BRAIN ACTIVITIES FOR MOTOR MOVEMENT

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ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITI TEKNOLOGI PETRONAS

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Brain Activities for Motor Movement

By

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The requirements for the

Bachelor of Engineering (Hons)

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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Approved by,

(Dr. Nasreen Badruddin)

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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WAFAA ELSAYED ELBASTY

ABSTRACT

Brain Computer Interface (BCI) is hardware and software system which allows interaction between the human's brain and some surrounding activities without depending on their muscles or peripheral nerves. The main objectives of this project are to design a brain computer interface algorithm that takes Electroencephalography(EEG) signals as its input, translates them into commands for movement control and to test the performance of the designed algorithm on human subjects.

The research covers the procedure of designing the BCI algorithm and this consists of three stages firstly recording EEG brain signals, secondly EEG signals pre-processing, Last stage is EEG signals classification.

The EEG signals classification is divided into 2 parts which includes feature extraction and feature classification. Multivariate adaptive auto regressive (MVAAR) method is used in the feature extraction part because it is suitable for motor imaginary. Feature vectors are used to differentiate the different brain activity signals associated with the user's attention, Linear Discriminate Linear (LDA) method is used in feature classification step to achieve these goals.

The Feature extraction method MVAAR couldn't extract the actual feature for the four movements so we couldn't classify between them.

ACKNOWLEDGEMENTS

Praise be to Allah, The Most Gracious and The Most Merciful for His endless blessings throughout my life and the success He granted me during this Final Year Project. My deepest heart gratitude is to my fiancé and my parents who strived to get me where I m now and for their endless support and encouragement during this final year. My utmost appreciation and gratitude towards my supervisor Dr. Nasreen Badruddin , for the dedication of his time and effort, teaching, guiding and helping me in all my work-related tasks despite his many other obligations. My gratitude is extended to the master students for giving advice whenever it was needed. Last but not least, I thank my friends and everyone else who supported me throughout this project.

TABLE OF CONTENT

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

1.1 Background of study

Paralyzed people with motor disabilities can't perform their activities such as moving their hand or even their wheel chair. The current communication technologies methods require some muscle control such as voice, hand movement and writing. This is not really helpful for people who are totally paralyzed.

Nowadays, many researches are conducted on using the brain waves for communication and without requiring motor ability and muscle control.

Brain computer interface (BCI) is a new technology that allows communicate between the brain signals and computer and uses The Electroencephalography (EEG) channels to communicate and control some activates such as "mental tasks" without direct connection. In other word, it's not dependent on peripheral nerves and muscles. BCI helps those with motor disabilities to perform some daily life activities and gives them the chance to adapt with their environment.

EEG's function is to record the electrical brain activity from the scalp, by measuring the voltage fluctuations resulting from ionic current flows within the neurons of the brain.

BCI uses EEG to record the signals of the brain activities to perform control such as moving the cursor in a computer screen or to choose icon or letter. To do thus, BCI converts the EEG input signals from the user into output to control the devices by using translation algorithm.

Currently BCI researches are conducted with medical and environment applications, where the medical application covers mental operation such as "robot, wheel chair"

and human subject monitoring such as sleep disorder, neurological diseases, attention monitoring, neuroscience researches and man machine interaction which interact between the computer and humans. For the environment application, BCI technologies could be used to switch on or off the light or TV and speak with virtual persons.

1.2 Problem statement

Our brain is the leader of our body which controls everything that we do. The Paralyzed people and those with motor disabilities can't practice their normal life as the other people and this is because they can't move their bodies, so by using BCI technologies that communicate with the brain, they can perform activities without depending on muscles and peripheral nerves.

1.3 Objectives

The objectives of this project are:-

- To collect data through experiment.
- To apply digital signal processing methods to do some analysis.
- To analyze and compare the Motor movement effects on the brain signals.

1.4 Scope of study

The scope of work for the first semester of final year project was more on the literature review and theories. For conducting experiments, collecting data, analyzing and post processing the data in the second semester.

1.5 Project Feasibility

This project is considered as feasible since all needed facilities such as laboratory equipment are available at the place of study "University Technology PETRONAS, UTP" and based on the proposed methodology and Gantt chart, we are able to complete all the activities within the timeframe.

CHAPTER 2
LITERATURE REVIEW

2.1 Brain Internal Structure

The experiment is conducted in this research is more related with biomedical research engineering, and to get the knowledge about the real effects on the brain, the brain structure involved in doing tasks and visuals function are studied in detail. This is to know which regions are involved the watching and concentrating on the images and which one is processing and motorizing and so on.

Figure 1 shows the brain and corresponding regions.

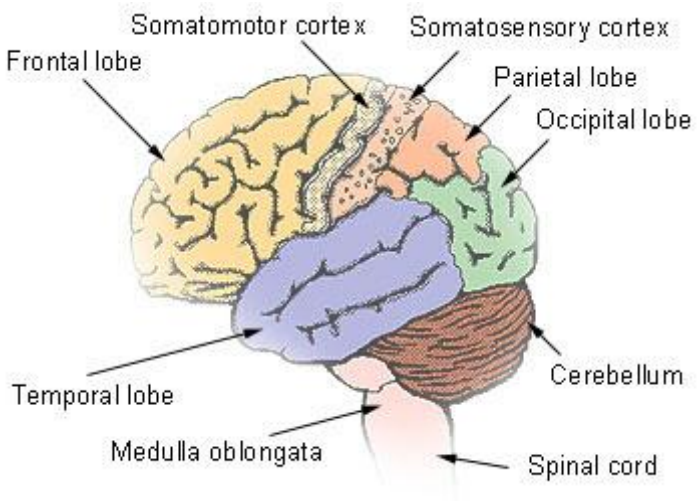


Figure 1:- Brain Regions

The human brain is divided to 2 parts which are cerebellum and cerebrum.

