Alcoholism Detection using EEG Signals : A Machine Learning Approach

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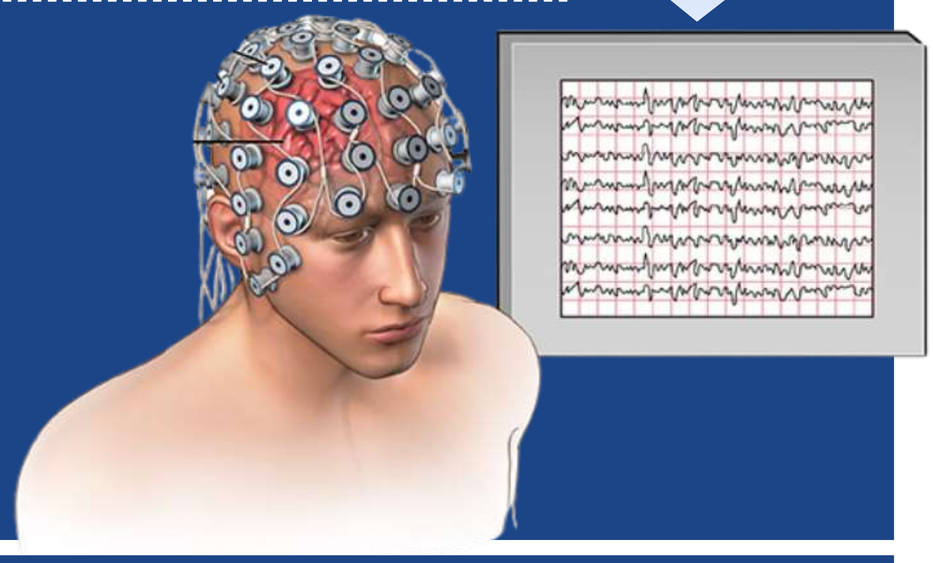
Introduction

With time, alcoholism keeps spreading, gradually taking over our society bit by bit. Alcoholism, or AUD (Alcohol Use Disorder), is a chronic disease marked by an inability to stop or cut down on drinking despite adverse consequences. It involves physical dependence on alcohol, increased tolerance of its effects, and withdrawal symptoms when alcohol consumption is reduced or stopped. Long-term grave consequences of alcoholism are psychic, social, and physical health disturbances [1]. An electroencephalogram (EEG) records brain activity using electrodes placed on the scalp, capturing the electrical signals from neurons. It provides insights into brain function by measuring different brain waves—delta, theta, alpha, beta, and gamma—each linked to specific mental states like sleep or cognition [4]. Studies show alcohol use disorder (AUD) alters EEG signals, especially in the frontal and parietal regions, which are crucial for decision-making and attention.

2.6 M

According to the WHO, worldwide, 2.6 million deaths were due to alcohol consumption in 2020 [3].



Methodology

Raw EEG Signals → EEG Preprocessing (Butterworth-Bandpass Filtering) → Signal Visualization → Feature Extraction → ML Algorithms → Alcoholic or Non-alcoholic

8 subjects

64 electrodes

256Hz Sampling Rate

Each subject was exposed to either a single stimulus (S1) or to two stimuli (S1 and S2) which were pictures of objects chosen from the 1980 Snodgrass and Vanderwart picture set. When two stimuli were shown, they were presented in either a matched condition where S1 was identical to S2 or in a non-matched condition where S1 differed from S2.

