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Article *in* Design Engineering (Toronto) · July 2021

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Design Engineering

ISSN: 0011-9342 | Year 2021
Issue: 6 | Pages: 2544 - 2551

Eye State Classification Based on EEG Signals

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Abstract:

EEG (electroencephalogram) signals are used to study the information about the state of the brain. Such information is useful for monitoring mental state of an individual and can avoid critical situations in one’s life. In this paper, we have implemented various machine learning algorithms on EEG eye state dataset to predict human eye state based on previous EEG signals. Random forest, decision tree, FURIA and bagging were implemented for comparative analysis. The experiment shows that random forest obtained the prediction accuracy of 92.43% which is the best among other implemented techniques.

***Keywords**: Machine Learning; EEG signals; Random forest; Eye state*

I. INTRODUCTION

Drink and drive is one of the foremost reason for road accidents and leads to an alarming rate of deaths all over the world. As per the numerous reports alcohol is considered as one of the abused drug in India and a major cause of central nervous system depressant. According to WHO report, alcohol is responsible for 6000 deaths per day worldwide [1]. The impact of alcohol is based on the amount of blood alcohol content (BAC) [2]. Human brain continuously emits EEG signals which contains vital information of what the individual is thinking. With the intake of 1-2 drinks person feel excited or more talkative. With more and more alcohol in the system, they become more sedated and began to lose control of their movement and may experience impaired thinking and memory [3] [4].

An EEG signal is a great tool to and can be used to identify and monitor various conditions

ISSN: 0011-9342 | Year 2021
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affecting the brain. It is also helpful in detecting symptoms such as seizures. Another major usage of EEG signals is to detect epilepsy, which is the main reason for seizures [5]. In this paper different machine learning techniques have been applied on the EEG eye state dataset to correctly classify the eye state of the user whether he is drunk or not. Eye state detection is the task of identifying whether the eye of the user is open or closed.

Various methods have been implemented for the correctly classification of eye state from EEG signals. Ali-Al Tai presented a comparison between three different machine learning methods. He implemented support vector machine, radial basis function and hidden markov map on EEG data for the detection of eye state whether the eye is open or close. The author also proposed their model based on ensemble method with random forest and kstar method. Their proposed model was able to achieve the accuracy of 97.27% [6].

Wang et al in their study proposed a novel technique for the identification of the eye state based on EEG signals. They implemented Incremental attribute learning (IAL) for the successful detection of the eye state. For the experimental purpose the authors have used dataset from UCI machine repository. They have implemented four different approaches for the experimental purpose. The IAL time series classification achieved the error rate of 27.45% whereas the IAL classification without using time series produced an error rate of 27.4793%. The third approach is with time series but used batch training method, this method was able to get an error rate of 29.50% and the last method was implemented using neural network without time series and the method was able to get an error rate of 30.63% [7].

Narejo et al proposed the prediction of eye states using EEG signals with the help of deep neural networks. They have successfully implemented deep belief network and stacked auto encoders for the detection of eye states. The stacked auto encoder model outshines the deep belief network and was able to achieve the accuracy of 98.9% [8].

Singla et al in their work presented the implementation of support vector machine (SVM) and artificial neural network (ANN) for the detection of eye state. Their research revealed that SVM performed better than ANN in terms of accuracy [9].

Wisesty et al in their study proposed a two stage system where in the first part they implemented differential evolution for the prediction of EEG signal and in the second part they implemented neural network with different optimization techniques. Their experiment was able to achieve the accuracy of 73.2% [10].

Devipriya, et al. in their study shows the importance of feature selection. They have implemented Information Gain feature selection method to filter out the significant features.

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Their study proved that the features F7, P7, O1, O2, F8 and AF4 channels were the most significant attributes. Further, the author implemented J48 classification technique for the identification of eye state on EEG data and their model was able to achieve an accuracy of 80% [11].

Gurve et al proposed a convolutional neural network (CNN) based approach for the identification of bio medical signals. They have implemented a CNN model for the detection of eye state. They used spectrogram of EEG signal as input with non-negative matrix factorization feature to the fully connected neural network. Their model was able to achieve the accuracy of 96.16% [12].

II. MATERIALS ANDMETHODOLOGY

For experimental purpose the dataset has been taken from UCI machine Learning Repository [11.] The data was recorded with the help of 14 electrodes positioned at different positions of the scalp. The EEG neuroheadset gives the recording of the electrical activity along the scalp over a short period of time. Total 14980 records with 14 features were recorded with the measurement of 117 seconds. The state of the eye was recorded using a camera during the EEG measurement. For the sake of experiment “1” indicates closed eye and “0” shows that the eye is in open state.

