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ORIGINAL ARTICLE

A Study of Engineering Student IQ and EQ Based on Analyzing of Electroencephalogram (EEG) Signals

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ABSTRACT – The influence of individual's Intelligent Quotient (IQ) and Emotional Quotient (EQ) on the development of innovative thinking is significant. An IQ alone is not adequate to measure the success of a person. EQ also affects individual's performance which shows that both IQ and EQ are vital in determining individual's character and thinking skills. Hence, the main objective of this study is to measure IQ and EQ level of engineering student by analyzing their brain signals through several exercises. A single channel Electroencephalogram (EEG) instrument is used to record the EEG signals from 6 different subjects with three different conditions: do nothing, perform IQ and EQ test. The results of the study conclude that the IQ level of an individual is affected by the Beta band of the EEG signals. Meanwhile, Alpha band of the EEG signals is more dominant in the determination of EQ level of an individual. When Alpha band is higher than Beta band, it indicates that the subject is EQ dominant person. If Beta band is higher than Alpha band, then IQ is the dominant quotient for the subject. The highest k-NN classification accuracy is obtained at 80:20 classification with 81.84% accuracy using Mean features and 79.53% accuracy using Standard Deviaton features. The Graphical User Interface (GUI) is constructed in MATLAB to show the analysis and classification processes of EEG signals. Meanwhile, IQ and EQ analyzer is constructed to indicate IQ and EQ level after the classification of the selected EEG features.

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INTRODUCTION

Engineering course is among the most relevant courses. To be a good engineer, ones need to be creative, innovative in solving a problem or creating a solution. Both IQ and EQ of an individual is important to ensure that engineering student nowadays are ready for the industry. Commonly, the Intelligent Quotient (IQ) is divided into two components: fluid and crystallized intelligence. On the other hand, crystallized intelligence depends on experience and knowledge, and it could be defined as the ability to use these factors. Generally, Vocabulary and Verbal tests are used as a measure of this aspect of intelligence [1]. IQ is seen to be a key factor for analyzing someone's potential and their actions to accomplish the particular job [2]. Intelligent Quotient or IQ offers precise details about an individual's ability to assess and solve problems, which is incredibly helpful. IQ is characterized by the ability to adapt to environment, rational thinking, comprehend intricate concepts and acquire knowledge proficiently [3]. Intelligence is essentially linked to attention due to the significance of stimulus selection in a system with constrained capacity to process the information simultaneously [4]. Emotional quotient, commonly referred to as emotional intelligence is the ability of an individual to acknowledge and deal with their own feelings as well as their social environment [5-7].

Electroencephalogram (EEG) is a test that observe and measure countless electrical activity of a brain. Assorted of the electrical activity corresponds to different state of brain. Any physical action or thought that made by a person is a type of brain activity that will create an electrical signal. The produced signals are then can be recorded using the EEG and study to obtain and conclude data. The frontal, temporal, parietal, and occipital lobes, which are identified by prominent grooves, are the four lobes that make up the cortex. Each lobe contains specialized ridges called gyri that perform particular cognitive tasks[6]. Figure 1 shows the dominant characteristic of both IQ and EQ of an individual [1].

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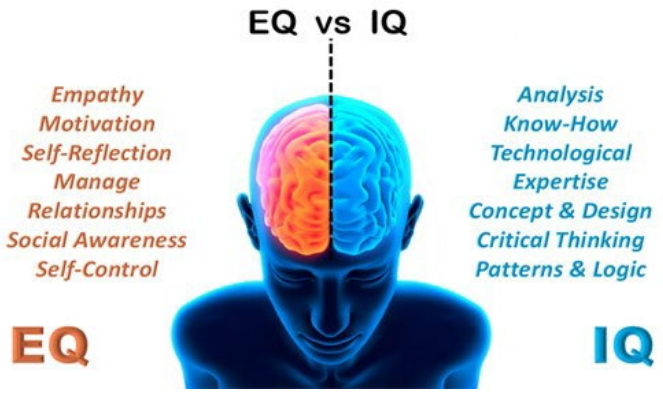

Figure 1. Differences of IQ vs EQ [1]

METHODOLOGY

Subject Selection

Since the aim of the project is to analyse the IQ and EQ of an engineering student, the subject selection is among the undergraduate engineering students of Universiti Malaysia Pahang Al-Sultan Abdullah with range of age between 23 to 26 years old. The subjects are selected from both genders to add variety to the data with three females and three males to ensure that the data comparison is balance.

