

Attention Detection Using EEG Signals And Machine Learning

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Abstract—Now a days people spend their most of the time overthinking and are not attentive in many situations such as while driving, in classrooms, studying, flying airplane and many other situations. Therefore, we can make them alert then they can increase their attentiveness and be cautious and avoid risks. This task of alerting an individual to be attentive can be achieved with the help of analysis of EEG signals. The EEG signals are collected from the scalp of human brain. The part of human brain from where we collect these signals is called as frontal cortex. This part of brain generates signals which can give us the accurate value of attention level of our brain. These EEG signals are generated as activity of neurons and it is measured in volts. The attentive state of an individual is predicted by using the raw EEG signals and processing by techniques like denoising which include FIR filter, Wavelet Transform and Hilbert Transform, feature extraction, feature selection and classification techniques like SVM, Tri layered Neural Network and Medium KNN available in MATLAB. Therefore, using these EEG signals we can efficiently train our algorithm to classify the state of human being as attentive or non – attentive.

Keywords— Attention, EEG signals, Denoising techniques, Classification.

I. INTRODUCTION

The motivation of the project is to detect the attentiveness of a person so that the person can be attentive and increase his capabilities of doing work. If a person is given feedback of attentiveness while doing work it will be of great benefit to him. If a person is sitting in front of screen without blinking his eyes, then by giving alert to be less attentive can save his eyes from any disorder. Machine learning is a part of artificial intelligence which allows us to predict outcomes accurately. It uses dataset as input to predict the output values. Using the Mind-wave Mobile 2 Headset the EEG signals are generated and a dataset is obtained for the corresponding values in the EEG ID application. This dataset will be trained using machine learning algorithms.

Attention detection helps to evaluate the person's attention and give them an alert. By detecting this it will increase their capabilities. The Electroencephalogram (EEG) is a representative signal enclosing information about the function of the brain. A Brain Computer Interface (BCI) is a computer-based system which studies the brain signals and obtain the output to perform desired action. The research papers we studied mainly focused on wearables and applying machine learning algorithms. Various machine learning and statistical approaches have been applied for artifact detection such as Hand Crafted Methods, Signal Decomposition Methods, Supervised Approaches. In [1] we studied about the feature extraction and it states that EEG signal consists of alpha range (8-13Hz) and beta range (14-20Hz) which give us information about the relaxed or attentive state of mind. Also, it stated that features like mean, entropy, power and ratio of alpha and beta bands which help in classification of attention state accurately. We then studied different denoising techniques FIR, wavelet transform and Hilbert transform.[2] In wavelet transform first decomposition of signal is done using wavelets we have selected the Daubechies wavelet for decomposition.[3] In Hilbert transform as well we carried out empirical mode decomposition in which we got imf2 corresponding to beta band and imf3 corresponding to alpha band. In FIR high pass and low pass filter was used..

II. PROPOSED SYSTEM

The real time EEG dataset is generated with the help of Neuro- brain wave kit, it will be generating a csv file. The csv file contains various parameters like EEG raw value in volts, alpha value, beta value, attention value, meditation value, blink strength, delta, theta, alphaLow, alphaHigh, betaLow, betaHigh. To determine attention, we will be considering only alpha values and beta values. Using these values denoising, feature extraction and selection is performed. First denoising of raw EEG signal is done to remove noises using FIR filter, Wavelet transform and Hilbert Transform and compared them.

Then the features which need to be extracted are entropy- based feature, maximum power of each frequency band, mean value, ratio of alpha band energy to beta band energy. The data will be pre-processed using MATLAB. Then we train and test the dataset using classification learner app and identify whether the person is attentive or not.

III. METHODOLOGY

A. Dataset

We have used real-time dataset of 7 people in 3 different states of attention like horror, meditation and normal state using the EEG Nuerosky mind wave device. The horror state is considered as non-attentive, meditation and normal state is considered attentive. Using the eegID app the signal is recorded and converted into a csv file.

timestamp	poorSigna	eegRawVa	eegRawVa	attention	meditation	blinkStren	delta	theta	alphaLow	alphaHigh	betaLow	betaHigh	gammaLo	gammaHi	tag	event	location
1.65E+12	0	57	1.25E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	50	1.10E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	81	1.78E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	40	8.79E-06	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	0	0	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-266	-5.84E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-263	-5.78E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-126	-2.77E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	64	1.41E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-265	-5.82E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	44	9.67E-06	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	20	4.39E-06	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	105	2.31E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	38	8.35E-06	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	86	1.89E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-307	-6.75E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	-178	-6.11E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	13	2.86E-06	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown
1.65E+12	0	54	1.19E-05	51	64	40	34452	3469	4018	16752879	8470	4146	1360	1132	Tag0		unknown

Fig 1. Csv file generated

eegRawValue
88
76
-526
-12
99
82
91
115
113
90
98
-116
269
523

Fig. 2. eegRawValue column of csv file.

