Identification of FFI Disorder Using Dragon Fly Optimization Technique

Sudha Ramya Karri¹, Daisy Rani Ali² and Annepu Bhujanga Rao³

¹Research Scholar, Department of Instrument Technology, Andhra University, AP, India

²Assistant Professor, Department of Instrument Technology, Andhra University, Visakhapatnam, AP, India

³Professor, Department of Instrument Technology, Andhra University, Visakhapatnam, AP, India

Corresponding author email: ramyakarris@gmail.com

ABSTRACT

One of the most important signals to detect sleep disorder is Electroencephalogram (EEG). To process the study of sleep disorder, EEG database is been used which are available in Physionet databank. Among many sleep disorders fatal familial insomnia (FFI) is one of the most familiar sleep disorders in today's scenario. FFI diagnosis became a challenging task for physicians. The standard database is obtained from PhysioBank (www.physionet.com/EEG/sleep_disorder_data). From the databank total of 635 patient's data is considered for processing the proposed work. The features from the signals are extracted and then reduced using reduction techniques like PCA, ICA and LDA. Dragon fly Optimization (DFO) technique is applied and classified using support vector machine. The proposed Dragon fly Optimization technique that is performed to optimise the features is compared with other existing optimization techniques like GA and IWO. The metrics are evaluated. The rate of accuracy is obtained is 93.2%, the metrics are sensitivity 77.8%, specificity 93.8, precision 94.4% and F1 score is 0.936. The results obtained having high efficiency compared to existing methods. The proposed method have achieved high rate of accuracy in detecting the sleep disorder. Experimental results show that the algorithm can effectively detect normal and abnormal quality of sleep. The disorder is identified and the remedy is provided. GUI is created to show a computerized system.

KEY WORDS: FATAL FAMILIAL INSOMNIA DISORDER, EEG SIGNALS, PCA, LDA, DRAGON FLY ALGORITHM, SUPPORT VECTOR MACHINE.

INTRODUCTION

In the current scenario, human beings depends lot on the technology which is upgrading day-by-day. The use of technology in medical diagnosis helps in achieving good results for identification of diseases in earlier stages. Sleep disorder is one form of disease that many of the people are suffering from. Inorder to identify the sleep disorder, brain waves play an important role. The signals obtained from brain helps in diagnosing the patients. The

EEG signals that are generated brain are been recorded, these brain waves have different patterns that helps to classify the sleep disorders. The functioning of brain and time to time change positions of signals in brain region are determined using EEG signals. Understanding of EEG data is a difficult task (John GW, 2020).

The EEG signal amplitude varies continuously based on the external environment and the mental ability of the person. Both internal and external factors affect the amplitude of brain signal. Typical amplitudes in EEG waveforms are of the order of 50–200 μ V (Srinivasan N, 2017). Basically, the brain waves are categorised using the frequency bands, among all bands five are considered as important i.e.: delta (δ), theta (θ), alpha (α), beta (β) and gamma (γ).

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Figure 1: EEG waveforms at different stages

The psychological symptoms of disorder person have multiple impacts on his life. These symptoms will make human brain mentally imbalance. Sleep disorders are closely related to psychological disorders. These kinds of disorders create distress in the human beings. They are different types of sleep disorders. Type of disorder along with the symptoms is shown in table 1. In the year 1818, Johann Heinroth first identified the psychosomatic disorder, Insomnia is a disorder which effects the quality of sleep or percentage of sleep (Mellinger GD et al.,1985) Insomnia disorder has a symptoms of falling asleep for long time on bed, repetitive wakeup over the nights, time for going back to sleep when disturbed, walking up early in the morning etc. (Saddicha S, 2010).

Table 1. Sleep disorder and Symptoms

Sleep Disorder	Symptoms
Rapid Eye Movement	Kick, punch, hit, grab, leap out of bed while sleeping
Periodic Limb Movement disorder	Repetitive cramping, Jerking of legs during sleep
Obstructive sleep apnea	Stop breathing during sleep, snoring loudly
Nocturnal frontal lobe epilepsy	Inability to concentrate, Involuntary movement, Tongue biting
Narcolepsy	Sudden loss of muscle tone, Hallucinations
Fatal Familial Insomnia	High blood pressure, rapid heart rate, weight loss, trouble in controlling body temperature

Table 2. Insomnia Disorder classification among the population

Age Group	Effected Percentage
Adult Population	33-50% (Ancoli-Israel S et al., 1999)
General Population	10-15% (Roth T et al.,2001)
Divorced, separated or widowed people	Higher rates (Dollander M et al., 2002)
Older age and female population	Moderate rate (Hohagen F et al.,1993]
White population	Moderate rate(Riedel BW et al.,2004)
co-morbid medical or psychiatric illness	40% (Buscemi N et al., 2005)