Random Forest

It is an ensemble method which involves an amalgamation of various learning methods. Random Forest comes under the category of supervised learning algorithm. It is applicable for generating regression output as well as classification. The algorithm generates numerous decision trees randomly at the training step. Each tree classifies the data and the final result is based on the voting mechanism as a result problem of overfitting of training data is also resolved [13].

Decision Tree

Decision Tree is a hierarchical tree like structure in which, outcome is calculated from every branch and every leaf node is assigned a class label and a test condition to separate the records that having different characteristics is represented by all the internal nodes. The top node is always known as root node in a tree. An iterative process has been followed for creating partitions of the dataset. The procedures for selecting a best node for the split are based on the degree of impurity of the child nodes [14].

FURIA

The algorithm uses the power of Fuzzy logic to generate the unordered fuzzy rule sets. It is

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the extension of RIPPER method. To extend the decision boundaries conventional rules are replaced by Fuzzy rules by using the power of fuzzy intervals using fuzzy membership functions.

Bagging

Bagging is the popular name of bootstrap aggregation algorithm. It is an ensemble method generates the classification result based on voting. To perform assembling it combines two methods namely bootstrapping and aggregation to avoid over fitting.

III. DATAANALYSIS AND INTERPRETATION

Table 1 shows the performance i.e. Accuracy, Error Rate, Kappa Stats and MAE and RMSE by implementing Random Forest, Decision Tree, Fuzzy Unordered Rule Induction and Bagging algorithms. Random Forest achieves the highest accuracy i.e. 92.43%, lowest error rate of 7.56% and the highest value of Kappa i.e. 0.8461. On the other hand Decision tree achieves the lowest accuracy of 82.30% and highest error rate of 17.69%. Bagging is an ensemble method of supervised learning. Bagging achieves the second highest accuracy of 88.4% and error rate of 11.59%. The results shows that in this case Random Forest outperforms the other models implemented in this work.

TABLE I: Accuracy/Error/Kappa/MAE and RMSE of models using all the features

MODEL	ACCURACY (%)	ERROR RATE (%)	KAPPA	MAE	RMSE
Random Forest	92.43	7.56	0.8461	0.2025	0.2651
Decision Tree	82.30	17.69	0.6408	0.1915	0.4026
FURIA	85.91	14.08	0.7129	0.1504	0.3235
Bagging	88.40	11.59	0.7644	0.2277	0.3043

Design Engineering

ISSN: 0011-9342 | Year 2021
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TABLE II: TPR/FPR/Precision/Recall/F-Measure and ROC of models using all the features

MODEL	CLASS	TPR	FPR	PRECISION	RECALL	F-MEASURE
FURIA	Yes	0.810	0.102	0.864	0.810	0.836
	No	0.898	0.190	0.856	0.898	0.876
DECISION TREE	Yes	0.788	0.149	0.808	0.788	0.798
	no	0.851	0.212	0.834	0.851	0.842
RANDOM FOREST	yes	0.894	0.052	0.933	0.894	0.913
	no	0.948	0.106	0.918	0.948	0.933
BAGGING	Yes	0.853	0.091	0.882	0.853	0.867
	no	0.909	0.147	0.886	0.909	0.897