- ***Cerebellum***

The smallest part which occupies 11% of the brain's weight, and is responsible for movement, and important to motor task performance. The mechanical movements such as touch typing could be done by cerebellum [6].

- ***Cerebrum***

The largest area in the brain which occupies 80% of the brain's weight, and is responsible for controlling the function of the thinking, memory, speech and muscular movement.

It's divided to four main lobes, each of these lobes has special functions [6]:-

1- Frontal lobes

Its position is in the front of the brain which is associated with thinking, planning, monitoring, solving problems and regulating the excess of the emotional system.

2- Parietal lobes

It is placed behind the frontal lobes and it is associated with calculations, orientation, types of recognition.

3- Occipital lobes

It is placed at the back of the brain and it is associated with visual processing.

4- Temporal lobes

It is located near the ear region and it is associated with sound, music, face and object recognitions.

5- Motor Cortex

It is located between frontal and parietal lobes; the body movement is controlled by motor cortex.

6- Somato sensory

It is located behind the Motor Cortex and it processes touch signals received from different parts of the bodies.

At present, there are 3 technologies EEG, Functional Magnetic Resonance (FMRI) and Electrocorticography (ECOG) that are used to record the brain activity signals. Table 1 shows the differences between EEG, FMRI and ECOG technology.

Name	Definition	Characteristics
Electroencephalography (EEG)	Records the electrical brain activities from the scalp by using electrodes [5]	-Non invasive. -Low signal-to-noise ratio. -Low spatial resolution.
Functional Magnetic Resonance (FMRI)	Record the blood oxygen level dependent signal variations linked to neuronal activity across the whole brain with high spatial resolution [3].	-Non invasive s -High signal –to-noise ratio -High spatial resolution -Expensive , large scanner
Electrocorticography (ECOG)	Record the neural signal by electrodes embedded in flat strip or grid that is located on subdural surface of the cerebral cortex [4].	-invasive -Very high signal-to-noise ratio -High spatial resolution

Table 1:- Brain Measurement Comparison.

From the comparison that shows in Table 1, I select Electroencephalography (EEG) technology is selected to use in this project because it is non invasive.

2.1.1 Electroencephalography (EEG)

EEG is a technology used to read the brain activity from the scalp. It's measured by micro volt, the electrodes are a small metal discs put on the scalp in special position where the International 10/20 System are used to classify the positions. Figure 2 shows the electrode positions named with letters and numbers where the letter refers to the brain lobes, for the number, the even number is referred to the right side of the brain and the odd number is referred to the left side of the brain [5].

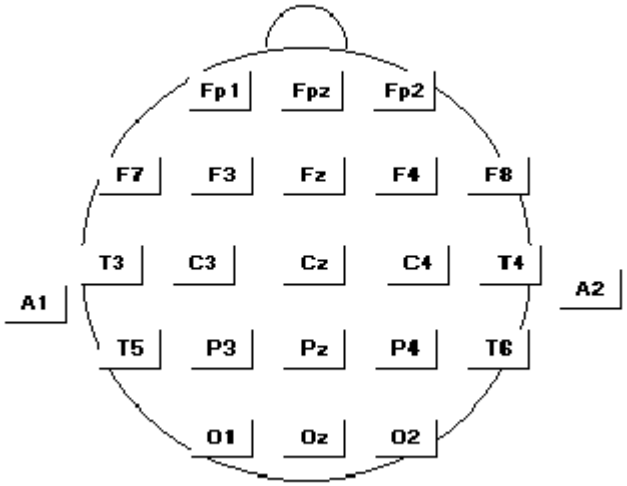


Figure 2:- 10/20 System of electrode placement.

Because of the value of EEG voltage is in micro volts which are very small, EEG uses differential amplifier which measures the difference between two inputs signals. The differential amplifier has 2 inputs which the target electrode and reference electrode. After the signal is amplified then presented as channel of EEG activity. In analog EEG, the signals are first filtered then the EEG signals output are sketched in amoving paper by racing. Nowadays, Digital EEG is used instead of analog to digital converter is needed to digitalize the amplified signals.

Event related potential or evoked Potentials are the most useful application in EEG, where evoked potentials are significant voltage variations from evoked neural activity [5].

One type of ERP is the P300 wave. The P300 could be recorded by EEG and it is positive peaks in the EEG are caused by visual or somatosenery stimuli. P300 responses are extracted at around 300 ms. P300 -based BCI does not need training but it has Low rate of information transmission [11].

2.1.2 Brain Waves Classification

EEG electrodes are used for measuring the electrical voltage of the brain signals. Next, Fourier transform is performed to set the power spectrum from the raw EEG signal and brain waves are categorized into 5 bands. Table 2 shows the different frequency ranges found in brainwaves, and the behaviours associated with them [7]

Bands	Frequency domain	Associated with
ALPHA	8-12 HZ	Relaxation "stated with first stage of sleep"
BETA	13-30 HZ	Alertness, problem solving, concentration, thinking
DELTA	0-4HZ	Deep sleep
THETA	4-7HZ	Pre sleep and dreams, anxiety
Mu	7-11HZ	Motor movement

Table 2:- Brain Waves Classifications.

2.2 Brain Computer Interface (BCI)

Brain computer interface is new augmentative communication systems for those suffering from Permanent paralysis. This technology helps them to communicate and perform control tasks without any using from peripheral nerves and muscles [1, 2, and 10].

BCI depends on the interfacing between two adaptive controllers. The activities are generated by the user's brain then it's measured by BCI system, the system converts those activities to specific commands. At present BCI information transfer rate is 5-25 bit/ min [1, 10].

