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ARTICLE

IMPLEMENTING AUTOMATIC BRAIN ABNORMALITY DETECTION SYSTEM USING REACTIVE OPTIMIZED CONVOLUTION NEURAL NETWORKS

Arjunan Kavitha[1]* and Vellingiri Krishnaveni[2]

[1]Department of Electronics and communication Engineering, Faculty of Information and communication Engineering Hosur, INDIA

[2]Department of Electronics and communication Engineering, Faculty of Information and communication Engineering, Coimbatore, INDIA

ABSTRACT

Epilepsy is a standout amongst the most perilous neurological ailments which make the epileptic seizure excessively numerous individuals on the planet.The seizure has been difficult to detectable because it may be occurred by brain injuries, brain tumors, birth defects, infection of the brain, stroke and genetic mutation. The difficulties present in the epilepsy have been effectively recognized by using the Electroencephalogram (EEG) because it captures the brain electrical activities in various conditions with effective manner. Several researches use the EEG for detecting the brain abnormalities but still they have some issues like error rate, performance of the system, sensitivity and specificity. So, in this paper develops the automatic brain abnormality detection system using the EEG measure. Initially the recorded EEG signal is preprocessed by applying the common average singular value referencing approach. Then the noise removed EEG is decomposed with the help of the Multi Resolution Second Generation Wavelet transform. From the segmented signal various invariant and entropy features are extracted and the dimensionality of the feature is further reduced with the help of the Memetic redundancy feature selection approach. The selected features are classified by using the Reactive optimized convolution neural networks. Then the efficiency of the proposed system is evaluated with the help of the various EEG dataset like CHB-MIT Scalp EEG Database and European database in terms of the error rate, sensitivity, specificity and accuracy.

KEY WORDS
Epilepsy, Electroencephalogram, CHB-MIT, Scalp EEG

INTRODUCTION

In the creating scene, epilepsy in one of the significant demise causes ailment because of the imperceptible issues, for example, cerebrum wounds, mind tumors, birth abandons, disease of the mind, stroke and hereditary change present in the human cerebrum [1]. As indicated by the different scrutinizes studies, 80% individuals kicked the bucket in light of the epilepsy issue which was demonstrated by the best perlustration. The quantity of the general population passings are expanded from 1990 to 2013 in light of the fact that, in 1990 the 112,000 people groups are kicked the bucket because of epilepsy seizure though in, 2013 116,000 people groups are kicked the bucket which demonstrates that number of death proportion is expanded often [2]. Further the overview obviously demonstrates that the most epilepsy seizure is influenced in the time of more youthful grown-ups because of the different weights and 5-10% of the seizure is influenced by the age 80 which is still dubious. This reviews are unmistakably demonstrates the epilepsy is more risky when contrasted with the other malady because of the imperceptible manifestations. In this way, the trouble present in the seizure is examined from utilizing the Electroencephalogram, fMRI, CT thus on [3]. Among the different mind movement measure EEG dissect the cerebrum exercises with high exact way in light of the fact that the EEG catch the electrical exercises regarding the milliseconds which implies, the EEG recognize the single neuron action change with precise way when contrasted with the other mind action measure.

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The EEG has been recorded by putting the quantity of anodes on the scalp up to specific day and age to breaking down the different mind exercises like backhanded marker, capacity of the cerebrum, persistent perfusion levels are checked continuously[4]. The recorded EEG sign is examine the diverse sorts of seizures, for example, Primary summed up seizures, Partial seizures with precise way by utilizing the different sign handling and machine learning strategies. The example EEG recorded setup is appeared in the [Fig. 1].

In this way, the different looks into use the changed philosophies like autonomous segment investigation, wavelet change, Fourier change, bolster vector machine, neural systems are utilized to examine the epilepsy [5]. These methodologies are proficiently perceiving the seizure however it has a few troubles like mistake rate and precision additionally the strategies are hard to handle the vast measure of dataset. Along these lines, the creator builds up the programmed cerebrum variation from the norm discovery framework utilizing the responsive based neural systems for beating the issues present in the current anomaly recognition strategies.