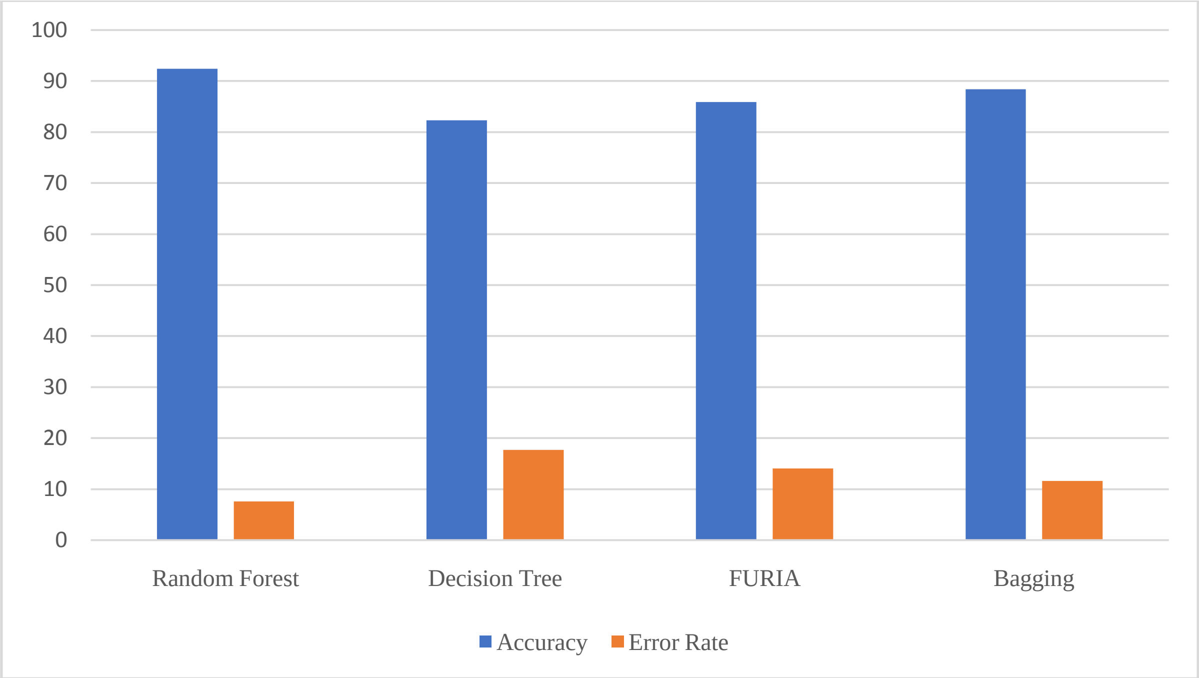

Fig 1: Accuracy and Error Rate

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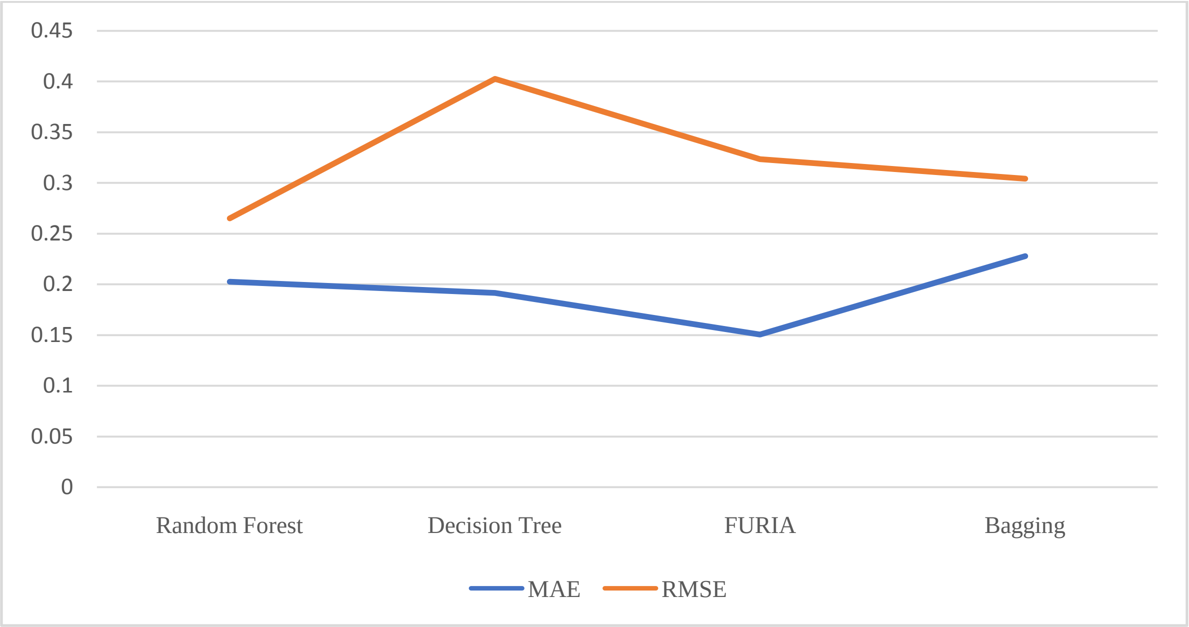