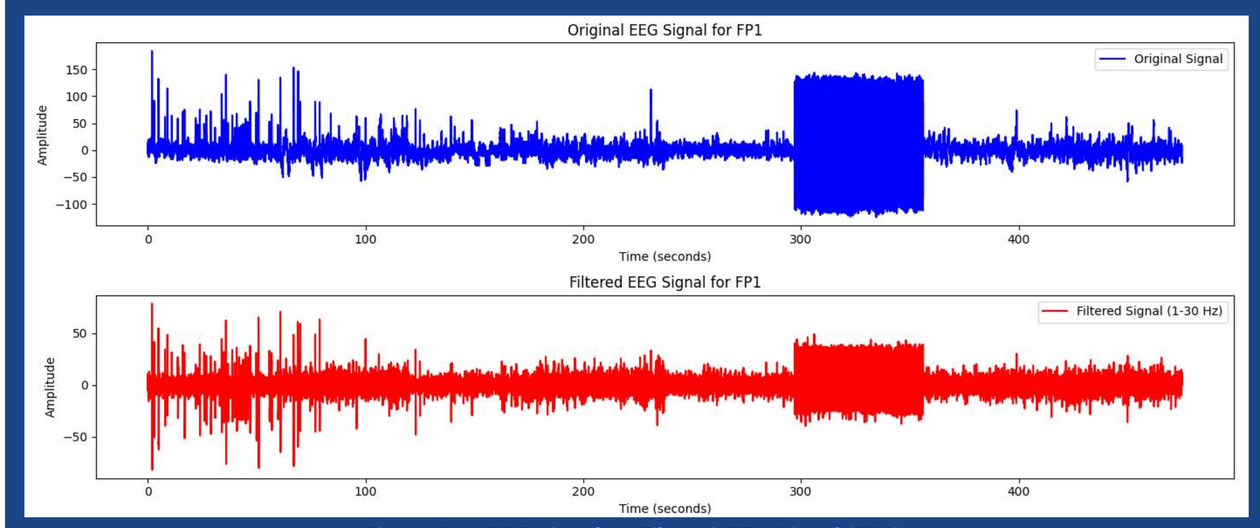


Fig. 1: Raw EEG signal vs Filtered EEG Signal (FP1)