***Corresponding Author**
Email:
arjunankavithaphd@gmail.com

The remaining of the paper is organized as follows; section 2 provides the related works made on the epilepsy detection using the EEG signal. Section 3 discusses that the proposed system methodologies and the related architecture. Section 4 provides the results and discussions. Finally, section 5 concludes the proposed work.

Fig. 1: EEG Capturing Setup.

RELATED WORKS

In this section reveals that the various research opinions about the brain abnormality detection system. Juarez-Guerra et al., [6] developing the automatic seizure detection system using the discrete wavelet and neural networks. The author analyzes the recorded EEG signal and decomposes the signal into different bands. From the decomposed signal various overlapping features are efficiently retrieved with the help of the Maximal overlap discrete wavelet transform. The extracted features trained by feed forward neural networks which uses the optimized training function. The efficient training function leads to analyze the abnormal feature set easily and the efficiency of the system is evaluated in terms of using the university of bonn dataset which achieves the highest accuracy with three fold cross validation.

Zainuddin et al [7] introducing the wavelet based neural networks for detecting the epilepsy disease. Author analyzes the recorded EEG signal using the wavelet method and the sub bands are extracted. From the extracted sub bands various features like standard deviation, minimum, maximum values are derived according to the wavelet co-efficient. The extracted features are fed into the neural network to analyze the abnormal features. The classified results are evaluated with the help of the Freiburg EEG database which ensures the high sensitivity rate and minimum error rate when compared to the other methods.

Yatindra Kumar et al., [8] analyzing the dangerous epilepsy disorder using the ApEn neural networks with minimum error rate. The captured EEG signal is preprocessed and the different coefficients are evaluated with the help of the discrete wavelet transform. From the wavelet coefficients various approximation values are derived. The derived features are fed into the feed forward neural networks to analyze the various abnormalities like dementias, partial seizure, primary seizure, stroke, brain injuries. At last the performance of the system is evaluated with the help of the experimental results and discussions. Thus the proposed system ensures the minimum error rate and maximum recognition accuracy while analyzing the abnormal features.

Yatindra Kumar [9] discussing the various machine learning and sampling techniques to diagnosis the seizure from the recorded EEG signal. The recorded signal is analyzed in terms of the optimum allocation sampling and random sampling techniques. The analyzed signal is evaluated in terms of applying the both rough set and OS set. From the analyzed data signal 11 different statistical features are extracted which are fed into the various classifiers like K-nn, SVM and MLP classifier which analyze the abnormal disease with efficient manner. Then the efficiency is evaluated using the experimental results and discussions. According to the various authors discussions, the proposed seizure detection system is created for overcoming the accuracy and database issue which are explained in the following section.

PROPOSED METHODOLOGIES

In the advancing scene, epilepsy is one of the perilous illness which prompts slaughter the general population in light of the imperceptible indications. At that point the troublesome seizure has been proficiently related to the assistance of the EEG cerebrum estimations. In this way, in this paper use the two diverse EEG databases to be specific, CHB-MIT Scalp EEG Database and European database with viable way. The proposed framework incorporates the four distinct strides, for example, preprocessing, highlight extraction, highlight determination and seizure characterization which are utilized to dissect and recognize the epilepsy in the human cerebrum. At that point the proposed framework square graph is appeared in the [Fig. 2].

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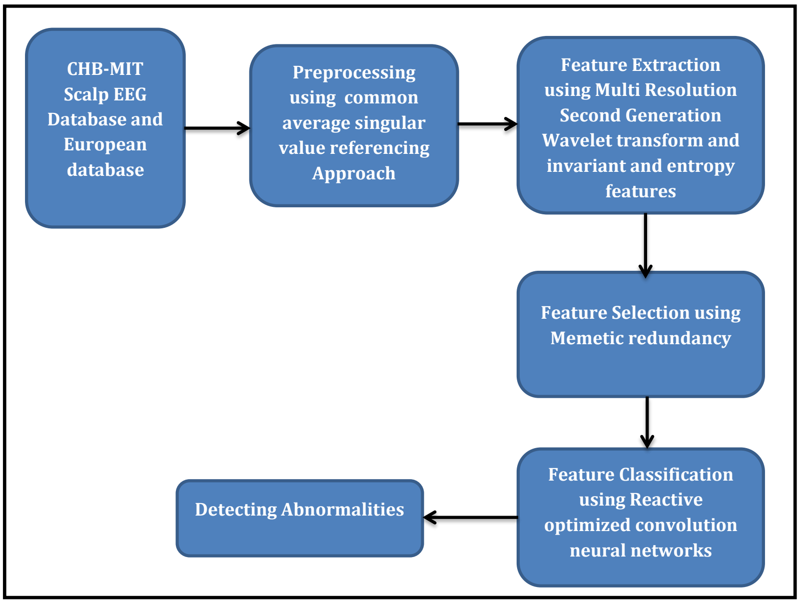

Fig. 2: Proposed system architecture.