Table 3. Categories of Insomnia

Type of Insomnia	Percentage
Occasional Insomnia	30%
Chronic Insomnia	10%
Fatal Familial Insomnia	25%

Majority of population facing insomnia sleep disorder are adult's i.e. up to 33-50% (Ancoli IS et al., 1999). The data obtained from various sources are shown in table2. According to various studies insomnia is categorised and shown in table 3 From the observation of previous study on sleep disorders, insomnia is very low recognized, low treated and also level of diagnosis is low, 50-80% of individual with insomnia disorder have very low follow-up i.e. once a year (Frazen P L et al.,2008). Fatal Familial Insomnia mostly occurs inpatients over the

age of 40 years with insidious and progressive insomnia accompanied by vivid dreams initially, and then syndromes caused by dysfunction of autonomic nervous system emerged, such as hyperhidrosis, palpitation, sexual impotence, and constipation. Various optimization techniques like Genetic Algorithm (Sudha RK et al., IJITEE, 2020) and Invasive weed Optimization (Sudha RK et al., IJAST, 2020) techniques are implemented. In this paper a dragon fly optimization algorithm is considered for obtaining accurate features in detecting the sleep disorder. The proposed method is done by processing of signal, detecting the sleep order and remedy is been presented. The graphical user interface module is created. The main objective of this paper is to identify and diagnose the sleep disorder using EEG signals.

MATERIAL AND METHODS

Dragon Fly Optimization: The algorithm initiates the swarming behaviours of the dragonfly. Two types of

moving patterns are involved during the process of hunting one is static and other is dynamic. Static type is considered while moving in small areas to hunt insects. The hunt process in static includes unexpected movements and local movements. Dynamic type is considered for long search, in this bunch of dragonflies forms a group and travel in single direction for longer interval (Mirjalili S, 2015). The static and dynamic swarming is shown in figure2. In this process of swarming two phases are involve i.e exploration phase and exploitation phase.

The performance of dragon-files algorithm depends on various parameters like separation (s), alignment (a), cohesion(c), food and enemy vectors (f,e) and inertia weight (w). These parameters helps dragonflies move to different paths. Two phases' exploration and exploitation depend on alignment and cohesion. High level alignment and low level cohesion parameters are used for exploration of the search space vice versa i.e low level alignment and high level cohesion parameters are used for exploitation of search space. The parameters need to be tuned during the process of optimization to maintain equality between the two phases. The transfer of phases i.e form one phase to other depends on number of iterations. The parameters are designed mathematically and are shown in below equations from eq 1 to eq 5. The separation can be calculated as mentioned by(Reynolds CW , 1987).

Figure 2: (a) Static Movement (b) Dynamic Movement

$$SP_i = - \sum_{j=1}^N P - P_j \quad (1)$$

In equation (1), The position of current dragonfly is given as P, Position of jth neighbour dragon fly is given as P_j, Number of dragonflies in the search space is given as N, and SP is the separation motion . For calculating of alignment parameter the below equation 2 is used:

$$AP_i = \frac{\sum_{j=1}^N}{\quad} \quad (2)$$

Where, the alignment motion of ith individual is given by AP_i and the velocity is represented by Ve.

The mathematical expression for calculating Cohesion function is given as,

$$CP_i = \frac{\sum_{j=1}^N P_j}{N} - P \quad (3)$$

Where, cohesion of ith individual is CP_i, size of neighbour is termed as N, Position of jth fly is P_j, current position of fly is indicated by P. Search of food and the attraction for food is calculated using equation 4 below:

$$Fd_i = P^+ - P \quad (4)$$

Where, food attraction is Fd_i for ith dragonfly, food source is position P⁺, current position of fly is P. In this algorithm the best objective function is the food. Distraction outwards predators are calculated as follows:

$$En_i = P^- + P \quad (5)$$

Where, Distraction of enemy is given as En_i for the ith individual, current position of enemy is termed as P⁻, and current position of fly individual is P. To update the positions in the search space two vectors are used one is step vector and other is position vector and denoted using ΔP and P. The step vector used over here is similar to the vector in PSO (Zhang Y et al., 2015). The updating of position is similar to PSO algorithm. The step vector is defined in (Mirjalili S 2015) as follows:

$$\Delta P_{t+1} = (sSP_i + aAP_i + cCP_i + fFd_i + eEn_i) + w\Delta P_t \quad (6)$$

wis the inertia weight; and t indicates the iteration counter. After the evaluation of step vector, position vectors are evaluated using equation 7.

$$P_{t+1} = P_t + \Delta P_{t+1} \quad (7)$$

Where, current process of iteration is termed as t.