Measurement Protocol

To ensure the data recorded is valid, a proper procedure need to be followed when recording the EEG signals of each subject. In this study, 6 healthy and normal subjects (3 Males and 3 Females) with range of age from 23 to 26 were chosen to involve where the EEG data of their brain were recorded according to the experiment measurement protocol. All the data recorded from 6 subjects were analyzed. All subjects were asked to relax and be calm before the EEG headset is set up and attached to their head [7-12].

The experiment duration for the EEG signals captured was 3 minutes maximum. 3 different activities were done to capture the trend of neural activity for each subject, in relax state, while answering IQ test and while answering EQ test. The EEG signals were captured using an EEG headset, Unicorn Hybrid Black. A total of 8 electrode placements for the device were located at Frontal (Fz), Central (C3, Cz, C4), Parietal (Pz, P07, P08) and Occipital (Oz) as shown in Figure 2. The sampling frequency for the device is set at 250Hz [13-14]. The captured EEG data are the raw EEG signals in time domain. The EEG data captured was then analysed via off-line. The data then will go through the signal processing step in MATLAB Simulation software to analyse the Theta, Alpha and Beta band power of the subject's brain.

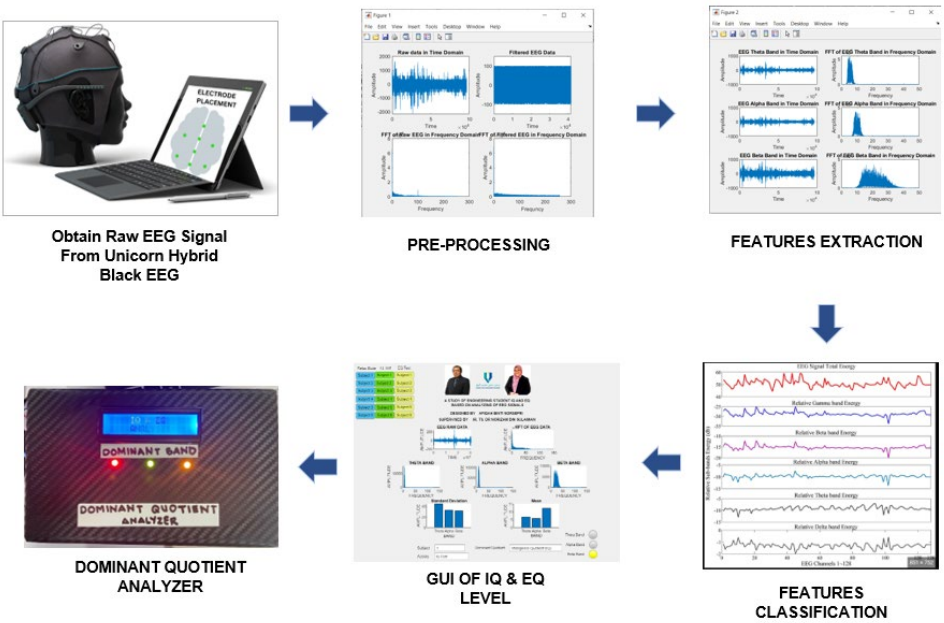

Figure 2. Block Diagram.

Experimental Flowchart

Figure 3 shows the overall flow of the study from the data acquisition up to hardware development. Based on the flowchart in Fig.3 below, the project started with preparation of an IQ and EQ question for the experiments. The data of experiment is recorded with three different situations for each subject. The situations or activities are while not doing anything, 17 during an IQ test and during EQ test. To determine the exact results from all phases, the experiment is run three times for each of the subjects. e. The EEG signal is converted in MATLAB software from its current form in the time domain to its ultimate form in the frequency domain during this phase. Those EEG signals is filtered into range of frequency, -100µV to 100µV [10]. a. The data then will go through a pre-processing step to spectral analysis in the MATLAB. The Mean and Standard Deviation value of the EEG signals for each subject is generated and classified.

The classification is done with KNN classification method which once the classification accuracy reaches the target, > 80%, it will link to the constructed GUI in the MATLAB. Hardware development is completely done once the GUI is fully constructed and run in the App Designer of MATLAB. The system is then tested to make sure it runs smoothly and produces the desired outcomes.