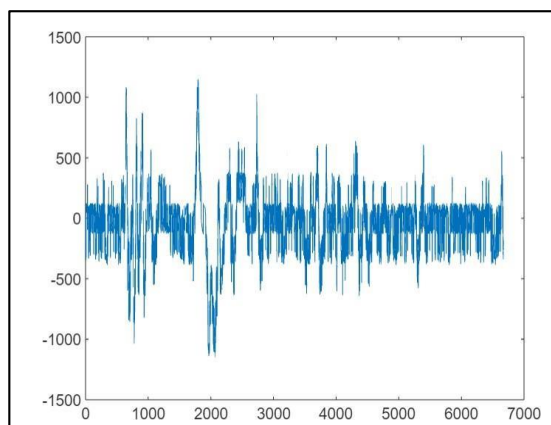


Fig 3.eegRawValue

B. Preprocessing

The preprocessing is done of the raw signal to remove unwanted noises and extract the denoised signals. This denoised signal is used for further processing. Three denoising techniques are implemented to extract the required alpha and beta signals. FIR filter, wavelet transform and Hilbert transform was implemented.

1) FIR:

FIR filter is used to extract the signals of some specified frequency ranges. In this we used high pass and low pass filter of frequency range 8-13Hz to get alpha and 14-30Hz to get beta signal.

2) Wavelet transform:

In wavelet transform the signal decomposition was done using functions in MATLAB. We selected the Daubechies5 (db5) wavelet function for denoising. The wavelet decomposes the signal up to five levels and these layers are called as wavelet coefficients. The level 2 and 3 corresponds to the beta and alpha range. So we have used these layers to extract the alpha and beta signals from the raw signal

3) Hilbert Transform:

In Hilbert transform we used empirical mode decomposition(emd) to decompose the signals and we got the imf's (intrinsic mode functions). These imf's correspond to different frequency spectrums. The first imf contains the highest frequency component. We had decomposed our signal in eight different imfs. After studying we found that imf2 corresponds to beta frequency range and imf3 corresponds to alpha range.