In a project by Dr. Jacques Vidal visual evoked potentials was used to control the cursor movement on a computer screen. There are two types of BCI; one relies on muscle control this is called EEG-based communication such as VEP and another one doesn't rely on muscle control which is called EEG-based control [1].

There are different applications of BCI for example:-

- Bioengineering application could be helped for motor disabilities.
- Human subject monitoring such as sleep disorder, neurological diseases, attention monitoring, neuroscience researches.

- Man machine interaction which interact between the computer and humans.

At present, companies are looking to use BCI in [8, 9]:-

- Gaming and entertainment.
- Safety and security which can help them to exposure the suspicious objects.

2.2.1 Brain Computer Interface Structure.

BCI procedure starts with signal acquisition with amplification and sampling the signals recorded by the EEG. Then the signal is pre-processes by cleaning the signals after it is sampled. The next step is signal classification to know what category of tasks is carried out. Finally, an appropriate algorithm is used on the signals that have been classified to perform certain computer interface [8, 10].

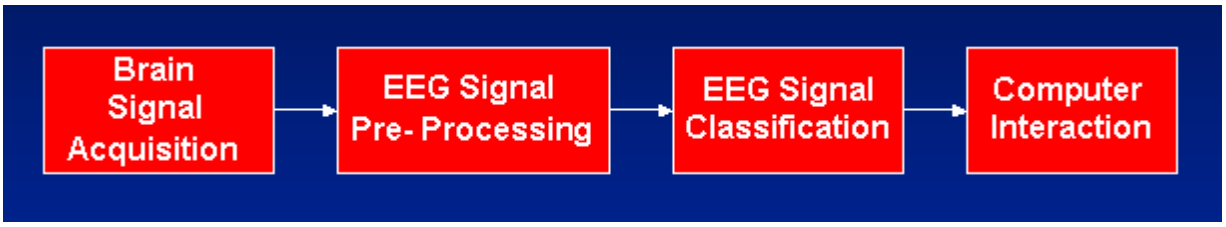


Figure 3:- BCI Common Structure.

BCI consists of input, output and translation algorithms. The input is the feature activity of the brain. These features could be in frequency domain such as EEG Mu, Beta rhythms or in time domain such as P300 Potentials. The input also involves the scalp electrodes type and locations, the reference method, the spatial and temporal filters. The translation algorithm of BCI that translates the input into output control signals. The output could be cursor movement, chosen letter …etc [1, 10].

2.3 EEG Signal Classification

2.3.1 Feature Extraction

The brain signals activities are represented as different patterns, each Patten is classified into class to its feature by BCI. Some of those features are extracted from the brain signals which reproduce the seminaries to certain class [11].

Table 3 shows a comparison between four methods could be used in Feature extraction stage.

Methods	Definition	Properties
Auto Regressive [11, 17]	-Is a modeling signals and its goal is to get filter coefficient which it will be used as the features of the signal.	- time domain - not appropriate for stationary signals - accuracy 70%
Multivariate adaptive auto regressive [11, 12]	-Is the adaptive version of Auto regressive. - Treats all the EEG channel signals data in order to provide enough information.	-Appropriate for non-stationary signals. -Accuracy 90% -suitable for motor imaginary
Wavelet [11, 14 and 15]	-Is a mathematical tool which is used in extraction data. It has 2 types 1- continuous wavelet 2- discrete wavelet	-Appropriate for non stationary signals - Present frequency and temporal information -accuracy 80%
Common Spatial Pattern [11,16 and 18]	-It's the popular method for feature extraction -attempt to projects multichannel of EEG	- Appropriate for non stationary signals. -suitable for synchronous BCI which it gives a very good

	subspace. -Plan to design spatial filter which converts the input to output data with optimal variance for following discrimination. -the spatial filter could affect the CSP performance.	result. -accuracy 80%

Table 3:- Feature Extraction Methods.

2.3.2 Feature classification

Classification algorithms is important step in BCI system which its goal is identification of user's intentions from the feature vector that has been differentiated the brain activity signals by feature extraction and selection method [11].
Table 5 shows three different methods of feature classification methods.

Method	Definition	Properties
Linear Discriminant Analysis (LDA) [11, 12]	-Linear classification method - classifying the best selective inn-dimensional.	-fast -very familiar in BCI which it's used for designing online BCI system. - has been applied in numerous BCI [P300,Multiclass,synchronous] -linear method
Artificial Neural Network (ANN) [11]	-it aims to design computer model to handle problems which could be solved simply by the biological brain. - Suitable for vision, speech recognition tasks.	-non linear method. -multiclass. -very flexible classifier. - MLP is the most famous ANN structures. It could be used to design synchronous and asynchronous BCI, also used as preprocessing method for EEG