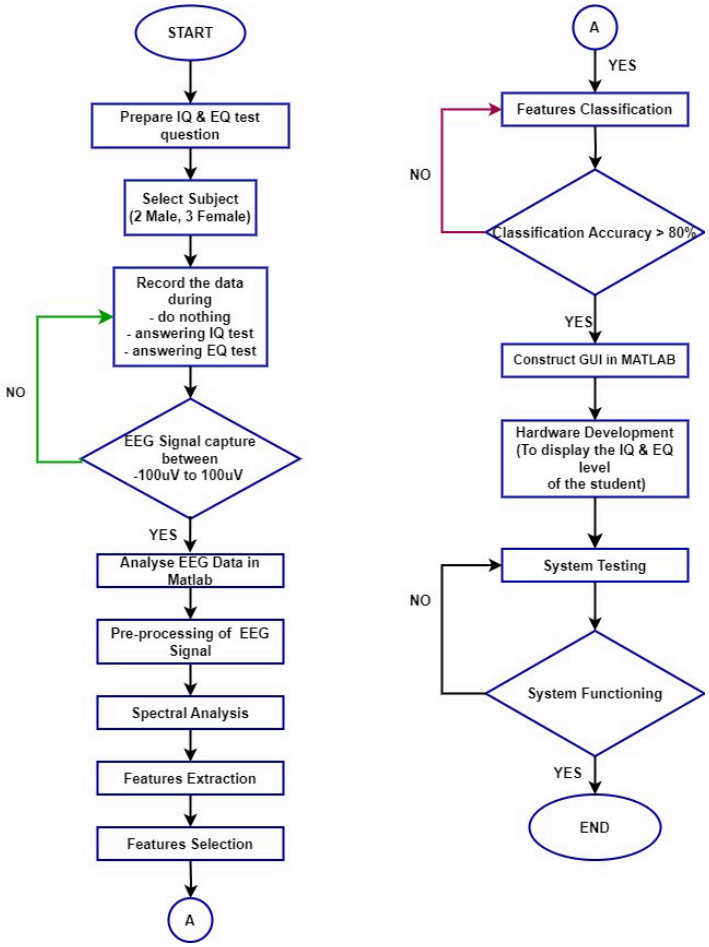

Figure 3. Flowchart of the study.

Features Extraction

Mean and Standard deviation parameters is applied in this study to analyse the dominant quotient of each subject based on the EEG signals produced. Mean is determined as a measure of location. The standard deviation, which is the square root of the variance, offers a measure of the dispersion of the values around the mean [15].

Measuring the dominant quotient of an engineering student requires the Mean and Standard Deviation to the spectrum density of EEG bands, Theta, Alpha and Beta. This is applied to identify and analyse the best features that represent the data that is measured to study the correlation of IQ and EQ with EEG signals. MATLAB is used for the features extraction step from converting time domain to frequency domain, power spectrum density to applying features extracted.

Features Classification

The core idea behind the nearest neighbour algorithm is to identify the k points in a multidimensional space that are closest to the unknown sample. The k points shown here are the unknown samples' k nearest neighbours. It is defined that the nearest neighbour of an instance are determined based on the standard Euclidean distance [16]. The KNN

classification algorithm begins a dynamic learning process when a test data prediction is made. Setting a suitable number for k and looking for the nearest neighbours across the whole training sample space are both required [17-18].

$$d(x_i, x_j) = \sqrt{\sum_{r=1}^{n}(ar(x_i) - ar(x_j))2} \quad (1)$$

The k-value set up for this study is between 1 to 10. The ratios of evaluation for the training and testing data are 50:50, 70:30 and 80:20 respectively. The classifier default settings, as well as the k value and training to testing ratio, are changed to find the best choice that can produce a high accuracy rate.

EXPERIMENTAL RESULTS

EEG Signal Processing

Figure 4 below shows the raw data of EEG produced by the brain activity of the subjects. This EEG signals are captured using Unicorn Hybrid Black EEG Headset. Range of amplitude set up in the system is ±50 Hz. The raw EEG signals are expressed and measured in terms of voltage.