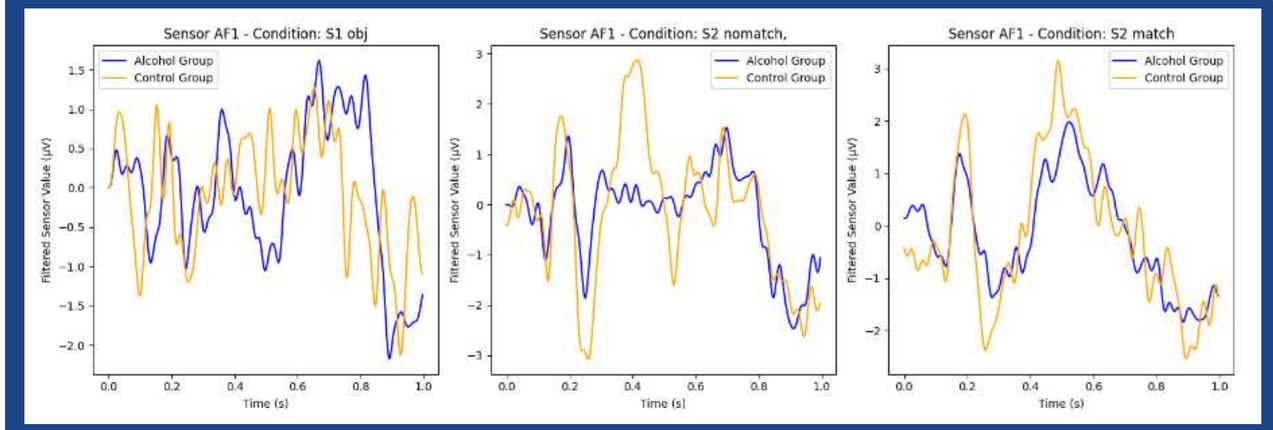


Fig. 2: Signal Comparison for alcoholic and non-alcoholic groups

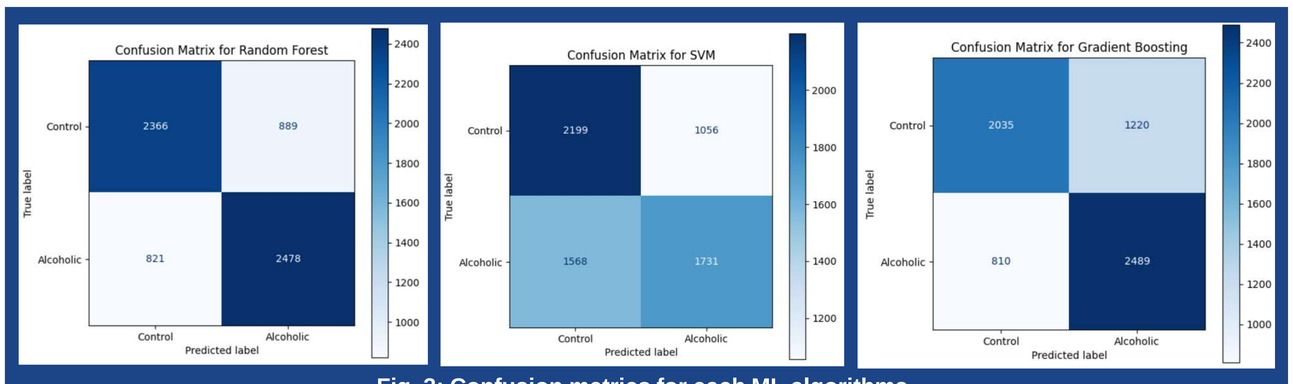
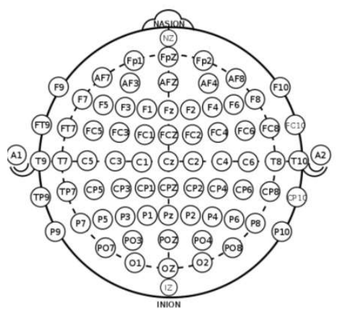


Fig. 3: Confusion metrics for each ML algorithms

Extracted Features

- Mean
- Variance
- Standard Deviation
- Maximum & Minimum
- Root Mean Square
- Skewness
- Kurtosis



The sensor positions provided in the dataset refers to the position of electrodes placed on subjects scalp, which is based on 10-20 international method. [2]

Table I. Frequency Range of EEG Bands

Bands	Frequencies (Hz)
Delta	0.5-3.5
Theta	3.5-7.5
Alpha	7.5-12
Beta	12-30

Results and Analysis

Three of the machine learning algorithms have been utilized with ensemble learning; those are Random Forest, Support Vector Machine and Gradient Boosting. 100 n_estimators and 42 as random state has been used for both Random Forest and Gradient Boosting. Likewise, SVM used linear kernel and random state of 42. The filtered data has been scaled within [0,1] by standard scaling for a better outcome.

Table II. Performance Metrics for ML Algorithms

Models	ALcoholic Group				Non-alcoholic Group			
	Acc.	Precision	Recall	F1-Score	Acc.	Precision	Recall	F1-score
Random Forest	0.78	0.78	0.80	0.79	0.78	0.79	0.77	0.78
SVM	0.60	0.62	0.54	0.58	0.60	0.59	0.67	0.62
Gradient Boosting	0.71	0.70	0.76	0.73	0.71	0.72	0.71	0.71

Conclusion

In this work, the detection of alcoholism from EEG signals with different machine learning models has been observed. Due to data scarcity and disappropiate signal processing or not taking the proper features of the signal, the classifiers have not done well in training and testing which is depicted in table 2. The future work can be exploring both time and frequency domain based features so that the performance of classification can achieve better results. Also diverse signal processing steps can play an important role in classification.

References

[1] American Psychiatric Association. (2013). Diagnostic and Statistical Manual of Mental Disorders (DSM- 5). American Psychiatric Publishing.
[2] “EEG-Alcohol,” Kaggle, Aug. 19, 2017. [Accessed: 20 October-2024]
[3] World Health Organization, Jun.28, 2024, ‘https://www.who.int/news-room/fact-sheets/detail/alcohol#:~:text=Alcohol%20has%20been%20widely%20used,and%200.6%20million%20among%20women.’
[4] D. L. Schomer and F. Lopes da Silva, “Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields”, 6th ed. Philadelphia, PA: Wolters Kluwer, 2012.