EEG preprocessing

The first stage of the seizure detection is preprocessing because the recorded EEG signal has several unwanted information which reduces the entire system performance [10]. So, in this paper uses the common singular value referencing approach for eliminating the entire unwanted information from the EEG signal with effective manner. Initially the common referencing method is applied to all EEG electrodes for removing the unwanted feature also enhances the signal to noise ratio. The average or mean value of the each electrodes are removed from the set of electrodes as follows,

$$CzCAR = C_z - (Fp_1 + AF_3 + F_7 + \cdots F_z + MA_1 + MA_2)/34 \qquad (1)$$

After removing the average mean electrode the filtering technique such as the singular value method is applied to remove all the additional noise present in the EEG signal. The method considered the total EEG signal into the mxn matrix which consists of three matrix that is represented as follows,

$$M = U \sum V^* \qquad (2)$$

Where Uis the mxm matrix of the left orthogonal matrix that is represented as the $U = [u_1, u_2 \dots \dots u_m]$ and $\sum V^*$ is the rectangular diagonal matrix and the conjugated transpose the $V\ V = [v_1, v_2 \dots \dots v_n]$of the nxn real matrix of the right orthogonal matrix which is represented as follows,

$$AA^t = U\Sigma V^* V \Sigma U^t = U\Sigma^2 U^t \qquad (3)$$

Where $AA^t\ is\ the\ eigen\ vectors\ of\ columns\ of\ mxm\ matrices$

$$A^t A = V\Sigma U^t U \Sigma V^t = V\Sigma^2 V^t \qquad (4)$$

Where $A^t A\ eigen\ vector\ of\ nxn\ matrix\ column$

$\Sigma\ is\ the\ singular\ value\ which\ is\ having\ the\ non-negative\ values\ that\ is\ represented$

As,

$$\Sigma = diag(\sigma_1, \sigma_2, \dots \dots \sigma_n \qquad (5)$$

Where, $\sigma\ is\ the\ singular\ value\ of\ the\ A$

According to the matrix the first value is direction of the greatest data variants and other values are orthogonal direction of the data. Finally the rotation operation is performed for analyze and the highest ranked electrode features are eliminated successfully.

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At last the bipolar and unipolar direction of electrodes also removed, which is completely eliminated the unwanted electrode feature successfully. The preprocessed EEG signal is fed into the next feature extraction stage.

Feature extraction

The second phase of the seizure discovery procedure is highlight extraction. Before extricating the component from the EEG flag, the preprocessed EEG sign is decayed into various groups for determining the proficient elements. The sign disintegration [11] is finished with the assistance of the multi determination second era wavelet. At first the sign is investigated in an alternate heading for social affair the part of data additionally diminishing the data misfortune while disintegrating the EEG signal. The second era wavelet change, investigate the sign and sifting the EEG into various groups with the assistance of the lifting plan. The method analyzes the preprocessed signal and decomposes into detailed and the approximate band which eliminates the unwanted information. During the decomposition process, the given input EEG signal is spilt into the odd and even samples like $\gamma_1\, and\ \lambda_1$ which is used for decomposition process. According to the sample details, the detailed coefficient value is retrieved from the signal using the even value of the signal in the multi direction.