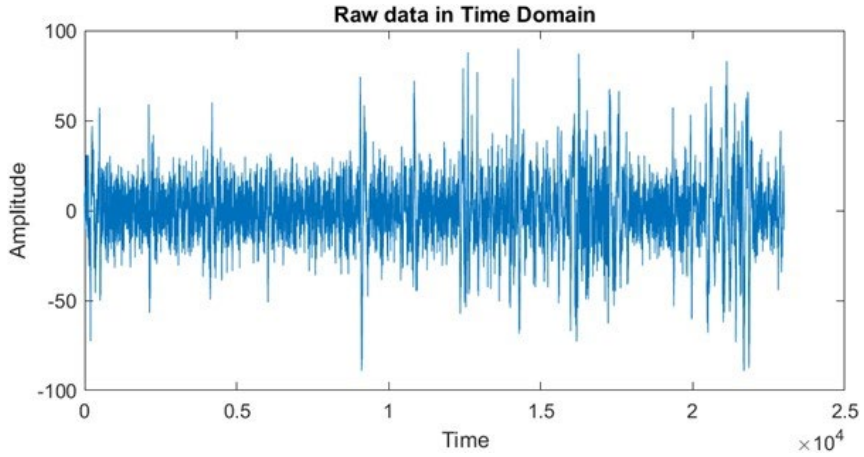

Figure 4. Raw EEG Data.

Once raw EEG data is imported to the MATLAB, a preprocessing step of filtering the unwanted noise and artifacts is done to remove any unwanted signals. Low pass filtering is applied to reduce the noises recorded during the experiment.

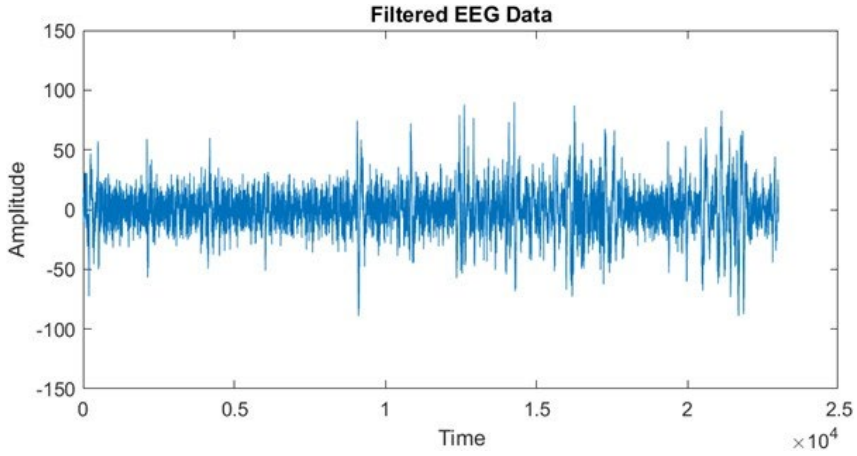

Figure 5. Filtered EEG Data.

Once the filtering step is done, the signal is then converted from time domain into frequency domain to measure the signal's frequency component and analyses its underlying frequency characteristics. Once the signals are converted, Fast Fourier Transform technique (FFT) is applied to gain the power spectrum density of the EEG signals as shown in Figure 6 below.

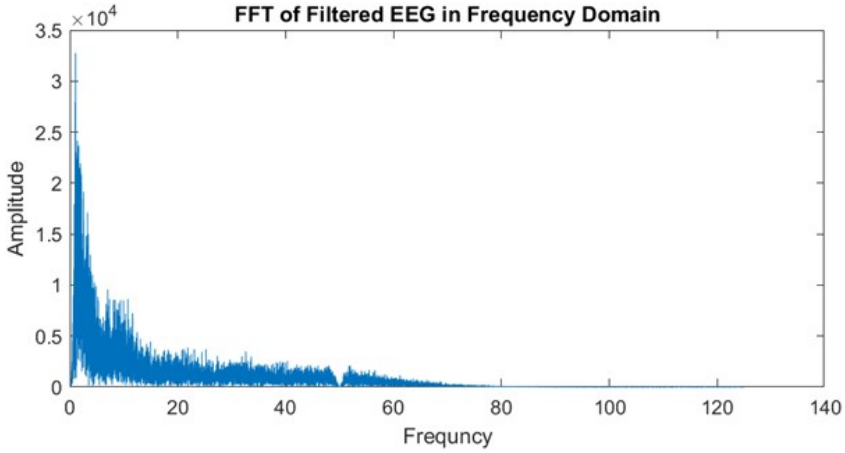

Figure 6. Power Spectrum Density of EEG.