Figure 3: Process flow of proposed Methodology in GUI

To raise the likelihood of investigating the entire choice space by an improvement calculation, an arbitrary move should be added to the looking through method. At the point when no neighbouring arrangements are there, to build irregularity, stochastic conduct, and investigation of fake dragonfly people, dragonflies are needed to utilize an arbitrary walk (L'evy flight) to fly all through the inquiry space. In dragonfly algorithm, a set of solutions are created randomly in the starting of optimization process. Boundaries are created and the values for step and position vectors are given initially between the lower and upper boundaries. The updating of position and step vectors of each dragonfly is done at every stage of iteration using equation 6 and 7. The Euclidean distance is calculated to choose the neighbours. The position will be updated until the global best solution is obtained.

Figure 4: Optimized features obtained for normal signal, Brux signal and FFI signal

Detection and Remedy Process: In this process they are different stages entitled for detection of sleep disorder and for providing the remedy. The remedy is provided based on the output disorder obtained for the given input signal. The stages are (a) Input signal and Pre-Processing (b) Feature Extraction (c) Features reduction and Optimization (d) SVM classifier. In final stage the classifier is which determines the rate of accuracy in finding out the disorder. The process flow of work is shown in Fig 3. A GUI is created for all the things to get performed. The signal is uploaded from the dataset, processed internally by using the techniques that are

used and displays the types of sleep disorder along with its remedy.

Input Signal: In this stage the EEG signal database is considered. The database consists of different EEG signal out of which some of the signals are of normal patients, some are brux disorder patients and some are FFI disorder patients. These signals are considered as input for process our experimentation. The standard database is obtained from PhysioBank([www.physionet.com/EEG/sleep disorder data](http://www.physionet.com/EEG/sleep_disorder_data)). From the databank total of 635 patient's data is considered. These EEG signals are pre-processed for obtaining the features from the signals. In the pre-processing step, the EEG signals were filtered between 0.5-40Hz using a low pass filter to remove noise. They were then normalized and any epochs containing amplitude levels above the 250 μ V were removed. After pre-processing, feature extraction is performed.

Table 4. Metric evaluation for two combinations i.e. normal and Brux

Parameters		GA-SVM(Sudharamya et al.,2020)	IWO-SVM(Sudharamya et al.,2020)	Proposed DFA-SVM
N/B	A	89.1	91.8	93.5
	Se	73.8	76.3	79.2
	Sp	88.9	91.1	93.8
	Pr	86.2	92.4	95.4
	F1	0.89	0.912	0.94

Table 5. Metric evaluation for two combinations i.e normal and FFI

Parameters		GA-SVM(Sudha RK et al.,2020)	IWO-SVM(Sudha RK et al.,2020)	Proposed DFA-SVM
N/FFI	A	90.8	92.5	94.3
	Se	82.0	84.3	87.8
	Sp	89.2	91.8	94.2
	Pr	86.4	92.3	96.1
	F1	0.90	0.92	0.952

Table 6. Metric evaluation for two combinations i.e. FFI and Brux

Parameters		GA-SVM(Sudha RK et al.,2020)	IWO-SVM(Sudha RK et al.,2020)	Proposed DFA-SVM
FFI/B	A	88.6	92.1	93.8
	Se	70.4	75.2	78.6
	Sp	89.6	91.8	94.1
	Pr	85.6	92.3	95.5
	F1	0.88	0.917	0.938

Feature Extraction: One of the main step for detecting the disorder to extract the desired features from the EEG signals. From one channel of EEG data 28 number of features are extracted. For every 30s of the input data

features are extracted which are related to sleep stages. The extracted features are listed as mean, standard deviation, kurtosis, skewness, max, min, different ratios of alpha, theta and delta. The signal amplitude levels determine the time domain features and also describes statistics with higher order. In frequency domain, welch's method is used on the entire length of signal. Based on the ranges of these features as shown in (Sudha RK et al. IJITEE, 2020) the type of disorder can be derived. To find accurate results feature reduction process is performed and is optimized to improve the rate of accuracy.