$$\gamma_2 = \gamma_1 - P(\lambda_1) \qquad (6)$$

After deriving the detailed coefficients the approximate coefficients are retrieved as follows,

$$\lambda_2 = \lambda_1 + U(\gamma_2) \qquad (7)$$

From the above eqn P represented as the prediction operator and U is the updating operator which is used to analyze the detailed and approximate coefficient with efficient manner. This way of decomposing process enhance and fastest the decomposing methodology while analyzing the EEG. after decomposing the EEG signal various invariant and entropy features are extracted. The invariants analyze the decomposed EEG signal [12] with the relative position of the key features because the particular key feature does not change from one human brain measure to other. During the feature extraction process it has following steps like key point detection, key point location, orientation assignment and keypoint descriptors. The key point detection combines to work with the Gaussian filter which analyze the maximum and minimum value of the each sub band which is calculated as follows,

$$D(x,y,\sigma) = L(x,y,K_i\sigma) - L(x,y,K_j\sigma) \qquad (8)$$

Where $D(x,y,\sigma)$ the difference of the Gaussian filter band is $L(x,y,K\sigma)$ is the convolution value of the band, $I(x,y)$ is the Gaussian blur value,

$$L(x,y,K\sigma) = G(x,y,k\sigma) * I(x,y) \qquad (9)$$

After retrieving the key point from the signal, point location is estimated which is done with the help of the Taylor series which is estimated as follows,

$$D(x) = D + \frac{\partial D^T}{\partial x}x + \frac{1}{2}x^T\frac{\partial^2 D}{\partial x^2}x \qquad (10)$$

Finally the orientation has been assigned as follows, which is used to identify the direction of the particular key point is measured by the magnitude and orientation estimation.

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \qquad (11)$$

$$\theta(x,y) = atan2(L(x,y+1) - L(x,y-1)),(L(x+1,y) - L(x-1,y)) \qquad (12)$$

Where, $m(x,y) = magnitude\ of\ the\ key\ band$
$\theta(x,y) = orientation\ \ the\ key\ point\ band$

Finally the key point descriptors are extracted by analyzing the key point detector and the orientation assignment process. In which the decomposed signal key descriptors various features are extracted which are listed in the [Table 1].

Table 1: List of features

Features	Related Formula
Entropy	$\sum_{i,j=0}^{n-1} -\ln(P_{ij})P_{ij}$

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Variance	$\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(i-\mu)^2 . p(i,j)$
Mean	$\sum_{i=0}^{2(n-1)} i . p_{x+y}(i)$
Standard Deviation	$\sqrt{\left(\sum_{i=0}^{2(n-1)} i . p_{x+y}(i)\right)^2}$

The extracted features are fed into the next feature selection process which is done with the help of the Memetic redundancy feature selection method which is discussed as follows.

Feature selection

The third phase of seizure recognition procedure is highlight choice which is finished with the assistance of the Memetic repetition approach. The element area [13] strategy breaks down the common data estimation of the specific element and the closeness of the elements is evaluated utilizing the mimetic methodology. From the figured shared data esteem, normal quality is taken for every element and the related class with the successful way which is computed as takes after,

$$D(S,c) = \frac{1}{|S|}\sum_{f_i \in S} I(f_i;C) \qquad (13)$$

Where S represented as the redundancy value of the particular feature set average value of the particular mutual information between the two different features which is defined as follows,

$$R(S) = max_s[\frac{1}{|S|}\sum_{f_i \in S} I(f_i;C - \frac{1}{|S|^2}\sum_{f_i,f_i \in S} I(f_i;f_i)] \qquad (14)$$

Amid the normal figuring process, the two distinct components are proficiently picked by qualities of the specific element which finished with the assistance of mimetic procedure. The comparability is evaluated in the all bearing utilizing the specific element qualities like, component significance, effect of the elements et cetera. Subsequently the ascertained contrast worth is investigated against the base esteem and picked the base diverse quality considered as the upgraded highlights which are sustained into the following seizure classifier with the powerful way.