The PSD data frequency covers half of the sampling frequency set which is 125 Hz of 250 Hz from the Unicorn Hybrid Black device. The frequency is divided into 2 based on the Nyquist theorem to prevent aliasing from occurring. Figures below shows the spectrum density that have been divided into bands of EEG. 3 bands of EEG measured in this study, Theta, Alpha, and Beta band. The power spectrum density of Theta band is shown in the Figure 7 as follows.

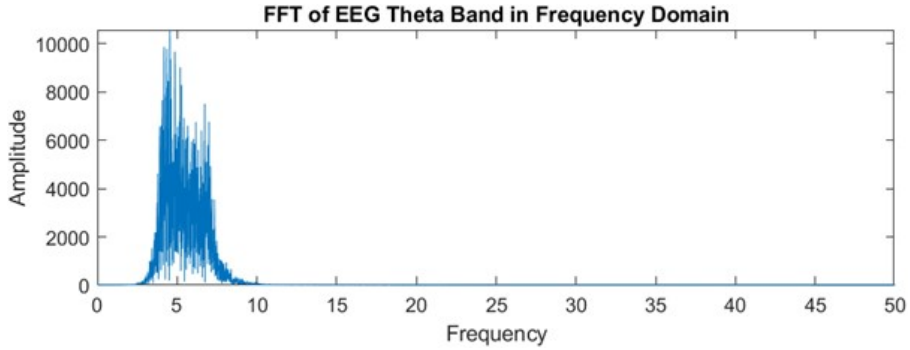

Figure 7. Theta band in Power Spectrum Density.

The power spectrum of Alpha band of the EEG Signals is shown in the Figure 8 below. Range of frequency for the Alpha band is from 8 to 12 Hz.

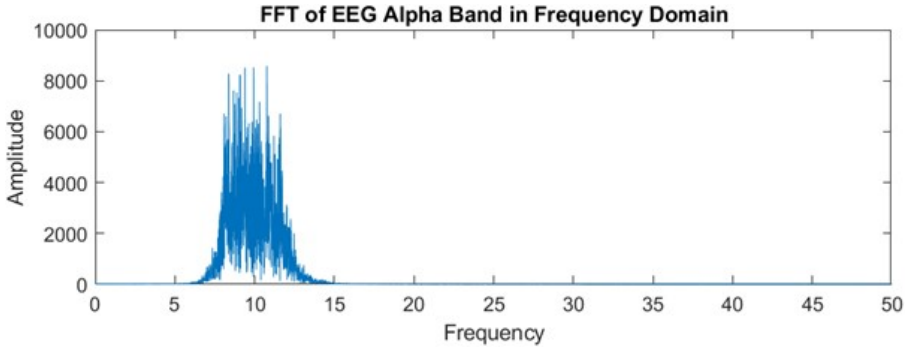

Figure 8. Alpha band of the Power Spectrum Density.

Figure 9 shows the frequency signal of Beta band of power spectrum density. The frequency range is from 13 Hz up to 30 Hz. Meanwhile, the amplitude of EEG Beta band is lower than EEG Alpha band.

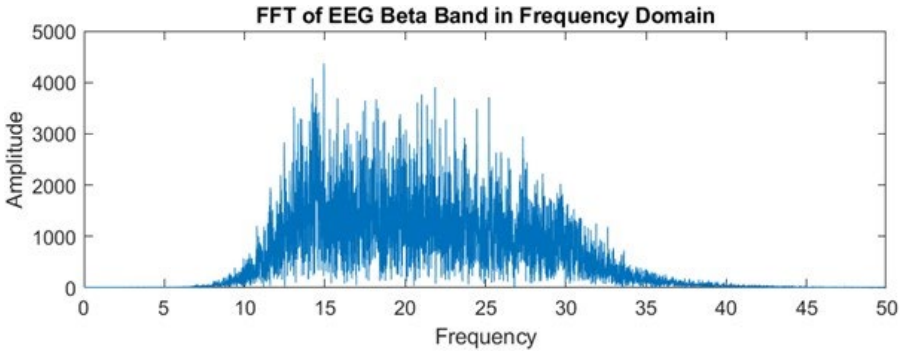

Figure 9. Power Spectrum of EEG Beta band.

EEG Features of Mean and Standard Daviation

The extracted features of the EEG signals are Mean and Standard Deviation of the EEG Beta, Alpha and Theta bands. These features are analyzed to the level of the IQ and EQ. The histogram graph of Mean and Standard Deviation of EEG is illustrated by Figure 10. These features are applied to observe and identify the dominant quotient based on EEG signals.