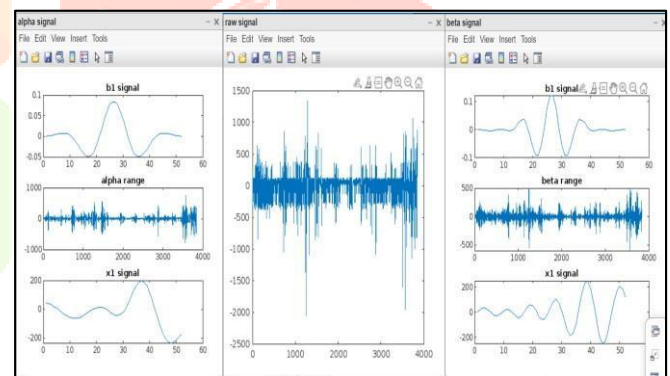


Fig 4..Denoising with FIR filter

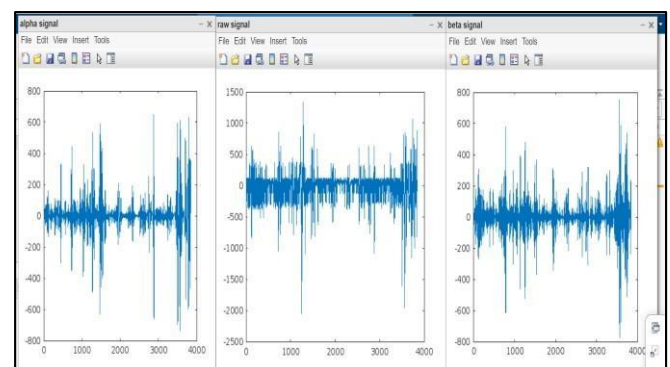


Fig 5.Denoising with wavelet transform

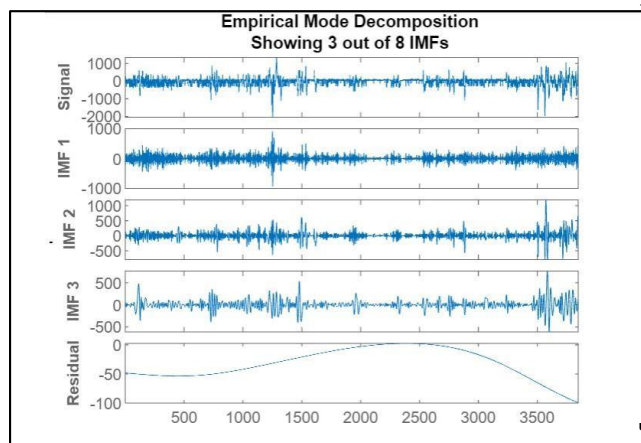


Fig 6.Denoising with Hilbert transform

C. Feature Extraction

To train the classifier it needs input attributes called features which need to be extracted from the signals. The features which are used to classify attention state are mean, minimum and maximum entropy, power, ratio of energies of alpha and beta signals. These features were extracted from signals obtained from three different denoising techniques and then they were saved in a csv file.

Entropy min	Entropy max	Mean	$z=Ea/Eb$	Power	
0.7125	0.7815	-0.0284	1.2184	5.37E+03	horror person 1
0.722	0.7558	-0.0501	1.5203	2.73E+04	horror person 2
0.7898	0.851	-0.166	0.7398	5.25E+03	horror person 3
0.7051	0.7391	-0.0151	1.088	2.78E+03	horror person 4
0.7755	0.8388	-0.0529	0.889	2.35E+03	horror person 5
0.7449	0.7754	0.1235	1.0089	7.45E+03	Meditation person 1
0.5075	0.868	0.0474	0.6038	1.08E+03	Meditation person 2
0.6803	0.7061	0.0068	1.4147	1.41E+04	Meditation person 3
0.808	0.8843	-0.0498	0.5545	2.81E+03	Meditation person 4
0.7566	0.844	0.0476	0.664	964.4264	Meditation person 5
0.8262	0.8845	-0.0062	1.1278	1.74E+03	Meditation person 6
0.7327	0.7542	0.1089	1.1168	1.08E+04	normal person 1
0.6379	0.7934	0.1937	1.1259	5.73E+03	normal person 2
0.6478	0.7408	-0.0762	1.2284	8.53E+03	normal person 3
0.8196	0.892	0.0749	0.6119	5.67E+03	normal person 4
0.6266	0.7788	0.1509	1.3699	1.53E+04	normal person 5

Fig 7.CSV file of features

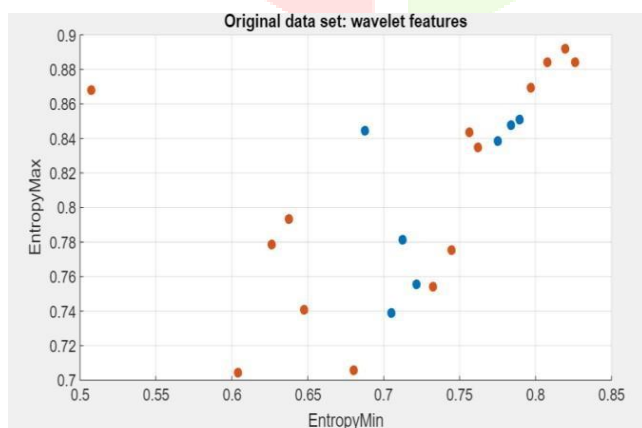


Fig 8.Scatter Plot

Classification

After importing the features to the classification learner app we got the scatter plot of the values. These extracted features were then given to three different classifiers for comparison. Support Vector Machine, trilayered neural network and medium KNN classifiers were used and their outputs were compared using accuracy, precision, recall and score.

1) TNN:

TNN is classified into three classes like input, output and hidden. It is a neural network which consists of four-dimensional input layer, two-dimensional output layer and one-dimensional hidden layer. The input values are given at the nodes of the input layer whereas the output values are obtained at nodes of output layer. The hidden layer where the calculation takes place and contains the intermediate results of output from the input values.

2) KNN:

Called as K-nearest neighbour algorithm. It is based on the supervised learning technique. KNN is mostly used for classification but can also be used for regression problems as well. In case of KNN it stores the dataset and while classifying it directly performs on the given dataset. So, it is called as lazy learner algorithm as it stores the dataset and performs action later on it. In KNN it finds the similarity and classifies the new dataset into the category close to previous categories. It is a non-parametric algorithm.

3) SVM:

Called as support vector machine. It is one of the most popular classifiers. It is a type of supervised learning algorithm. It is generally used for classification of two classes.