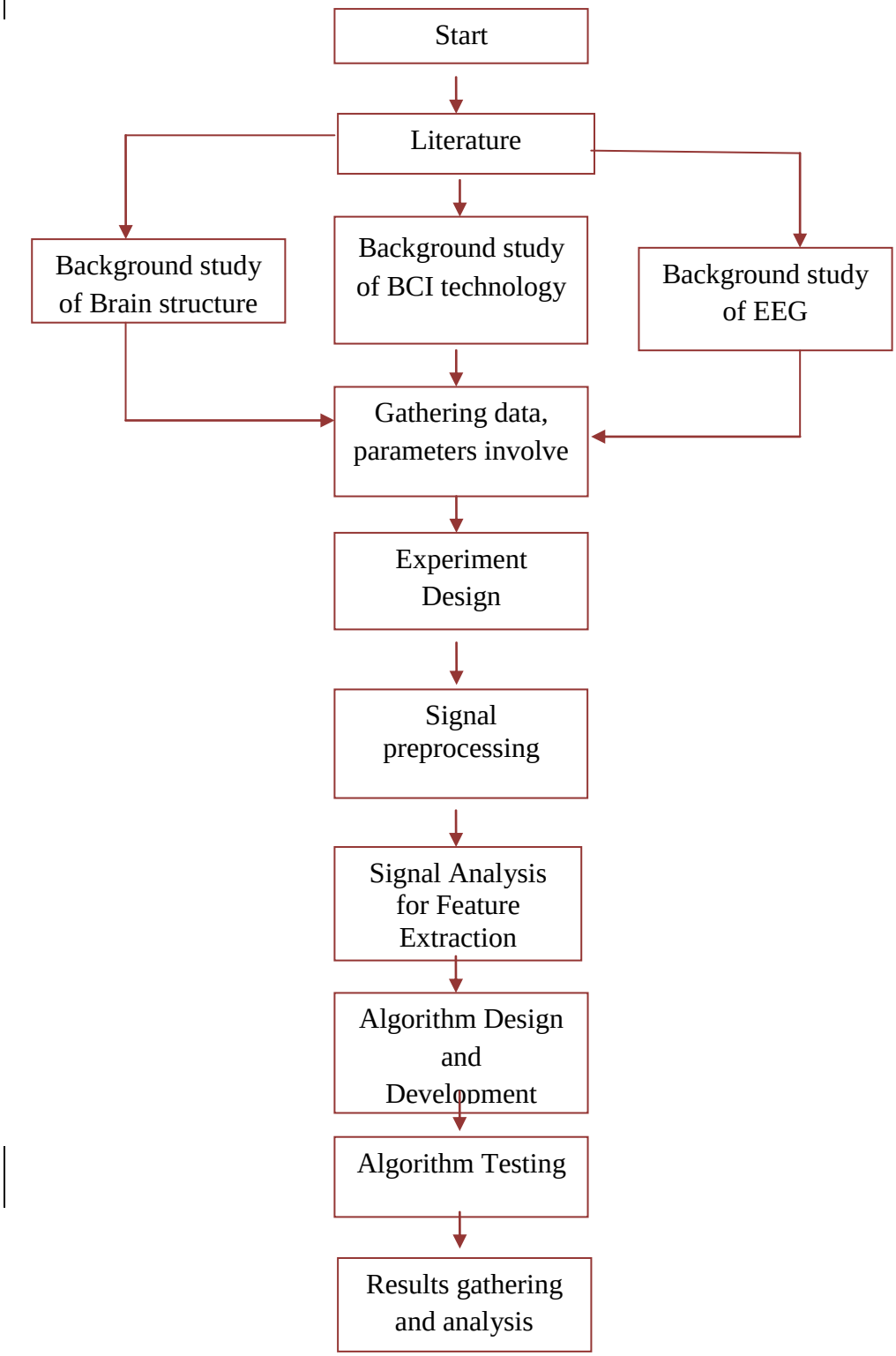
		signals that's to develop the separability off EEG feature
Support Vector Machine (SVM) [16. 22]	-similar method as LDA -it aims to divide the feature vector in numerous classes by creating hyperplane or set of hyperplane	- Linear and nonlinear method. - has been applied in synchronous of BCI. -commonly used in BCI that's because it's a very simple classifier and it needs for large training set for getting a good result. -binary and multiclass method - Quick enough for real time.

Table 4:- Feature Classification Methods.

CHAPTER 3

METHODOLGY

3.1 Procedure Identification



3.2 Details of the Procedure

Throughout this project, there are some procedures to be followed. This is to ensure that the project can be accomplished within the given timeframe.

3.2.1 Data research and gathering

Elements of projects involved in this stage include the study of BCI Technology methods, EEG, to gather knowledge on different tasks of movement control and identify the tasks that the participants suppose to do.

3.2.2 Experiment Design

A. Subjects

Initially, ten healthy young human subjects have been recruited to participate in the experiment according to a standard pre-questionnaire. We excluded the subjects who wear braces, take medication, had history with head injuries or even having a headache easily. Apart from that, people who have skin allergies have been disqualified, since we used certain EEG gel on the head for connecting the EEG cap, which may cause allergic.

There is a briefing that will be delivered to the participants by the experimenter to give instructions is to them to prepare before coming to the experiment

- The participants will be advised not to eat a heavy meal directly before the experiment, also not to drink any caffeine such as coffee, tea etc.
- The participants should come to the experiment after they have washed their hair with shampoo only. They should not use conditioners, creams or oil on their hair or skin.
- The participant also will be asked not to put on any accessories from metal such as earring or clips.

At the subject arrivals to the experiment room,

1- He/she will be given the consent form,
2- The participant's head will be measured to select the electrode cap with the appropriate size.
3- We prepared the Electrode solution consists of one battle of water energy, one spoon of electrode powder and one spoon of shampoo Jonson.
4- The EEG cap put in this solution for 5 minutes refer to figure 4.

5- The impedance of all the electrodes has been measured and Electro cap electrodes may be abraded if they showed high impedance. The Experimenter has applied two EEG sensors onto the second rib below the right and left shoulder blades to measure the heat beats.

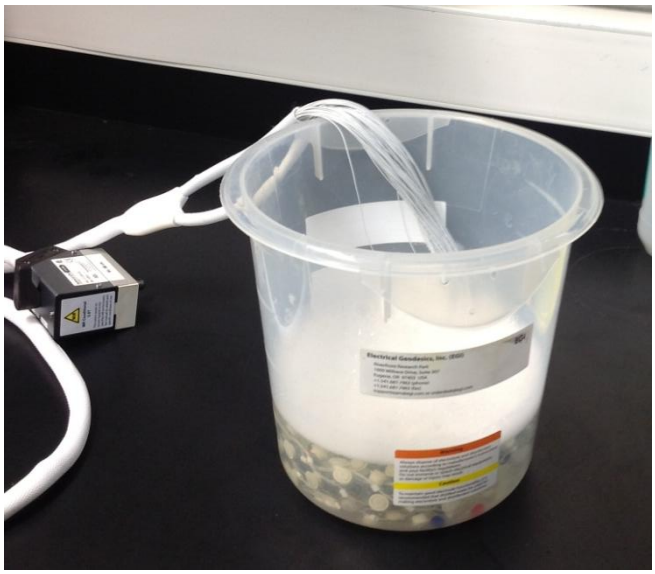


Figure 4:- EEG cap in Electrode solution.

