Emotiv EEG Classification System to Determine the Motor Speed of a Wheelchair

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Abstract: This paper describes the use of the 14-channel Emotiv as a low-cost method of acquiring raw EEG signals, for human-machine interfaces as a possible aid for persons with disabilities. To demonstrate the feasibility of using raw EEG signals obtained using the Emotiv system, a classification algorithm based on Fuzzy logic is implemented as an example. The proposed algorithm has been found to be effective in detecting and classifying brain signals which can then be translated into valid commands for the human-machine interface. The performance of the proposed approach is studied using fuzzy logic. The results obtained indicate a high level of classification accuracy, therefore, indicating that the Emotiv EPOC can be used as a valid tool for research.

1 INTRODUCTION

The research presented here is a continuation of research that has been carried out using a type of neurosky mindset sensor which is a Brain Computer Interface (BCI) (Siswoyo, Arief, & Sulistijono, 2015). The BCI refer to a type of system that combines electroencephalographic (EEG) activity measurement technology with computational development to convert brain activity into real applications. The EEG sensor type Emotiv 14-channel, which has a difference in the number of points on the electrodes, is used in this study. This study maps study data by application (BCI, signal processing, experimental research, and validation) and location of signal use.

The interest in BCI has mainly focused on medical applications (Mahajan & Bansal, 2017); (Saifuddin Saif, Ryhan Hossain, Ahmed, & Chowdhury, 2019); (Cincotti et al., 2008). However, due to the increasing desire of scientists and engineers to develop new technologies, it is now also possible to find BCI in applications such as video games, vehicle manipulation, and psychological research. Related work explaining how BCI can be used to control drones to help people with disabilities can be found in (Marin, Al-Battbootti, & Goga, 2020); (Abiyev, Akkaya, Aytac, Günsel, & Çağman, 2016). A review paper (Alotaiby, El-Samie, Alshebeili, & Ahmad, 2015), discussed some EEG channel selection techniques for different applications taking into consideration the different criteria developed in the literature for channel selection evaluation. Of course, there are many possibilities for BCI-EEG applications (Banach, Małecki, Rosół, & Broniec, 2021); (Megalingam, Thulasi, & Krishna, 2013).

The classification of EEG signals is of significant importance in BCI systems. Aiming to achieve intelligent classification of EEG, a classification methodology using sparse representation and fast compression residual convolutional neural networks is proposed (Huang, Li, Chen, Lin, & Yao, 2020). This study propose an EEG classification system of rule-based Emotiv Epoc signal output to identify signals for moving wheelchair speeds. Therefore, we believe that applying the Emotiv Epoc signal classification to wheelchair speed movements, has better results than the signals obtained from the neurosky mindset.

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2 MATERIALS AND METHODS

2.1 EEG Data Recording

The raw EEG data were obtained from the 14-channel electrode EEG data record of Emotiv Epoc (Figure 1). The EEG is recorded when the test user thinks about certain mental commands by imagining the movement of objects. The test subject must be focused, relaxed, and not have many distracting movements when performing mental commands. The experiment uses the "Mental Command Suite" to help test subjects perform mental commands that allow test subjects to control the movement of a 3-dimensional cube using their minds. The 3D cube can move up, down, left and right according to the mind of the test subject.

Figure 1: Emotiv Epoc 14 channel.

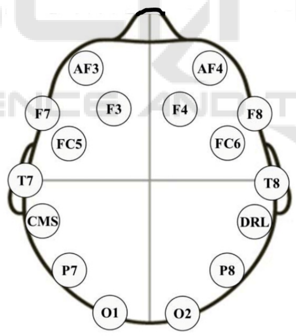

Figure 2: Location of 14 Emotiv electrode channels.

2.2 Test Procedure and Environment

The use of the sensor is first given a saline solution on the foam which is located at each electrode (Figure 2). Then do a check using the built-in software for the connectivity of the electrodes with the location on the scalp. When ready, a red colour will appear on the indicator in the default software application.

2.3 EEG Data Analyses

All Emotiv 14 channel EEG data files were processed and analyzed with MATLAB software (The Mathworks, Inc.).

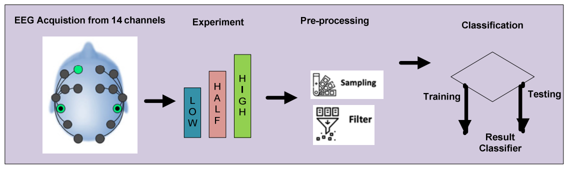

Figure 3: Experiment and data analysis.