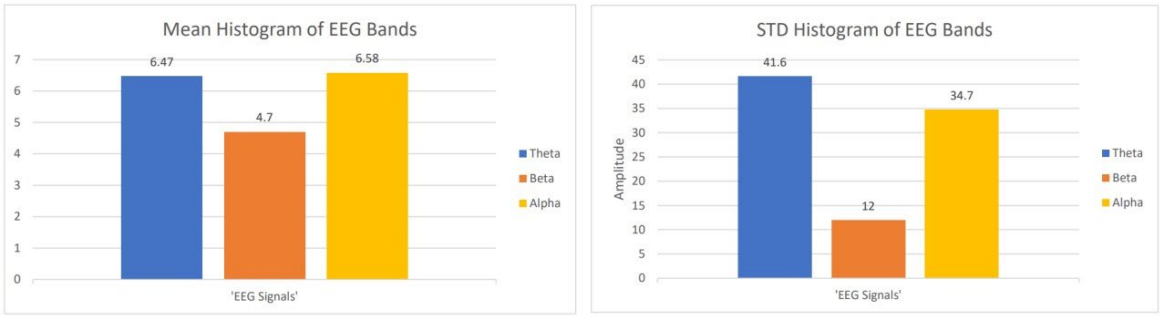

Figure 10. Histogram Graph of EEG Extracted Features (Mean & Standard Deviation of EEG Beta, Alpha and Theta Band).

K-NN Classification

Table 1 below shows the accuracy result from the prediction of KNN based on the training and testing data set of Mean and Standard Deviation. The percentage of correct prediction are 57.34% for ratio 50:50, 73.48% for ratio 70:30 and 81.84% of ratio 80:20 accordingly. Equation (2) indicates the formula of calculating the mean value for the data with $\bar{X}$ is the mean value, X is the value of data with N is the total amount of data. Equation (3) shows the formula to find the standard deviation of the data. The μ denotes the average of the data while N is the total amount of time that the EEG data is collected.

$$\bar{X} = \frac{\sum X}{N} \tag{2}$$

$$SD = \sqrt{\frac{\sum |x-\mu|^2}{N}} \tag{3}$$

Table 1. Accuracy of Features based on KNN Classification.

Ratio	Mean (%)	Standard Deviation (%)
50:50	57.34	49.76
70:30	73.48	69.51
80:20	81.84	79.53

The selected EEG features in term of Mean and Standard Deviation of EEG Alpha and Beta band is classified by k-NN classifier in order to determine the k-NN classification accuracy with various training to testing ratios. The highest k-NN classification accuracy is obtained at 80:20 classification with 81.84% accuracy using Mean features and 79.53% accuracy using Standard Deviaton features.

MATLAB GRAPHICAL USER INTERFACE

The Graphical User Interface of the project is developed and shown in Figure 11 below. The front panel displays the raw, filtered and power spectrum density of the measured EEG signal. This GUI is built to display the analysis result produced from the study. The frequency signals of each band are also displayed in the GUI. The Histogram graph of Mean and Standard Deviation are also displayed in the GUI for a better understanding of the study. LED and Labels are also concluded in the GUI for a better visualization of the result. Different LED's color for different dominant band.