B. Experiment

The subject will sit in chair and looking at computer screen, the distance between computer and the chair is approximately 80 cm. The subjects will be asked to stay their arms and hands relax.

The experiment will be conducted using Sensor Net 128 channels EEG hardware, Net station, E-prime and Tobii software.

The recording session will take a total of 114 seconds and consists of four 16-seconds sessions for imagined motor tasks and 50 seconds for relaxation. This experiment will be repeated for 2 times per session. The subjects will be instructed to imagine a movement of the left hand, right hand or the right feet depending on the direction of the arrow that will be appear on the computer screen.
Figure 5 shows the experiment video that has been designed using Tobii software.

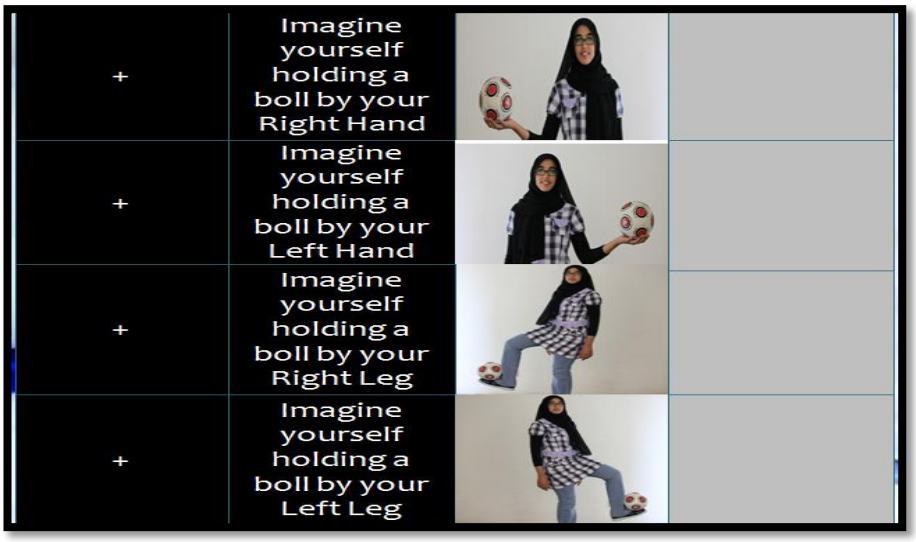


Figure 5:- Experiment design

The experiment includes the following:-

1- 10 seconds – relax mode.

2- 16 seconds – imagine movement of right hand.

3- 10 seconds – relax mode.

4- 16 seconds – imagine movement of left hand.

5- 10 seconds – relax mode.

6- 16 seconds – imagine movement of right foot.

7- 10 seconds – relax mode.

8- 16 seconds – imagine movement of left foot.

9- 10 seconds – relax mode.

- **EEG Pre-processing**

After the experiment has been recorded using Net Station software, we used the same software to do pre-processing work. All the data have been sampled at 250 HZ and filtering at 0.1 HZ high pass filter and 50 HZ for low pass filter.

- **Channel classification**

  This section is so important to be done after we get the data set to classify which channel is more activated power during the imagination of the 4 classes of movements.

  I have used the power spectral density equation which estimates the average power of the input signal vector X using Welch's averaged.

3.2.3 Signal Analysis for Feature Extraction

The brain signals activities are represented as different patterns, each Patten is classified into class to its feature by BCI. Some of those features are extracted from the brain signals which reproduce the seminaries to certain class. Refer to table 3 feature extraction methods, I have used MVAAR method to do the extraction work because it is suitable for motor imaginary which is related to the project tasks and it treats all the EEG channels signals data to give enough information.

- **<u>Multivariate adaptive auto regressive</u>**

  MVAAR is the last update of auto regressive method, which treats signals from all EEG channels. The EEG signal has been replicated using AR like the output random signal of a linear time invariant filter where the input is white noise with a mean zero and certain variance ofσ^2. This method aims to get the filter coefficient and those filter coefficients are going to be used as the feature of the signals.

  Mathematically the MVAAR model is showed as follow:-

  A m vector of EEG channel signal values at each point K can be describes as,

$$\vec{y}_k = [\vec{Y}_{K,1}, \vec{Y}_{K,2} + A_3\ \vec{Y}_{K-2}, \dots\dots\dots\dots \vec{Y}_{k,m}]^T.$$

  The MVAAR model could be represented as

$$\vec{y}_k = [A_1\ \vec{Y}_{K-1} + A_2\ \vec{Y}_{K-2} + A_3\ \vec{Y}_{K-2} + \dots\dots\dots\dots +\ A_P\ \vec{Y}_{K-P} +\ \vec{x}_k]$$

  Where,

  $\vec{y}_k$ is The data vector at the time K, $\vec{x}_k$ is the vector of white noise values, A_1 $\dots A_P$ is the model coefficients and P is the model order. The MVAAR coefficients might be calculated approximately using Kalman Filtering as scalar Kalman Filtering [12].

3.2.4 Signal classification

Classification algorithms is important step in BCI system which its goal is identification of user's intentions from the feature vector that has been differentiated the brain activity signals by feature extraction and selection method. Refer to table 4 I decided to use Linear Discriminate Analysis method because this method is the simple classifier with suitable accuracy without high computation requirements. LDA is good method for designing online BCI systems with a high response, although it's limited computational resources.