Table 7. Metric evaluation for two combinations i.e.Normal, FFI and Brux

Parameters		GA-SVM(Sudha RK et al.,2020)	IWO-SVM(Sudha RK et al.,2020)	Proposed DFA-SVM
N/FFI /B	A	86.2	89.6	93.2
	Se	72.6	74.8	77.8
	Sp	87.6	90.1	93.8
	Pr	83.5	91.1	94.4
	F1	0.86	0.894	0.936

Figure 5: GUI Processing of signal 1

Feature Reduction and Optimization: The extracted features will be reduced using reduction techniques like Principal Component Analysis (PCA), Independent Component Analysis (ICA) and Linear Discriminant Analysis (LDA). The LDA models the difference between the classes of the data while PCA does not work to find any such difference in classes. In PCA, the factor analysis builds the feature combinations based on differences rather than similarities in LDA. ICA separation of mixed signals gives very good results is based on two assumptions and three effects of mixing source signals. Two assumptions are, the source signals are independent of each other and secondly the values in each source signal have non-Gaussian distributions. The results show that LDA has better performance in reducing of features. These features obtained using LDA is given to

Optimization Technique to obtain the optimal and global best features. The dragon fly optimization is considered and the optimal features are obtained by the process discussed in section 2. These optimized features are been provide to classifier. In fig4, the results obtained using dragon fly optimization for the signals is shown. These are the best features to identify or detect the type of sleep disorder and to provide remedy. By using these optimized features the rate of accuracy can be increased.

Classification: Classifier is used to separate the features and find the rate of accuracy. Here Support vector machine (SVM) classification method is used. It is a method based on theory of statistical learning. The inputs given to this classifier are considered as vectors and are linearly separated to find the best results. SVM brings a concept of hyper plane by which the separation process takes place with maximum margin. The data which is given as input will be trained and tested. The 70% of data is used for training and 30% is considered for testing. After completing the training and testing of all signals are performed and the rate of accuracy is achieved.

RESULTS AND DISCUSSION

The experimental data used in this study comes from the Normal sleep and sleep disorder database, which is part of the Physionet database. The proposed algorithm is verified on the dataset that is used. K-fold cross verification is implemented in which training and testing is performed. For training k-1 folds are used and for purpose of testing kth fold are used. Every fold will be used for testing by the time it reaches stop criteria. We extract accuracy, precision and recall values for each class, as defined below:

$$\text{Accuracy} = \frac{Tp + Trn}{Tp + Tn + Fp + Fn}$$

$$\text{Recall} = \frac{Tp}{Tp + Tn}$$

$$\text{Precision} = \frac{Tp}{Tp + Fp}$$

The results obtained using proposed Dragon fly optimization based SVM is shown in below tables. Various combinations of detections are considered and parametric values are obtained.

From the above tables 4,5,6,7 it is shown that proposed method have good rate of accuracy compared to existing methods. The graphical user interface of showing the remedy for the detected disorder is shown in below figures. The proposed method is compared with existing techniques.

Case1: For the given Input signal the results obtained states that the disorder is Bruxism. From fig5, it is shown that sleep disorder is bruxism and the remedy is Muscle Relaxants & Botox Injections. This GUI gives better output progress and better understanding of outputs.

Case2: For the given input signal the result obtained states that the disorder is FFI. By clicking browse file we provide the input signal from the database. The status will be in progress until the above process which is discussed

in section 3 completed. After processing is done, the status shown is process completed. After completing the process, the important features are displayed. Based on the displayed features the disease is identified and displayed. From fig6, it is shown that sleep disorder is FFI and the remedy is zolpidem(Ambien),eszopiclone (Lunesta),zaleplon (Sonata), doxepin (Silenor). Cognitive behavioural therapy (CBT).Relaxation techniques.Avoid caffeine, alcohol and smoking.Do regular exercise.

Figure 6: GUI Processing of signal 2

Figure 7: GUI Processing of signal 2

Case3: For the given input the output is normal.From fig7, the result is normal and no kind of sleep disorder. The overall accuracy of the disorder detection is also shown in the GUI.

CONCLUSION

The EEG signals play an important role for identifying the sleep disorder in humans. The sleep disorder like bruxism and fatal familial insomnia are identified and the remedy have been displayed. The entire process is done using Matlab GUI tool. The graphical user interface helps to obtain results for every signal which is been processed and listed. The outputs shown gives an immense impression on how the detection of sleep disorder and remedy displayed with proper rate of accuracy using Dragon Fly optimization techniques. This technique helps in obtaining the best features for identifying the disorder. The accuracy and other parametric results obtained

using proposed methodology is compared with exiting techniques. The proposed method shows promising results in all aspects with an accuracy of 93.8%.

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