Seizure classification

The last stride of the seizure discovery calculation is seizure grouping which is finished with the assistance of the responsive streamlined convolution neural systems [14]. The convolution neural system is one of the managed neural systems; it comprises of four distinct layers, for example, convolution layer, pooling layer, corrected unit layer and lose layer. Every layer plays out their one capacity for acquiring the ideal yield when contrasted with other neural system in light of the fact that these layers are capacity to prepare even the clamor information. In the convolution layer [15], the greater part of info has been acknowledged from the element choice procedure which is dissecting the diverse course as far as measuring the three distinct parameters. Profundity, side and zero cushioning. In the wake of investigating these parameters pooling layer dissect the most extreme pooling estimation of every component which are nourished into the corrected unit esteem which computes the every element esteem by applying the actuation capacity. Since the enactment or learning capacity decides how quick and how exact the strategy orders the components with least mistake rate. In the wake of applying the enactment work, the blunder rate has been evaluated by contrasting the genuine quality and the related expected worth. On the off chance that the progressions happens, the weight and predisposition quality is redesigned persistently by utilizing the receptive enhancement strategy since it decreases the whole framework blunder rate with compelling way. At the time of output estimation process every layer input is multiplied its related weight value and bias value need to be added. The output calculation is done by using the following way,

$$Net\ output = \sum_{i=1}^{N} x_i * w_i + b \qquad (15)$$

Then the updating of the weights and bias or done with the help of reactive method because it easy to analyze features with every direction and objective manner. So, the objective of the feature weight and bias is estimated as follows,

$$f(x) = (f_1(x), f_2(x), \ldots f_k(x))^t \qquad (16)$$

According to the above objective function, the weights are updated continuously with previous value. After that the features are trained with the help of the sigmoid, Gaussian function. Then the network analyze all the inputs present in the network with effective manner and effectively classifies the seizure feature

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successfully also maximum recognition rate. The efficiency of the proposed system is evaluated using the following experimental results and discussions.

Statistical analysis

Statistical analysis was done using SPSS 20.0 v. Descriptive analysis was done to estimate the percentage of microorganisms and Chi Square test was done to assess the difference in proportions. Level of significance was taken at $p<0.05$.

RESULTS AND DISCUSSIONS

In this research work with two different databases such as CHB-MIT scalp EEG dataset and European Database is used for analyzing the efficiency of the proposed system. The CHB-MIT database consists of 256 recorded EEG signals [16] which are captured from the 22 different subjects whose age and sex has been varied. The next EEG database is European EEG [17] database which consists of 225 scalp recordings which are collected from the 275 patients which are used for our research purpose. By using these databases, the seizure features are trained up to 80% and the remaining 20% of the seizure is detected accurately in testing phase successfully. Then the performance of the proposed system is evaluated in terms of the accuracy, sensitivity and specificity.

Performance metrics

Sensitivity

Sensitivity [22] is used to measure how the proposed system correctly classifies the true positive.

$$Sensitivity = \frac{True\ Positive}{True\ Positive + False\ Negative} \quad (17)$$

Where True positive is successfully or correctly identified the seizure value and the False Negative is successfully rejected incorrect value.

Specificity

Specificity [23] is used to measure how the proposed system correctly classifies the false values.

$$Specificity = \frac{True\ Positive}{False\ positive + True\ Negative} \quad (18)$$

Where True negative is successfully or correctly rejected value and false positive is successfully rejected value.

Classification

Classification accuracy [24] is the measure which is used to estimate how the proposed system successfully classified the number of heart beats in the correct manner which is determined as follows,

$$Classification\ Accuracy = \frac{Number\ of\ instances\ classified\ correctly}{Total\ number\ of\ instances} \quad (19)$$

Performance analysis

The performance of the proposed reactive optimized convolution neural network is compared with the exiting methods correlation feature selection, particle swarm optimization, genetic algorithm. The feature selection process increases the overall seizure detection process which is shown in the [Fig. 3].

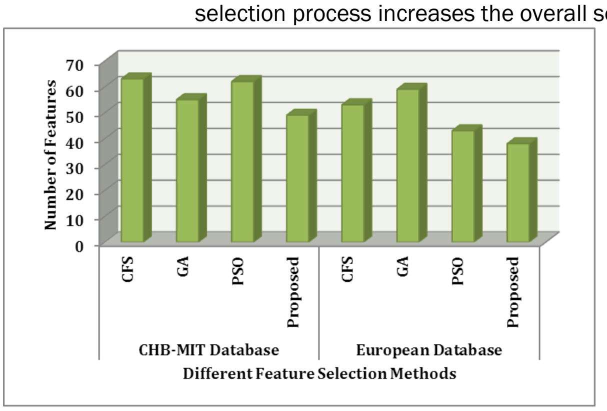

Fig. 3: Performance of various feature selection methods.