To classify between two classes, LDA presume that both of those two classes are linearly separate. LDA function is defined as below

$$g(x) = w^T x + w_0$$

Where,

w is The weight vector, x is The input vector and $w_0$is Threshold

This function characterizes a hyper plane in the feature space to differentiate the classes. The class to which the feature vector fits in will depend on the side of the plane where vector found.

The weight vector $w$could be calculated as follow

$$w = \Sigma_c^{-1}(\mu_2 - \mu_1)$$

Where,

μ_i is The estimated mean of class i and $\Sigma_c = \frac{1}{2}(\Sigma_1 + \Sigma_2)$ is the estimated common covariance matrix [11, 12].

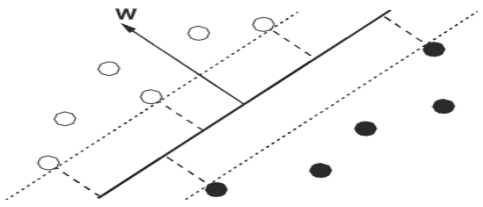


Figure 6:- Example of LDA classification.

3.3 Tools & Equipment

- Hardware

Sensor Net 128 channels EEG cap and LG 3D stereoscopic Television.

- Software

  Net station, Tobii, E-prime, EEG lab and MATLAB.

3.4 Grantt Chart for FYP1&FYP2

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of the project topic														
Preliminary research work (Background study of BCI technology, EEG and Brain structure)														
Preliminary report submission														
Experiment Research														
Submission of Interim draft report														
Submission of Interim Report														

Figure 7: Gantt chart for FYP I

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Experiment Design															
Data collection through the experiment															
Data analysis															
Signal Analysis for Feature Extraction															
Results gathering and Analysis															
Submission progress report															
Pre - EDX															
Submission of draft report															
Submission of dissertation & Submission of Technical Paper															
Oral presentation															

Figure 8: Gantt chart for FYP II.

CHAPTER 4
RESULTS AND DISCUSSION

The chapter will discuss the results of the project and the ways that has been used in interpreting the data.

4.1 EEG analysis:-

After we get the data set from the recording experiment we use EEG LAB on MATLAB to read those datasets. Using EEG LAB we can do a good analysis for the datasets. First I design the segmentation code to segment the data to 4 classes “Right Hand, Left Hand, Right Leg, Left Leg”, I have applied the segmentation code on 10 subjects. Figures 9,10 ,11,12 ,13 and 14 show the four movement “Right Hand, Left Hand, Right Leg, Left Leg” for 6 different channels “C3,C4,P3,P4,O1 and O2”.

