. The classifier accuracy is measured in terms of accuracy, specificity and sensitivity.

I. Methodology

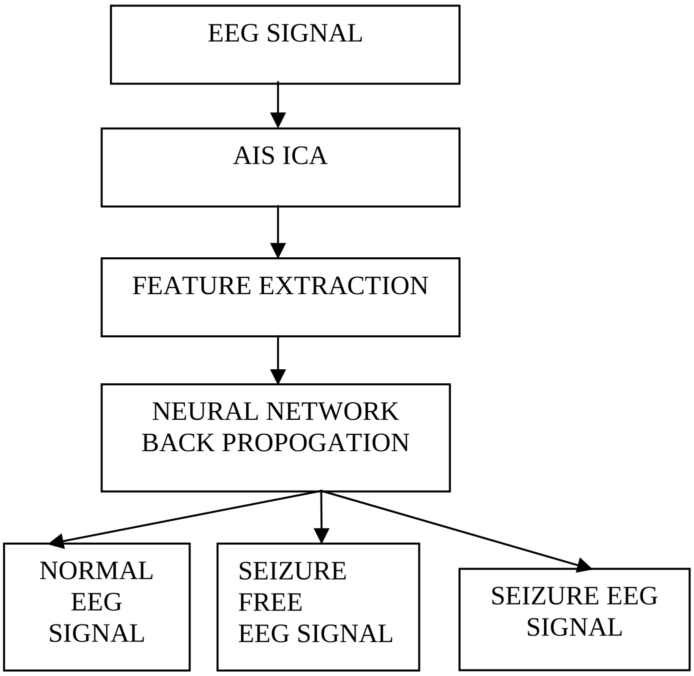

Fig 1: Block diagram of the proposed method

EEG SIGNAL

Since the signal is non stable, appropriate analysis is required for discrimination between normal, seizure free and seizure detection. Therefore the input is EEG signal by means of which the signals can be easily classified with high accuracy, specificity and sensitivity. EEG signal involves five datasets namely Z, O.N, F, S. Z and O are normal EEG signals. N and F are seizure free EEG signals. S is seizure signals.

AIS ICA

It is one of the pre-processing tool which can be used for analysing the given EEG signals. It involves the following steps namely data centering, data whitening, initialisation, cloning, mutation and selection. In data centering the vector is subtracted from its mean so that each component can have a zero mean. In data whitening, whitening matrix can be done so that frsh components can be easily obtained. In case of initialisation, fitness function is used and also the antibodies are initialised randomly. In the next step, the antibodies are cloned according to their affinities. In mutation, the clones are mutated in inverse proportion to their affinity. The final step is selection in which the antibodies are selected for next iteration.

FEATURE EXTRACTION

In general, feature extraction is the process of eliciting significant features from a set of signal collection that tends to appropriate classification and disease diagnosis. A measure that denotes the extent to which the peaks and troughs of a wave differs on an average from the mean voltage is said to be standard deviation. After decomposing the signals, some significant features can be extracted using the standard deviation. For analyzing the statistical feature of a signal, the signal's mean has to be computed. It can also be claimed that the mean value is the average value of a signal. The signal mean value is determined by:

$$\mu=\frac{1}{N}\sum_{i=1}^{N} x_i$$

NEURAL NETWORK BACK PROPOGATION

The extracted features are fed into a feedforward ANN consisting of N inputs, one hidden layer, and K outputs,where N is the size of the feature vector and K is the number of classes. ANN is a classifier containing large number of simple interconnected neurons which executes a simple numerical computational function. This paper involves the ANN classifier.The Levenberg - Marquardt (LM) algorithm is incorporated here into the Backpropagation algorithm for training the feed forward neural network. The neural network consists of an input layer containing the input variables to the problem and an output layer pertaining solution to the problem. The number of neurons in the hidden layer is chosen as 20. The activation function used in the output layer of the ANN is a linear function and that of the hidden layer is a hyperbolic tangent sigmoid transfer function. LM algorithm caters the numerical solution to the problem of minimizing a nonlinear function and memory limitation of LM training. It also minimizes the sum of squares error based on the maximum neighbourhood idea. As stated earlier, the LM algorithm is the combination of the best features of Gauss-Newton algorithm and Steepest descent algorithm. Moreover, it does not suffer from the slow convergence problem and provides good cost function than other training algorithms. The trained network classifies the test EEG signal into three categories specifically, normal EEG, seizure-free EEG, and seizure EEG. Moreover, the Mean Square Error(MSE) value has to be smaller to obtain appropriate results. Thus, it provides a better methodology for seizure detection in clinical practice. The classifier performance is measured by means of accuracy, sensitivity, and specificity. These parameters are defined by the following formulae:

Accuracy = (TP + TN) / (TP + FN + FP + TN)

Sensitivity = TP / (TP + FN)

Specificity = TN / (TN + FP)

TP (True Positive) is the number of correctly classified epilepsy cases, FP (False Positive) is the number of incorrectly classified epilepsy cases, FN (False Negative) is the number of incorrectly classified healthy patients, and TN (True Negative) is the number of correctly classified healthy patients. Accuracy is the percentage of correct classification of epilepsy cases and healthy patients. Sensitivity (or) Recall (or) True Positive Rate is the probability of the actual positive classes which are identified correctly. Specificity (or) True Negative Rate is the probability of actual negative classes which are identified correctly.

II. DATASET INFORMATION

The dataset utilized in this research is prepared by the Clinique of Epileptology of Bonn University [23]. Single channel EEGs are noted from people having different brain electrical potential components at a sampling rate of 173.61

Hz for 23.6 seconds. The acquired EEG data contain 3 different cases namely,

1. Data of Healthy people
2. Epileptic people during seizure-free interval (interictal)
3. Epileptic people during seizure interval (ictal)

Each case has five data segments: (Z, O, N, S, F). Sets Z and O are attained from healthy people under thecondition of eyes open and closed with respect to the external surface electrodes. The sets N and F are obtained from interictal people. The set F has been taken from epileptogenic sections of the brain that represent the focal intellectual activity, whereas set N has been taken from the hippocampal pattern of the brain that indicates non-focal interictal activity. The set S has been obtained from an epileptic subject during seizure interval. Each dataset contains 100 single channel EEG segments and each segment constitutes N=4096 samples. All these segments are noted for the subjects with the 128-channel amplifier that includes 12 A/D convertors at a bit rate of 12 and sampling frequency of 173.61 Hz.

III. SIMULATION RESULTS AND DISCUSSION

The input is the EEG signal which consists of five data sets namely Z,O,N,F,S. Then the input is fed to the Artificial Immune System which involves the following process namely data centering, data whitening, initialisation, cloning ,mutation and selection. In case of data centering, the given vector is subtracted from its mean so that each component have a zero mean. In data whitening, whitening matrix can be obtained so that fresh components can be easily depicted which requires Eigen values and Eigen vectors respectively. So Principal component Analysis is used in order to find Eigen values and Eigen vectors. Then these analysed signals are then fed to the Feature extraction which involves the extraction of features such as mean,standard deviation ,variance and median. Then these extracted features are then fed to the classifier which is nothing but the Feed Forward Neural Network Classifier in which LM algorithm is used to train the feed forward neural network. The EEG signal input signal is as follows