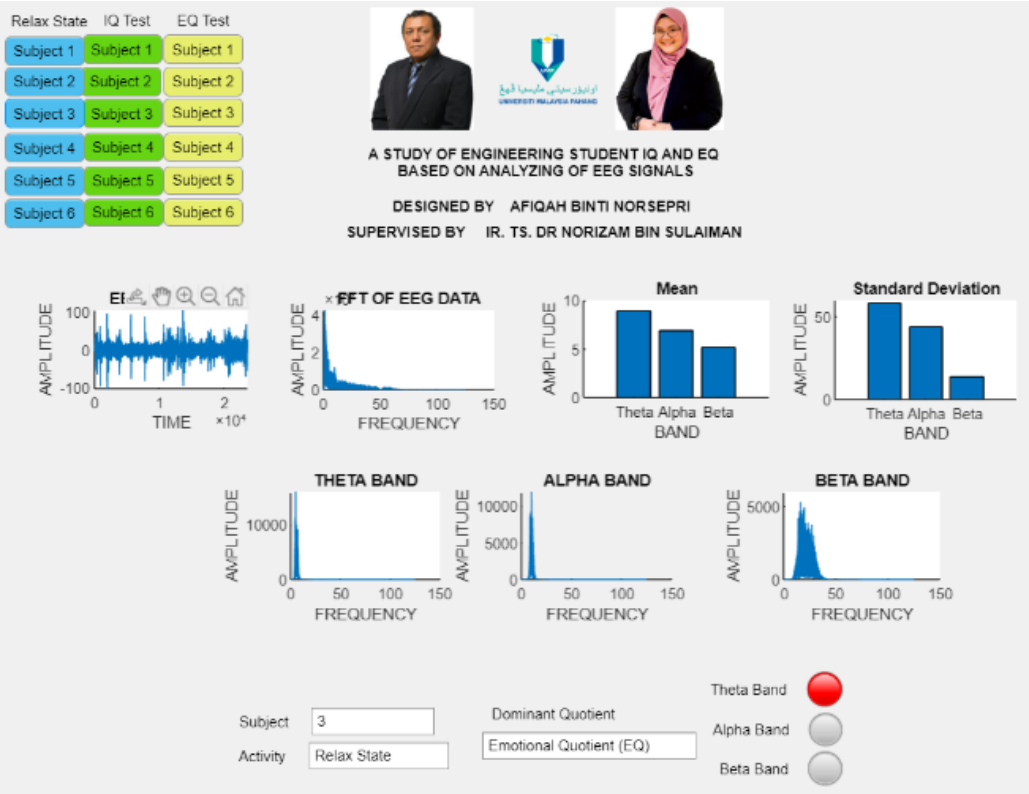

Figure 11. Graphical User Interface (GUI).

HARDWARE DEVELOPMENT

Figure 12 shows the schematic diagram constructed before proceeding to the hardware construction of the circuit. All component listed are attached and shown in the diagram. Three resistors with 220 Ohm values are used for each LEDs. Arduino Uno act as the microcontroller of the system with LED and LCD display as the output. The LEDs are connected to digital pin 5,6,7 for each pin accordingly. LCD's SDA and SCL pin are connected to analogue pin 4 and 5. By constructing a schematic diagram of the circuit, it helps to understand and observe the overall connection for each component.

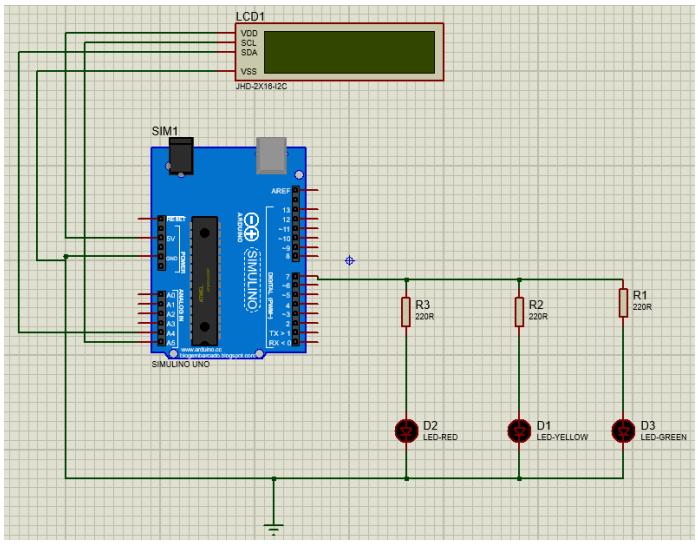

Figure 12. Schematic Diagram.

The Quotient Analyser, a piece of hardware constructed to visualize the output data that have been analysed is shown in Figure 13. There are 3 different LEDs that represent each frequecy band of EEG signals which are Theta, Alpha, and Beta band. Red LED to indicate that the Theta band is the highest during the activity which indicate the subject is in the light sleep mode. Meanwhile, Green LED for Alpha band indicate that subject is in EQ mode. The IQ mode is indicated by the Yellow LED where the Beta band is more dominant that the other EEG frequency bands. The functionlaity of the device is tested and run correcty.

Figure 13. Quotient Analyser.

