NEURAL NETWORK OPTIMIZED FEATURE ENHANCED EFFICIENT SEIZURE DETECTION SYSTEM

A. Phareson Gini 1, M.P. Flower Queen 1, Suresh Ponnan2

1Dept of Electrical and Electronics Engineering, Noorul Islam University, Kumaracoil, Tamilnadu. India.
2Dept of ECE, Vel Tech Rangarajan Dr Sagunthala R & D Institute of Science and Technology, Chennai, Tamilnadu – 600062. India.
1Email: sureshp@ieee.org

ABSTRACT

More than a decade, majority of the people affected with epilepsy in the world drastically. The detections and calibration of epilepsy seizure is the most of the critical and crucial process. The Electroencephalography (EEG) is a measured in human beings and it is the crucial component which also helps in the epilepsy evaluation. The manual seizure detections from EEG sometimes leads to mispredictions of the same, which causes failure treatment diagnosis. The Adaptive Artificial Neural Network (AANN) is proposed to overcome this issue in this article. The result reported with the proposed methodology is having good performance in the detection of epileptic seizure over the other with an automated epileptic seizure detection.

Keywords: Artificial Neural Network, Algorithm, EEG Signal.

I. INTRODUCTION

In recent years, the enormous research has been carried out to identify the human disease. One of the most brain disorder commonly after migraine is Epilepsy for human beings reported globally. The life time of the patients are improved considerably on epileptic seizures automatic detection [1]. For detection of diagnosis the widely used prime signal is EEG. Many challenges in human’s real lives has been encountered with EEG signa for detection and diagnosis [2]. In EEG signal several noises will be present which affects the originally and requires several features on extraction of original signal. On detection of epileptic seizures were negatively affected due to noise in EEG signal. The inspection of EEG signal visually leads unfortunately labor loss and it consumes more time [3].

The EEG plays a major role in monitoring the behavior of the nerve cells in human brain which gives useful information through the measured non-linear electrical function. It is one of the useful tool to evaluate the subject under treatment or in evolution [16]. Many methods available to detect the EEG from the patient and the same is slow and steady process. Throughout the world the many methods have been proposed, implemented and evaluated. A broad range of strategies is being investigated thoroughly, and an effort is put forth with utmost intervention to yield an approach for seizure detection. Automated seizure detection system fundamentally aims in providing a consistent algorithm by excavating in-depth knowledge of dynamical properties of the signal and clinical domains. Impediments are overcome and contingent cautioning is provided for the commencement of therapy for controlling seizures thereby minimizing the risk of injury to patients. The life time of the patients are improved considerably on epileptic seizures automatic detection [1, 17-19]. For detection of diagnosis the widely used prime signal is EEG. Many challenges in human’s real lives has been encountered with EEG signa for detection and diagnosis [20]. In EEG signal several noises will be present which affects the originally and requires several features on extraction of original signal. On detection of epileptic seizures were negatively affected due to noise in EEG signal. The inspection of EEG signal visually leads unfortunately labor loss and it consumes more time [3, 21].
A vast number of methods were developed with EEG signal for automatic seizure detection and also to extract the required features which has directly ensures higher performance on epileptic detection. Enormous techniques on extracting features have been discovered, reported by many researchers [4]. The hand-wrought features were used mostly in the frequency-domain, time-domain, time to frequency domain or in some cases both domain combinations. Three challenges we encounter by these domains are very sensitive, EEG data acquisition systems and most existing seizure detection systems to critical disparities in seizure patterns [5, 6]. To handle some of these issues and challenges a new method is presented in this paper to detect epileptic seizure.

Nowadays lot of researchers are involved in investigating EEG signal to detect epileptic seizure. Among them some of the papers are analyzed here; via Poincaré section with high dimensional phase space analyzing method [7] have presented an Epileptic seizure detection approach. Though the results have shown promises, the sensitivity could have been further increased for better performance. The epileptic seizures detection is done with new approach based on empirical mode decomposition and the same is presented [8]. The presented method has provided an effective result by detecting the changes because of epileptic seizure in the EEG signals which could have been further improved with noise reduced EEG signal. Bogaarts et al. [9] have proposed a new method in which the importance of training dataset selection has been shown by Optimal training dataset composition for automated epileptic seizure detection, SVM-based method and age-independent are discussed and also their performance have guaranteed that the proposed technique has overcomes the vast majority of the current strategies. Orhan et al. [10] have exhibited another component extraction strategy known as likelihood circulation dependent on equivalent recurrence discretization. The outcomes have indicated that the exhibited strategy can be utilized as opposed to measurable parameters for extracting the highlights of the EEG signals and their contributions to the classifiers. By deteriorating EEG flag up to six wavelet scales without down inspecting, Chen et al. [11] have proposed a methodology for seizure recognition. The outcomes have demonstrated that the proposed methodology is aggressive with a large portion of the current EEG seizure location strategies. Kabir et al. [12] have displayed a novel examination framework for distinguishing epileptic seizure from EEG signals which uses factual highlights relying upon ideal portion system with calculated model trees. The Presented method has been able to achieve better results in terms of the classification accuracy and the sensitivity.