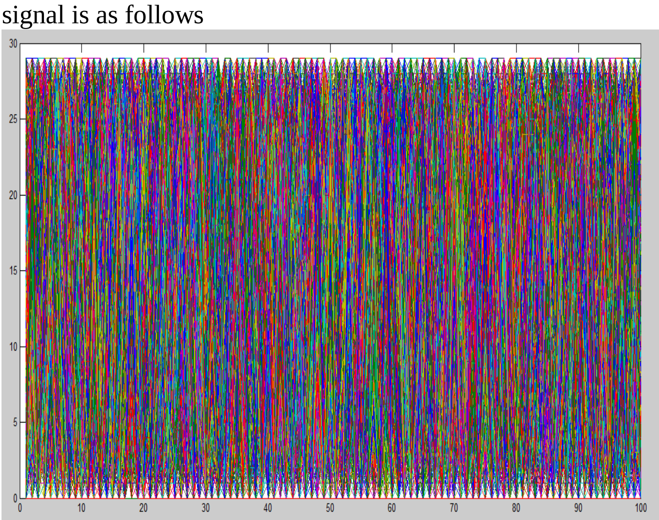

Fig 1: Input signals

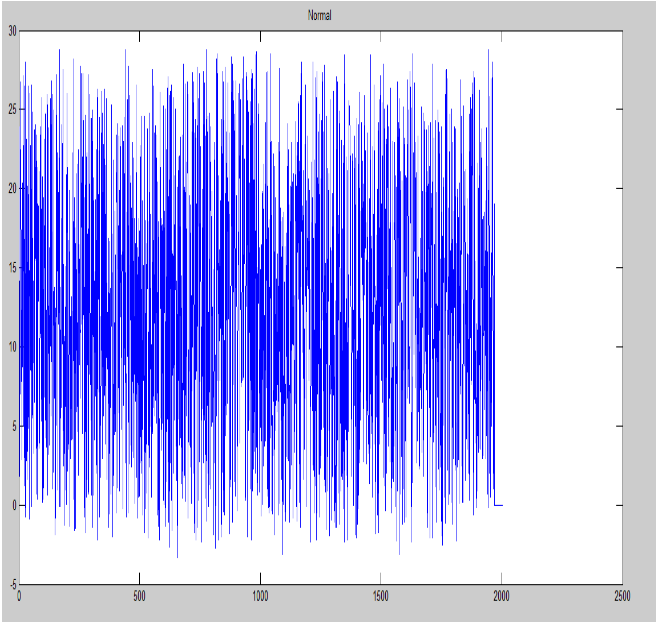

Fig 2: Normal EEG signals

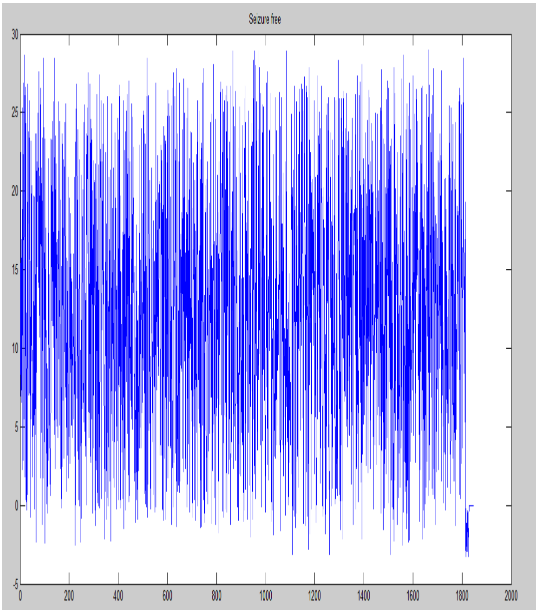

Fig 3: Seizure free EEG signal

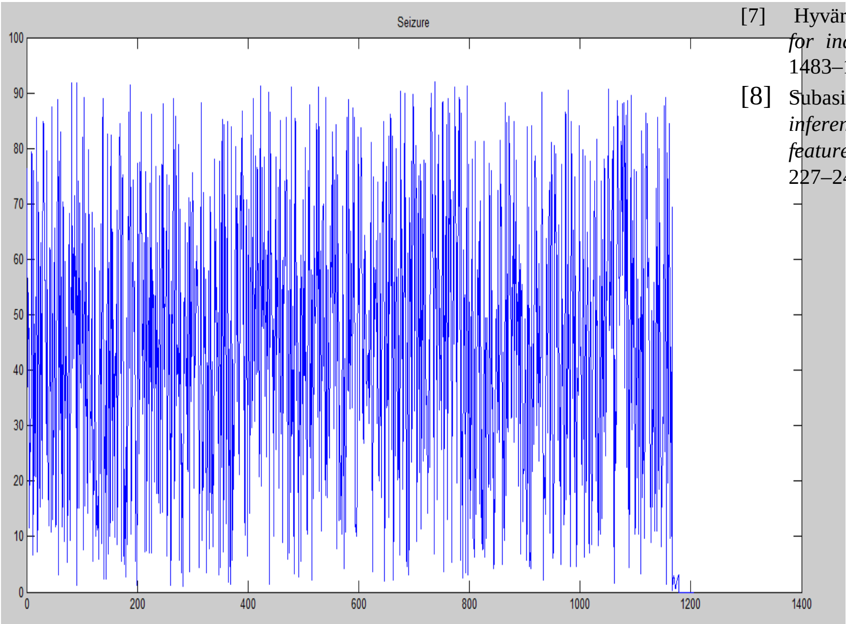

Fig 4: Seizure EEG signal

From the above waveforms it can be inferred that in case of EEG signals ,there will be many actions. For example in case of sitting, there will be one action. In this paper five data sets are taken into account which are Z,O,N,F,S which are then classified as normal. Seizure and seizure free signals.

IV. CONCLUSION

In this paper, a method has been proposed for effective classification of EEG recordings as normal and seizure. AIS ICA is used as a preprocessing step. It is followed by the feature extraction process on the basis of three parameters that is, standard deviation, mean, median and variance. Parameterization excerpts the significant features of the EEG signals that are given to the trained neural network for classification. Initially the neural network has been trained with an effective LM training algorithm to obtain the results in an optimal number of epochs. EEG signal classification using Feed Forward BPNN in terms of accuracy, sensitivity, and specificity. Three datasets (Z, S), (Z, N, S), and (Z, O, N, S, F) were tested to validate the performance of the proposed approach for EEG signal classification.. This method affords reliable computerized methodology for appropriate EEG signal classification and better decision making for epileptic seizure diagnosis in clinical practice.

V. REFERENCES

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