ANALYSIS OF DATA

Analysis of EEG Signal by Activity

The analysis of the result of studying the IQ and EQ of engineering student based on analyzing EEG signals is shown in Figure 14. The Alpha value is the highest for both activities, during Relax state and While Answering EQ test. This shows that most of the subjects are dominant in EQ during the activities. Beta band is the highest for While Answering IQ test shows that subjects are dominantly in IQ during the activity. The analysis of the result of studying the IQ and EQ of engineering student based on analyzing EEG signals for Standard Deviation features is shown in Figure 15. The Alpha value is the highest for both activities, during Relax state and While Answering EQ test. This shows that most of the subjects are dominant in EQ during the activities. Alpha band is the highest for the While Answering EQ test shows that subjects are dominantly in EQ during the activity.

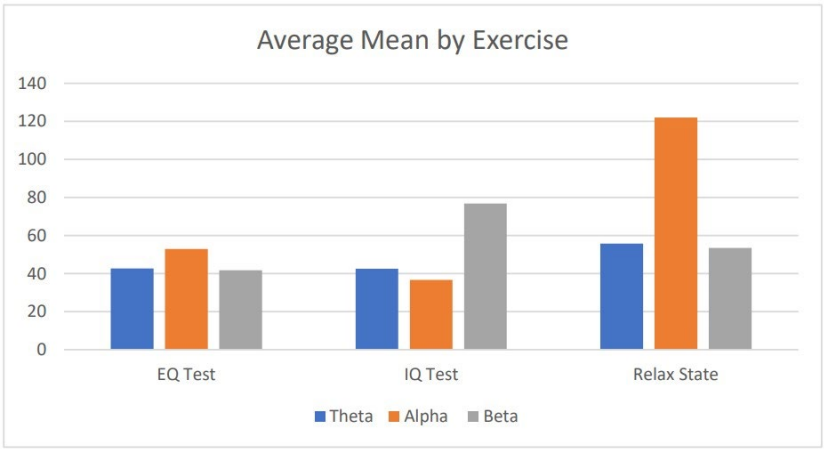

Figure 14. Average Mean of EEG Frequency Bands.

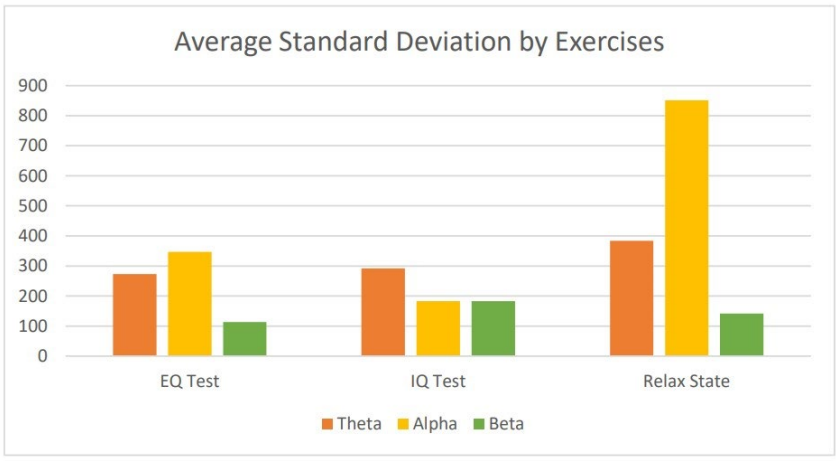

Figure 15. Standard Deviation of EEG Frequency Bands.

CONCLUSION

As for the conclusion, both IQ and EQ levels are interrelated that it is important and necessary to study the quotient of both to identify which parts are more triggering for engineering students' thinking ability. It can be said that the objective of the study, are achieved. A successful accomplishment of the Quotient analyser indicator system is done to point the dominant quotient of a student based on EEG signals. Result of the KNN classification done shows that Mean features have high accuracy of the prediction data based on the training and testing data compared to Standard Deviation. The ratio calculated for the accuracy of prediction are 50:50, 70:30 and 80:20 of training and testing data. It

is shown that the highest accuracy falls in range of ratio 80:20 of testing and training data. The value of Mean for each band then is retrieved to analyse the dominant quotient for each activity. Finding shows that Beta band is the dominant band corresponding to the IQ test. Alpha band is correlated with EQ test. Although certain data points differ from the expected EEG signal pattern, there is still room for improvement by collecting more data to increase its accuracy. In addition to that, the MATLAB GUI and Quotient Analyser device has been successfully created to indicate the dominant quotient based on IQ and EQ of each subject. As an overall conclusion, the relationship between cognitive skills, emotional intelligence, and brain activity is explained thoroughly in the first place

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