The proposed methodology and its architecture have been reported in section 2 which accomplish the epileptics seizure detection complete and its process, the mathematical formulation of the method also described. The findings of the proposed method have been evaluated in section 3 for the various approaches and in section 4 overall performance of the proposed system is discussed and concluded.

II. PROPOSED EPILEPTIC SEIZURE DETECTION

The major objective in this paper is to propose new methodology to effectively detect the seizure using optimal neural network technology. The proposed methodologies overall structure is illustrated in Figure 1. The proposed work compressed into three modules, namely preprocessing, feature extraction and epileptic seizure detection.

Figure 1: Overall structure of proposed epileptic seizure detection
2.1 Preprocessing
Initially, the collected EEG signals are given to the preprocessing stage for the removal of the noise and artifacts on or after each input signal, to do this the preprocessing band pass filter is used. After noise removal, the signals are decomposed into high frequency channel (HH band) and low frequency channel (LL band) with help of the discrete wavelet transforms (DWT). Here, the extracted HH band is utilized for further processing.

2.2 Feature Extraction
On completion of preprocessing stage, the significant highlights are extracted from HH band. The EEG signal is of non-direct and non-stationary in its property. In this manner, non direct parameter, for example, entropy expands the power of separating typical and unusual EEG signals. The randomness in a system is known as the entropy. The randomness and complexity of a signal can be measured using entropy.

2.3 Optimal Neural Network Method to Detect Epileptic Seizure
On completion of the feature extraction process, it is feed as the input to the artificial-neural network for classification of the signal to identify either it is normal nature or epileptic nature. In this, to increase the convergence speed of ANN; the weights are optimally selected with the help of oppositional crow search algorithm (OCSA). For classification, the dataset signals are classified in to two categories of datasets like training and testing. In training process, 80% of signals are used and in the testing process, the remaining 20% of the signals are used. The artificial neural network is a classifier which is used for many applications namely, recognition, prediction classification etc.

Normally, the neural network were classified in to three layers namely, input, hidden and output layers, were each layer consist of n neurons. Where the number of input neurons is based on the input data and the number of neurons of the hidden layer is selected empirically by the user. Lastly, the output layer comprises c neurons for the c classes. Each connection between two neurons is connected with a weight factor. At first, the weight values are randomly assigned. Then, this weight is optimally selected using OCSA during the training of the network according to input and output data.

Testing process:
After training process, the testing process is done with the help of remaining data. In this stage, the original input signal is classified as normal or epileptic signal. Here, at first, the features are extracted from each signal and extracted features are given ANN. The trained weights are assigned to the ANN. After the calculation, the corresponding score ($S_{\text{out}}$) is obtained for the input signal. Based on the score value, the signal is classified as normal or epileptic signal with the help of threshold value ($T_H$). For classification, the threshold value is depending upon the class value only. If the score value is above the threshold ($T_H$) means, the given signal is epileptic signal otherwise the signal is normal signal.

III. RESULT AND DISCUSSION:
The proposed approach has used optimal Artificial Neural Network for epileptic seizure detection system. Here, the weights have been optimally selected by utilizing oppositional crow search algorithm. The presented epileptic seizure detection approach has been implemented in the platform of MATLAB7.0 atmosphere running in an Intel Pentium processor with 3.00 GHz. The experimental used sample signals are given in Figure 2.
3.1 Evaluation metrics

The proposed epileptic seizure detection is evaluated with the help of three efficient metrics namely, accuracy, sensitivity and specificity. The metrics are given below;

\[ \text{Accuracy} = \frac{(TN+TP)}{(TN+TP+FN+FP)} \]  
\[ \text{Sensitivity} = \frac{TP}{(TP+FN)} \]  
\[ \text{Specificity} = \frac{TN}{(TN+FP)} \]

Where, TN, TP, FN, and FP denote a number of true positives, a number of true negatives, a number of false positives, and a number of false negatives, respectively.

The proposed methodology has been evaluated based on time and frequency domain signaling with the database CHB-MIT. The seizure detection from EEG signal has been evaluated and the same has been represented in this section. The frequency domain analysis with the database adopted are given below for different cases and subjects under evaluations.

3.2 Performance analysis

In this section, the performance of the presented method that has used ANN and OCSA optimization algorithm along with its analysis has been given. The presented method's performance has been analyzed in terms of accuracy, sensitivity and specificity. Finally, the presented method has been compared with other existing methods such as ANN and GA+ANN methods.