EEG data preprocessing gets input from reading the EEG signal which then forwards it to data classification as shown in Figure 3 (Alabboudi, Majed, Hassan, & Nassif, 2020). The processed raw EEG data files are first labelled for each trial as number "1" representing "slow wheelchair speed trial" then number "2" representing "moderate wheelchair speed trial" and number "3" represents "a fast wheelchair speed trial"

The experimental results of this study continue processing on the filtered data. EEG signal has weak time-frequency-spatial characteristics, non-stationary, non-linear, and weak intensity, so to extract adaptive features reflecting frequency and spatial characteristics, it is very important to adopt feature extraction method. For this study, we converted the time domain EEG data into the frequency domain of the segments converted into their respective frequency domains.

3 CLASSIFICATION MODELS

3.1 Classification Models and Metrics

When trying to collect signal data from Emotiv, data will be displayed on the Emotiv default application. There are 14 brain signal outputs, namely signals, AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4.

Figure 4: Run setup during data acquisition.

The subjects were asked to sit and comfortable armchair with their upper limbs placed on the armrests of the armchair (Figure 4). The EEG signal Emotiv Epoc device was placed in each subject, some of the technical descriptions include a sampling frequency of 128 Hz, this device has 14 electrodes and two ground references, and then data distributed to the computer as shown in the Figure 5.

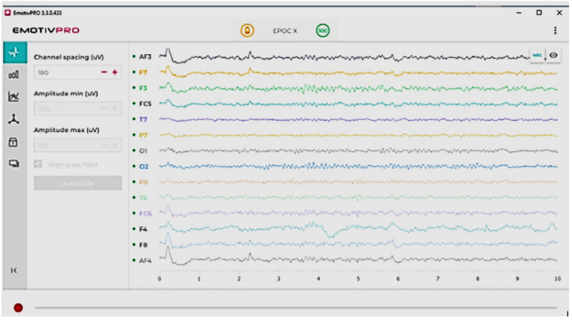

Figure 5: Emotiv Epoc output.

Figure 6: Signal F8, Frontal.

From the experimental results users, observing the output of 14 signals, the F8 signal gives a significant response when wheelchair users think to increase speed (Figure 6).

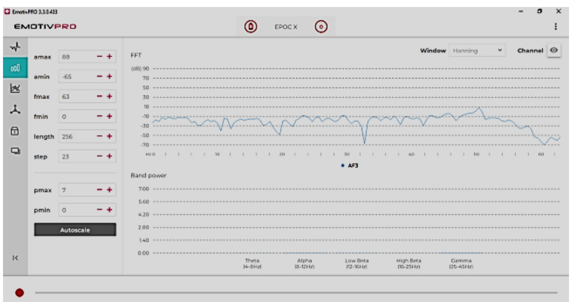

Figure 7: Signal AF3, Frontal.

Then the AF3 signal sometimes appears to have a significant spike in response at certain times of the user (Figure 7).

The data totalling 14 channels is sent to MATLAB, and then the data will be processed to MATLAB (Figure 8).

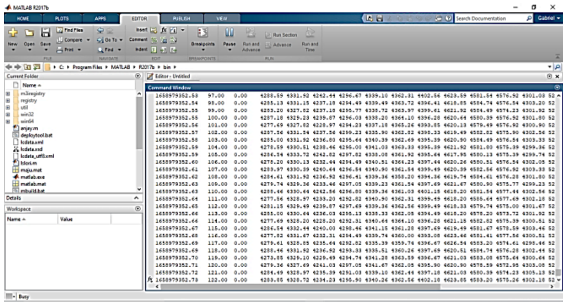

Figure 8: Data output Emotiv in Matlab.

Classification of brain signals using fuzzy logic (Siswoyo, Arief, & Sulistijono, 2017). From the results of the Emotiv signal reading data, then the signal data will be fuzzy. The research methodology uses Fuzzy Logic Controller in this study Fuzzy used the mamdani method, the input will be processed to get the F8 value from the user, and this value is used as a reference.

A complete fuzzy system consists of three main components, namely:

1) Fuzzification

Fuzzification is a process of mapping input values (crisp input) from a controlled system (non-fuzzy quantities) into fuzzy sets according to their membership functions from the emotive sensor itself. To change the crisp input to fuzzy input, you must first determine the membership function for each crisp input, then the fuzzification process will take the crisp input and compare it with the existing membership function to generate fuzzy input values.

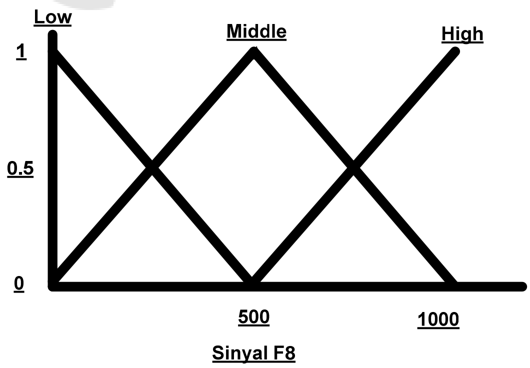

Figure 9: Membership fuzzy input Signal F8.