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[Fig. 3] clearly depicted that the proposed Memetic redundancy feature selection method selects the optimal features from the large collection of dataset when compared to the existing methods. In addition the proposed method works well on both dataset which is means it provides the efficient results on different type of EEG data. The optimized features improve the overall efficiency of the seizure detection system. This efficient feature reduces the entire system error rate which is shown in the [Fig. 4].

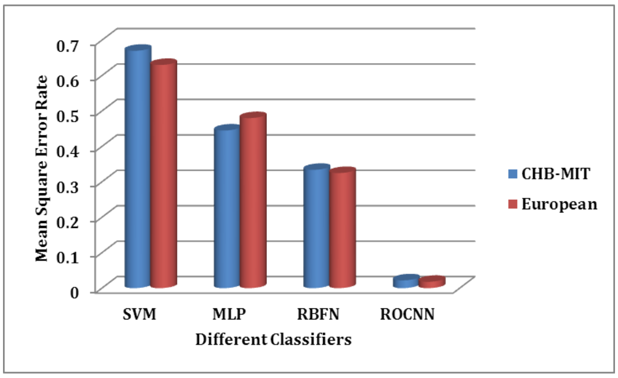

Fig. 4: Error value of the various classifiers.

The above [Fig. 4] depict that the proposed classifier reduces the entire system error rate which means it exactly identifies the seizure feature when compared to the other methods. Then the efficiency of the system is evaluated using the sensitivity, specificity of the proposed system which is shown in the [Fig. 5].

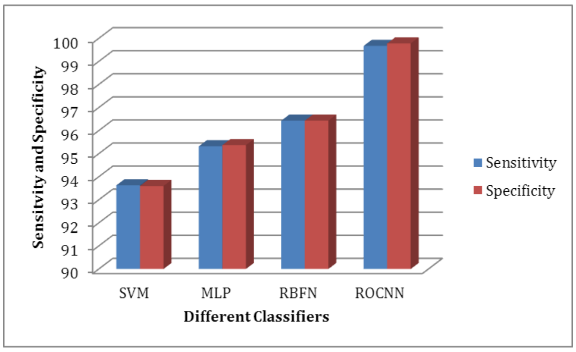

Fig. 5: Sensitivity and specificity.

[Fig. 6] shows the accuracy of different classification techniques, the proposed approach ROCNN attains 99.88 % accuracy overall, while the SVM, MLP; RBFN attains 94.6 %, 95.37% and 95.93%.

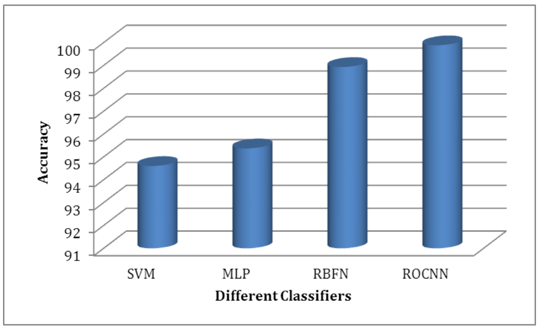

Fig. 6: Accuracy.

Thus the proposed system efficiently classifies the seizure epilepsy diseases when compared to the other traditional and existing methods like a support vector machine, Multilayer Perceptron and Radial Basis Function Networks. Further the proposed system resolves the existing researches drawbacks also reduces the entire dimensionality of the feature set. This minimum feature set reduces the entire error rate also increase the seizure recognition rate up to 99.88%.

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CONCLUSION

This paper analyzes and implementing the automatic seizure detection system using the reactive optimized convolution neural networks. Initially the EEG signal noise removed by applying the common singular value reference which evaluates the each electrode present in the recorded EEG signal. From the preprocessed EEG signal, the different EEG signal band is decomposed with the help of the multi resolution second generation wavelet transform which analyze the signal in terms of different direction. From the decomposed signal, invariant and entropy features are extracted and the dimensionalities of the features are reduced with the help of the Memetic redundancy feature selection method. The selected features are efficiently classified using the proposed classifiers and the efficiency is evaluated with the help of the CHB-MIT and European database in terms of mean square error rate, sensitivity, specificity and accuracy.

CONFLICT OF INTEREST
There is no conflict of interest.

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