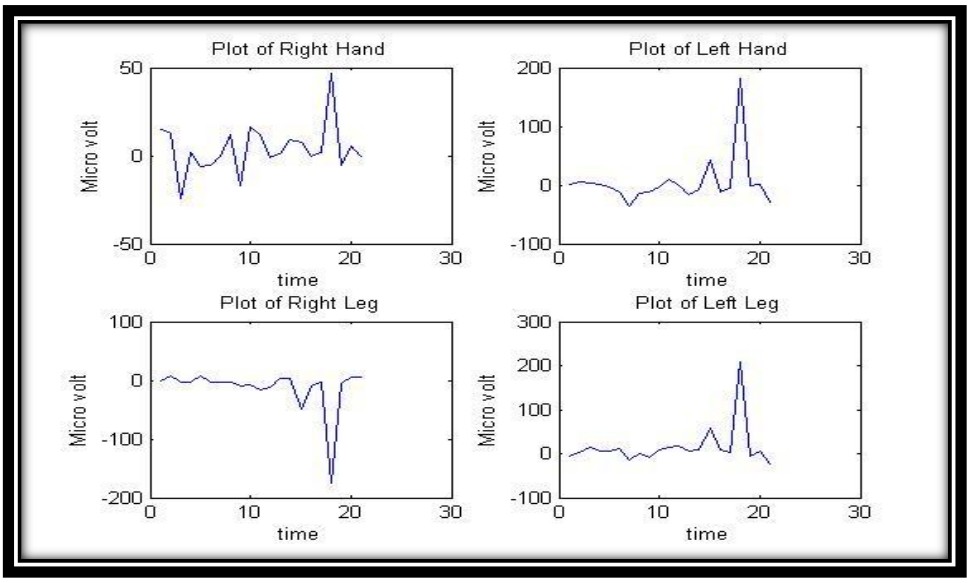


Figure 9:- The four movements of C3 channel

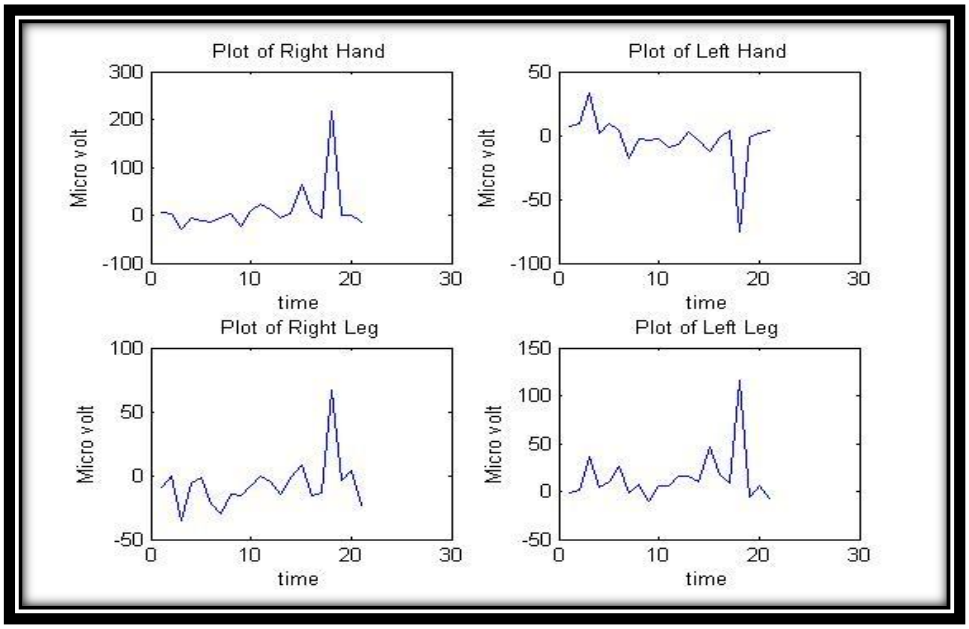


Figure 10:- The four movements of C4 channel.

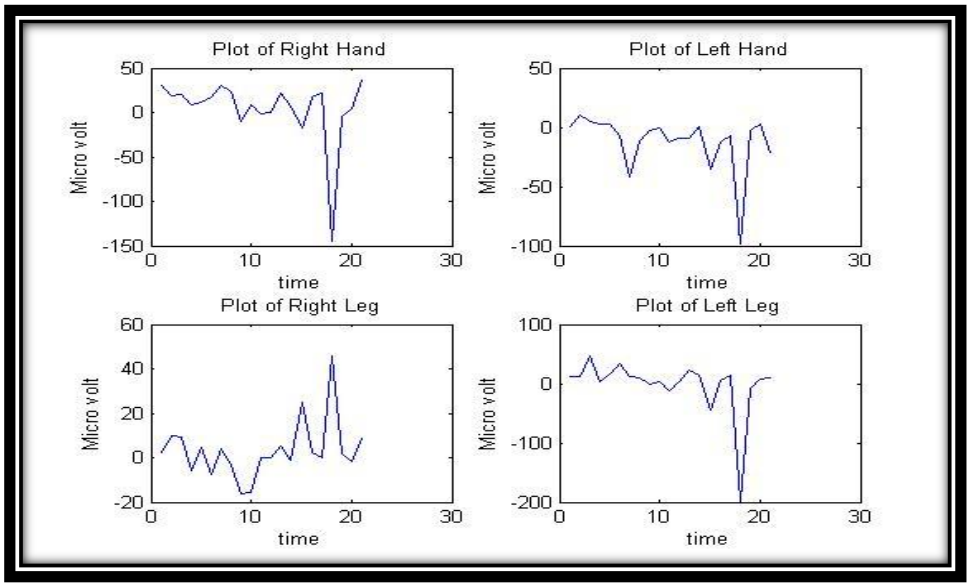


Figure 11:- The four movements of P3 channel.

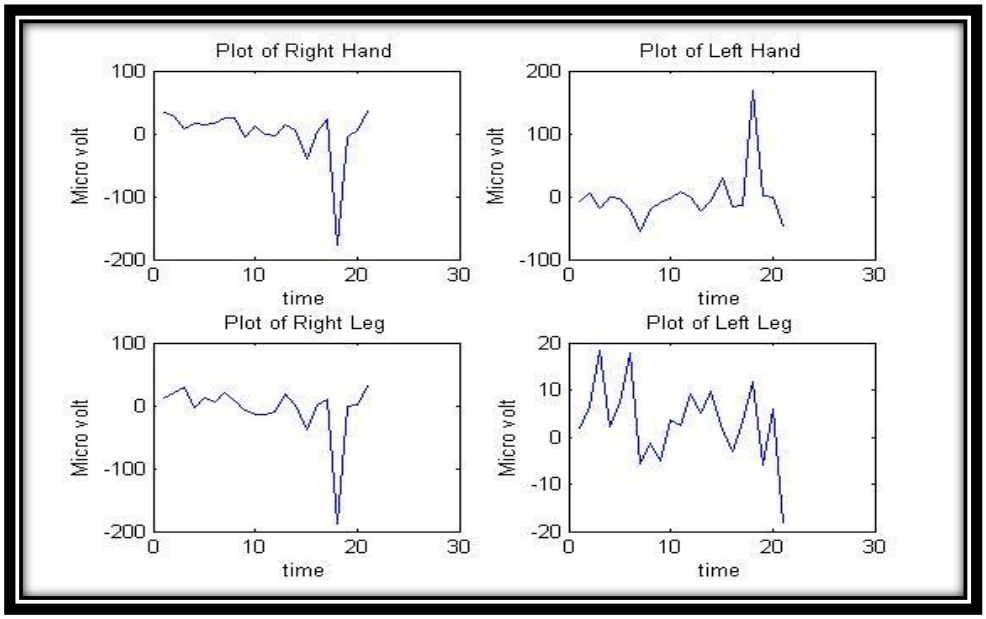


Figure 12:- The four movement of P4 channel.