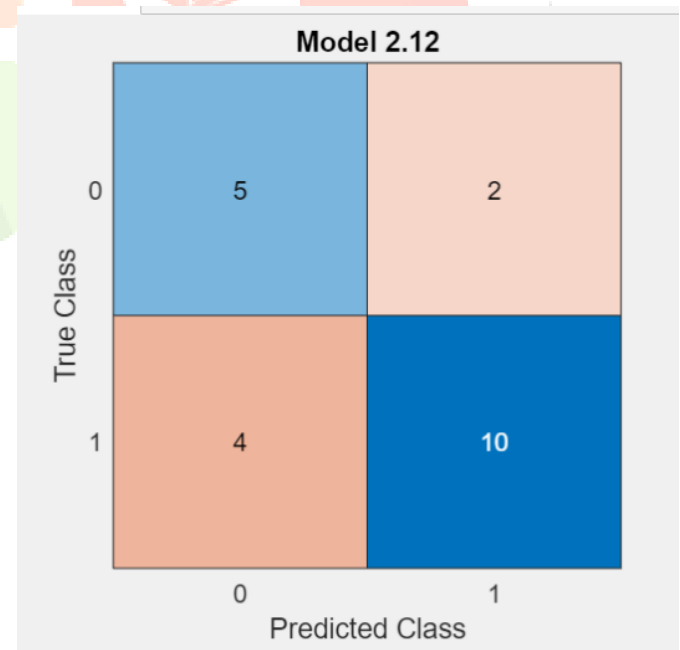


Fig 9.Confusion Matrix

IV. EXPERIMENTAL RESULTS

The result was determined by comparing parameters like accuracy, precision, recall and F1 score.

$$\text{Precision} = \text{TP} / (\text{TP} +$$

$$\text{FP})$$

$$\text{Recall} = \text{TP} / (\text{TP} +$$

$$\text{FN})$$

Where TP=True positive FN=False Negative and FP=False Positive. These values were obtained by plotting the matrix of true positive and false negative rates. From the matrix we got TP=85.7%, TN=71.4%, FP=28.6%, FN=14.3%. Through comparison we found that wavelet transform worked well to extract signals. SVM worked best with wavelet features giving 71% accuracy.

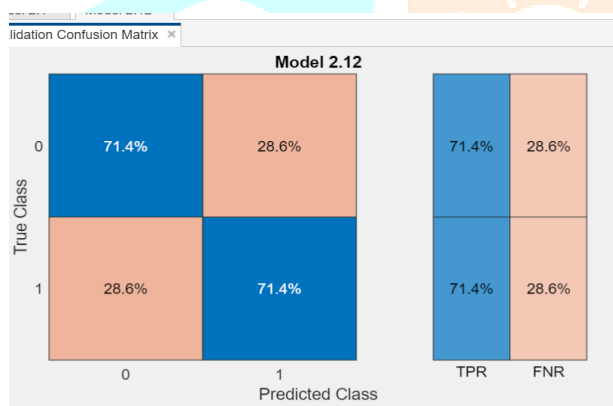


Fig 9. True Positive and False Negative rates.

TABLE I. Comparison of Output

Denoising technique	Classifier	Accuracy	Precision	Recall	F1 score
Hilbert	SVM	47.6	0.42	0.643	0.508
	TNN	66.7	0.62	0.71	0.66
	KNN	52.4	0.47	0.64	0.54
Wavelet	SVM	71	0.714	0.714	0.714
	TNN	81	0.74	0.85	0.79
	KNN	61.9	0.52	0.78	0.62
FIR filter	SVM	47.6	0.42	0.64	0.50
	TNN	23.8	0.25	0.28	0.26
	KNN	61.9	0.5	0.85	0.2

V. CONCLUSION

Attention detection is very important in this generation as many students face distraction while studying and doing other tasks. If such a device like Mindwave is used it alert the person to be attentive and make their life easy and productive. EEG is a reliable tool for the detection of attention. From this work of detecting attention using EEG signals it possess the ability to detect some of the severe health problems caused due to lack of attention. After performing the three denoising techniques on the dataset we compared the results and found that the wavelet transform worked well in denoising the signal. So the features which were extracted from the wavelet transform output signal when they were given to the classifier worked well and gave the highest accuracy and the three different classifiers which were used for training amongst them that fine tree and trilayered neural networks worked well.

So, after calculating different parameters and comparing them we came to know that SVM and trilayered neural networks has the maximum accuracy of 71% and 81% respectively.

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