2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

ALAS: Advanced Learner Assistance System for engineering education using wearable sensors

G.J. Alvarez-Espinoza, M.O. Candela-Leal, R. Abrego-Ramos, G. Olivas-Martínez, J.M. Garcia-Briones, K.L. Rodríguez-Hernandez, D.M. Botín-Sanabria, A.J. Aguilar-Herrera, E.A. Delgado-Jimenez, R. A. Ramírez-Mendoza, M.A. Ramirez-Moreno, J.J. Lozoya-Santos

***Abstract*— The ALAS system is based on neuroengineering and machine learning tools, applied in educational settings. It records different physiological signals, such as electroencephalography, heart rate, temperature, and others, estimating mental fatigue and cognitive performance of students to identify the best learning strategies. All these features are collected using a Raspberry Pi, and then transferred to a web platform for visualization at real time.**

I. Introduction

Education is one of the services that has been most altered due to the COVID-19 pandemic [1]. For the new modalities, a quantitative assessment of the effectiveness of different teaching strategies does not exist. The aim of this project is to provide educators useful tool to monitor and obtain biofeedback of their students, by visualizing in real-time relevant information (mental fatigue and cognitive performance) using wearable sensors, machine learning, and web services.

II. Methods

To provide a complete and secure system, we use biometric wearables such as: OpenBCI Cyton, Empatica and Hexiwear. These tools collect the physiological information that the system need to generate the feedback of mental fatigue (Fig. 1). The open BCI collect the information from 8 electroencephalography (EEG) channels. The Empatica and Hexiwear wearables measures temperature and heart rate. All signals are collected simultaneously using a Raspberry Pi 4.

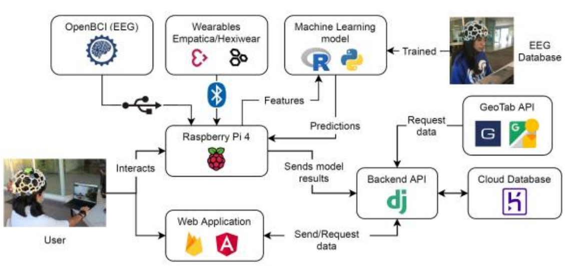

Figure 1. Flow diagram of the ALAS system.

A total of 30 students underwent the following experimental protocol: Subjects were asked to fill a Fatigue Assessment Scale (FAS) questionnaire and sit in a comfortable position. Total FAS score (1-50) was used to obtain the mental fatigue level: no (NF) <21, moderate (MF) between 21 and 35, and extreme fatigue (EF) >35. Physiological signals were filtered and normalized for each participant to obtain the Power Spectral Densities (PSD) of Delta (δ: 1-4 Hz), Theta (θ: 4-7 Hz) Alpha (α: 8-12 Hz), Beta (β: 13-30 Hz) and Gamma (γ: 30-50 Hz) respectively. Power ratios of EEG signals were also calculated, by dividing PSDs (prior to normalization) within the same channel. For example, the ratio of δ and γ in the P7 channel of the OpenBCI is represented in the eq 1.

$$\left(\frac{\delta}{\gamma}\right)_{P7} = \frac{\delta_{P7}}{\gamma_{P7}} \quad (1)$$

Feature selection process (FSR) was carried out computing the Gini importance of each feature which is the information gain of the different classes according to node splits. The purpose is to obtain the most correlated features to the mental fatigue. A Random Forest (RF) model using the 10 most correlated features was built following a 70:30 training/testing data splitting ratio to evaluate model accuracy.

* Research supported by the NOVUS program of Instituto Tecnológico y de Estudios Superiores de Monterrey through grant N19106.

III. Results

The FSR revealed 10 features among the most relevant. After evaluating best RF model obtained an accuracy of 92% at predicting correctly mental fatigue levels of students every minute (Fig. 2).

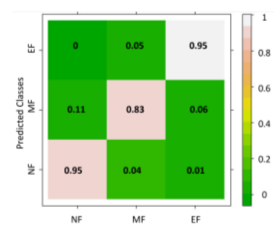

Figure 2. Confusion matrix of the machine learning model.

Currently, the ALAS system was implemented towards teaching of automotive electronics, and a driving simulation.

IV. Discussion & Conclusion

We can conclude that the ALAS system it is a powerful tool that can be used to improve teaching strategies' quality and allow course customization, by analyzing and providing real-time feedback on the mental fatigue of students.

References

[1] L. Mishra, *et al.*, "Online teaching-learning in higher education during lockdown period of COVID-19 pandemic," *Int. J. Educ. Res. Open*, vol. 1, no. June, p. 100012, 2020.