Table 1: Epileptic Seizure Detection using ANN

<table>
<thead>
<tr>
<th>Training and Testing</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>FAR</th>
<th>FRR</th>
<th>GAR</th>
<th>Accuracy</th>
</tr>
</thead>
</table>

Figure 2. Sample EEG Signal
Table 1 shows the ANN based Epileptic Seizure Detection performance. When analyzing table 1, ANN based Epileptic Seizure Detection approach attains the maximum accuracy of 93.7%, 92.5% and 91.2% for training and testing data of 90:10, 80:20 and 70:20, respectively. In table 2, GA+ANN based Epileptic Seizure Detection performance are analyzed. Here, the method attains the maximum accuracy of 94.87%, sensitivity of 96.35% and specificity of 85.77%. The performance of proposed Epileptic Seizure Detection is given in table 3. when analyzing table 3, our proposed method attains the maximum accuracy of 96.4%, 95.5% and 94.6% for training and testing data of 90:10, 80:20 and 70:20, respectively. Compared to other two methods, our proposed approach attains the better result. The reason for this is the use of the OCSA algorithm in the proposed method.

The performance analysis of the proposed OCSA+ANN approach along with ANN method and GA+ANN method based on their sensitivity has been shown in Figure 5. When the hidden node is 10, the accuracy of the proposed OCSA+ANN method is 95.5%, the accuracy of ANN is 92.15% and the accuracy of GA+ANN is 93.24%. The proposed method has higher accuracy than ANN and GA+ANN. The accuracy of the proposed OCSA+ANN method is 96.42%, the accuracy of ANN is 93.71% and the accuracy of GA+ANN is 94.87% when the hidden node is 20. The accuracy of proposed OCSA+ANN method is higher than ANN and GA+ANN.

The performance analysis of the proposed OCSA+ANN method with ANN method and GA+ANN method based on their sensitivity has been shown in Figure 5. When the hidden node is 40, the sensitivity of the proposed OCSA+ANN method is 95.1%, the sensitivity of ANN is 93.01% and the sensitivity of GA+ANN is 94.1%. The proposed OCSA+ANN method has the highest sensitivity when compared with ANN and GA+ANN. The case is same for all the values of hidden nodes. The presented approach can be considered as the efficient one in terms of sensitivity.

Table 2: Epileptic Seizure Detection using GA+ANN

<table>
<thead>
<tr>
<th>Training and Testing</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>FAR</th>
<th>FRR</th>
<th>GAR</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>'90%-10%'</td>
<td>0.95346</td>
<td>0.82451</td>
<td>0.049387</td>
<td>0.00246</td>
<td>0.998162</td>
<td>0.948775</td>
</tr>
<tr>
<td>'80%-20%'</td>
<td>0.96358</td>
<td>0.81588</td>
<td>0.026875</td>
<td>0.002916</td>
<td>0.985469</td>
<td>0.937864</td>
</tr>
<tr>
<td>'70%-30%'</td>
<td>0.96234</td>
<td>0.857451</td>
<td>0.025656</td>
<td>0.002856</td>
<td>0.98945</td>
<td>0.927618</td>
</tr>
</tbody>
</table>

Table 3: Epileptic Seizure Detection using OCSA+ANN

<table>
<thead>
<tr>
<th>Training and Testing</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>FAR</th>
<th>FRR</th>
<th>GAR</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>'90%-10%'</td>
<td>0.999549</td>
<td>0.8365</td>
<td>0.0352</td>
<td>0.0018</td>
<td>0.99763</td>
<td>0.964</td>
</tr>
<tr>
<td>'80%-20%'</td>
<td>0.99125</td>
<td>0.82643</td>
<td>0.01634</td>
<td>0.0015</td>
<td>0.98524</td>
<td>0.955</td>
</tr>
<tr>
<td>'70%-30%'</td>
<td>0.985156</td>
<td>0.86241</td>
<td>0.02146</td>
<td>0.0022</td>
<td>0.98769</td>
<td>0.946</td>
</tr>
</tbody>
</table>
In Figure 6, the performance analysis of the proposed OCSA+AANN method with ANN method and GA+ANN method based on their specificity has been presented. The specificity value of ANN is 74.23%, the specificity value of OCSA+AANN is 85.35 and the specificity value of GA+ANN is 84.12 when the hidden node is 10. The proposed OCSA+AANN method has higher specificity than compared ANN method and GA+ANN method. The order of values is same for 20, 30 and 40 hidden nodes. From the results, we clearly understand our proposed method effectively detects the normal signals and epileptic signals.

IV. CONCLUSION

An efficient epileptic seizure detection method using entropy features with optimal neural network has been presented. Initially, the features have been extracted and for classifying a signal as normal or epileptic, the extracted features have been provided to the input of ANN. For optimally selecting the weights during the training of network, the Oppositional Crow Search Algorithm has been utilized. This has enhanced the overall effectiveness of the approach. The presented method has been analyzed for its performance based on sensitivity, specificity and accuracy. Also, the existing approaches such as ANN based epileptic seizure detection and GA+AANN based epileptic seizure detection have been compared with the presented OCSA+AANN based epileptic seizure detection approach so as for calculating its efficiency over them. The results reported have shown that the proposed OCSA+AANN method has outperformed the other methods compared.

REFERENCE