Fig 2: MAE and RMSE

We also measured the performance of models based on True Positive Rate, False Positive Rate, Precision, Recall and F-Measures. Table 2 shows the result of these performance measures. Random forest achieves the highest TPR rate for yes class as well as no class also. It has also achieved high precision and high recall as well as the value of F-measure also outperforms other models. FURIA achieves the value of TPR for yes and no class 80% and 98% respectively, and value of FPR is 0.102 and 0.190 for yes and no class and precision of 86% and 85% for yes and no class respectively. In case of Decision Tree the value of TPR for both the classes are 78% and 85% and value of FPR is 0.14 and 0.21 for both the classes. In case of bagging the value of TPR for both the classes are 85% and 90% respectively. Figure 1 shows the comparison of accuracy and error for all the models. Figure 2 shows the MAE and RMSE for all the methods. Figure 3 shows comparative results of other performance measures

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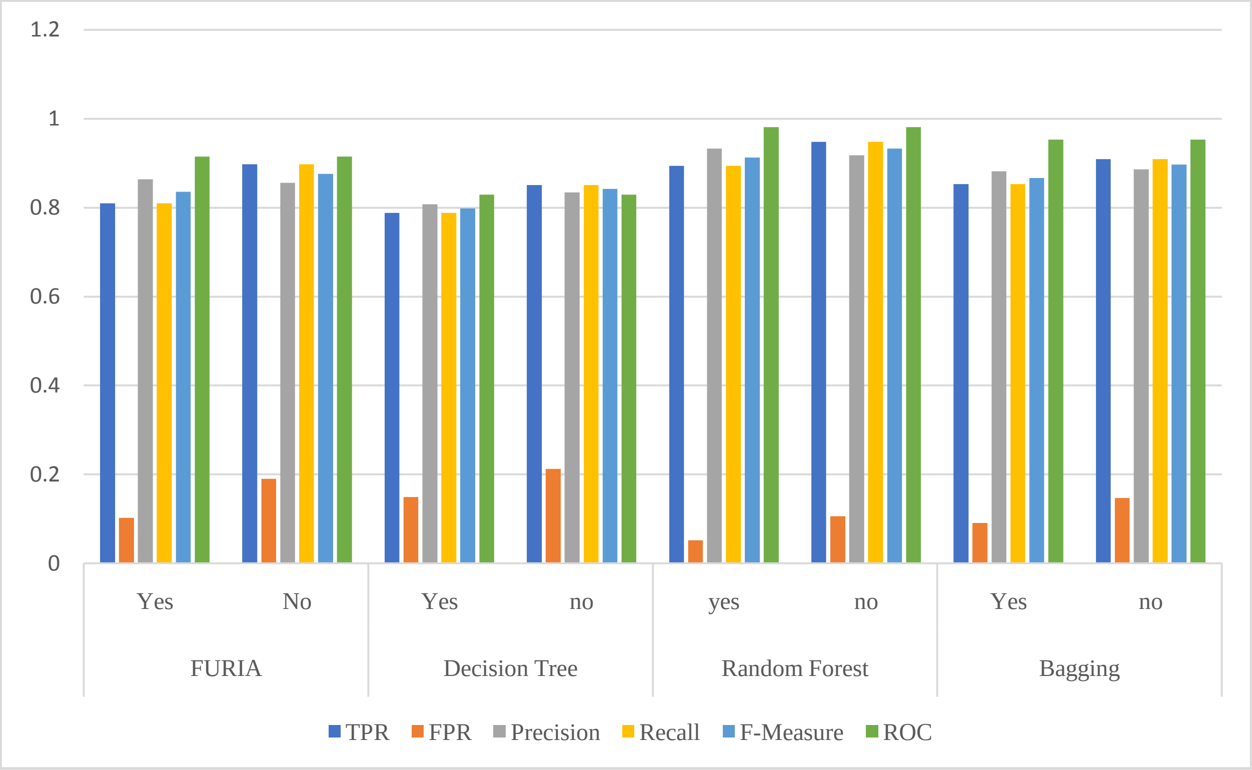

Fig 3: Performance Parameters

IV. CONCLUSION

The objective of this article is to check the effect of alcohol on EEG signal that results in loosing of self-control. As a result, while driving in such state causes accidents that even causes death. In this experiment, the outcomes provide insight to applicability of machine learning approaches for eye state detection using ECG signals. Two eye states are considered i.e. open and close. The algorithm considered for eye state detection are Random Forest, FURIA, Decision Tree and Bagging, Seventy percent data is used to training the model and thirty percent data is used to test the model. The results obtained shows that Random Forest achieves the highest identification accuracy and lowest error rate. Hence, such models can be used for various applications to avoid road accidents after intake of alcohol.

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