The F8 signal size indicates the level of focus. The value ranges from 0 to 1000 (Figure 9). The level of mind focus increases when the user focuses his/her mind.

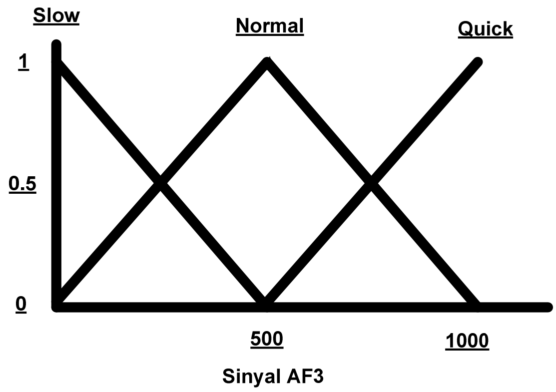

Figure 10: Membership fuzzy input Signal AF3.

The size of the AF3 signal indicates the level of focus. The values range from 0 to 1000 (Figure 10). The level of focus increases when the user focuses his/her mind. Figure 11 shows a variable output with a range from 0 to 255.

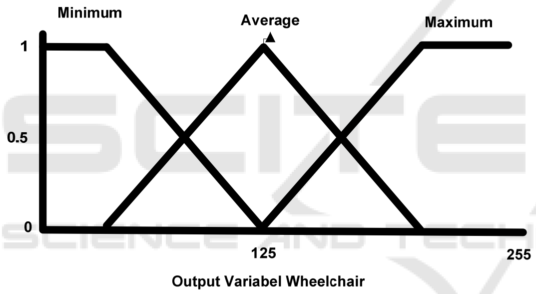

Figure 11: Membership fuzzy wheelchair.

2) Design Rule Base

Here is the design rule of fuzzy logic that we can use as shown in Table 1.

Table 1: Design rule of fuzzy logic.

Rules				
	F8 Signal			
AF3 Signal		Low	Middle	High
	Slow	Minimum	Average	Maximum
	Normal	Average	Average	Average
	Quick	Minimum	Average	Average

3) Defuzzification

From Table 1 we can get the defuzzification as:

a) If (F8 is LOW) and (AF3 is SLOW) then (SpeedMotor is MINIMUM)
b) If (F8 is LOW) and (AF3 is NORMAL) then (SpeedMotor is AVERAGE)
c) If (F8 is LOW) and (AF3 is QUICK) then (SpeedMotor is MINIMUM)
d) If (F8 is MIDDLE) and (AF3 is SLOW) then (SpeedMotor is AVERAGE)
e) If (F8 is MIDDLE) and (AF3 is NORMAL) then (SpeedMotor is AVERAGE)
f) If (F8 is MIDDLE) and (AF3 is QUICK) then (SpeedMotor is AVERAGE)
g) If (F8 is HIGH) and (AF3 is SLOW) then (SpeedMotor is MAXIMUM)
h) If (F8 is HIGH) and (AF3 is NORMAL) then (SpeedMotor is AVERAGE)
i) If (F8 is HIGH) and (AF3 is QUICK) then (SpeedMotor is AVERAGE)

Nine rules were created for the system controller to make up the rule base. The use of this fuzzy logic method will follow a trial and error model.

4 CONCLUSIONS

Table 2 summarizes the selection criteria for the type of EEG sensor for comparative analysis. Selection criteria including the accuracy, sampling rate, ease of use, number of channel, software application used, communication method, learnability, and performances.

Table 2: EEG Sensor type comparison.

No	Compare	Neurosky Mindset	Emotiv Epoc
1	Accuracy	Moderate	High
2	Sampling rate	512Hz	128 Hz
3	Ease of use	Easy	Easy
4	Signal input channel	4	14
5	Software application	Open	Licence
6	Communication	Bluetooth	Wireless
7	Learnability	Moderate	Easy
8	Performance	Moderate	High

New users of Emotiv Epoc can gain control over a single action fairly quickly. Learning to control multiple actions usually takes practice and becomes increasingly difficult as additional actions are added. The user learns to train a reproducible mental state for each action; detection becomes more and more precise. Most users usually achieve their best results after practicing each action several times. Practice and experience will help determine the ideal amount of training required for each individual user to successfully control wheelchair speed.

In this research, a two input from signal Emotiv Epoc sensor, one output MFIS in fuzzy tool box of Matlab software was used for control speed wheelchair. Grading results obtained from fuzzy logic showed a good general agreement (91%) with the results from the human experts, providing good flexibility in reflecting the expert expectations and grading standards into the results. This model demonstrated that, control speed evaluation based on this method is more exact than experts, and provides a better representation control speed grading.

Another topic for future work is the effectiveness of EEG signals used for the needs of people with disabilities. Different users allow different responses to the same stimulus. Ease of extracting task-relevant EEG patterns from recordings signal.

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