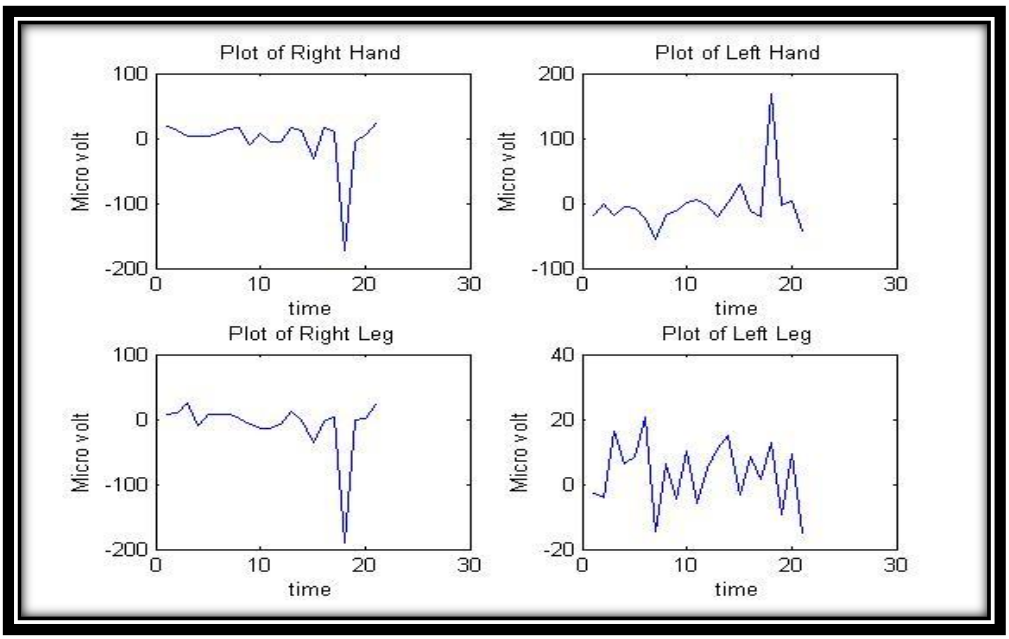


Figure 13:- The four movement of O1 channel.

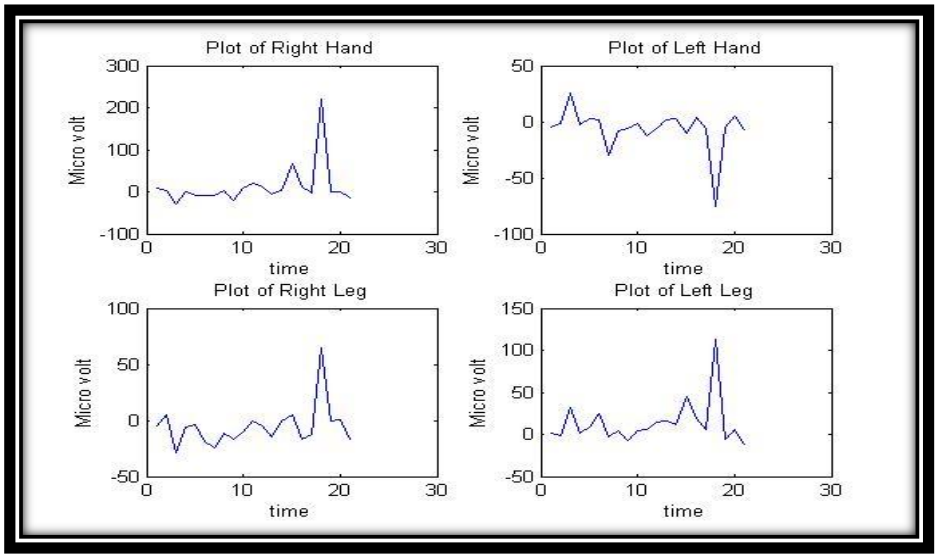


Figure 14:- The four movement of O2 channel.

- **Channels classification**

  This step is so important because depend on choosing a good channels will be affected on the rest of the result.

  Power spectrum density (PSD) is used to classify the channels which PDS estimates the average power of the input signal vector X using Welch's averaged.

  After I Applied PSD on the 4 classes for 10 subjects, I compared between all the channels in each class. Generally, the power will increase when the activation of brain increase. So the brain is trying to capture the thinking of four movements.

  Figure 15 shows PSD of one channel.

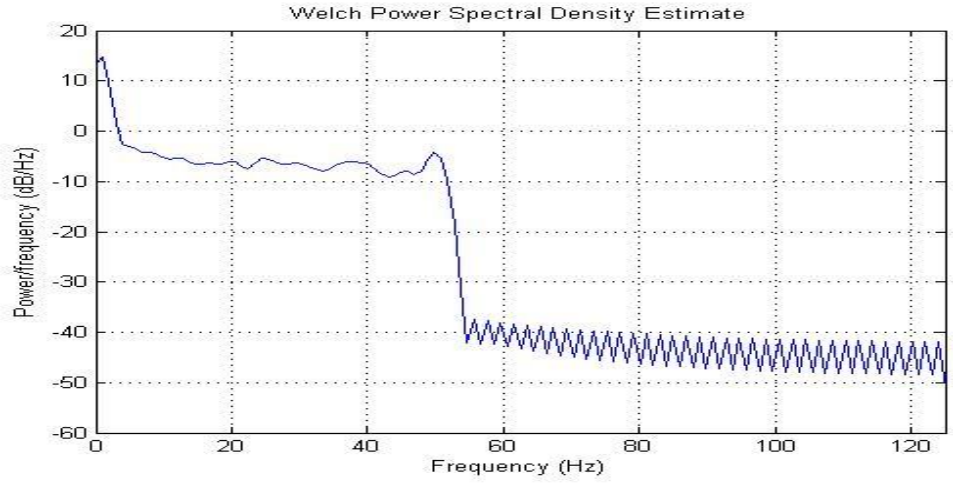


Figure 15:- PSD of O2 Channel.

The brain is divided to two sides called right hemisphere and left hemisphere. Right hemisphere channels are F4, C4, P4, O2, A2, and T4. Left hemisphere channels are F3, C3, P3, O1, A1 and T3. Using PSD function we get the average power for all the channels of each movement, then we have compared between Right hemisphere channels and left hemisphere channels (i.e. C4,C3) for 4 different movement. Figures 16,17,18 and 19 show the channels of Right Hand, Left Hand, Right Leg and Left Leg.

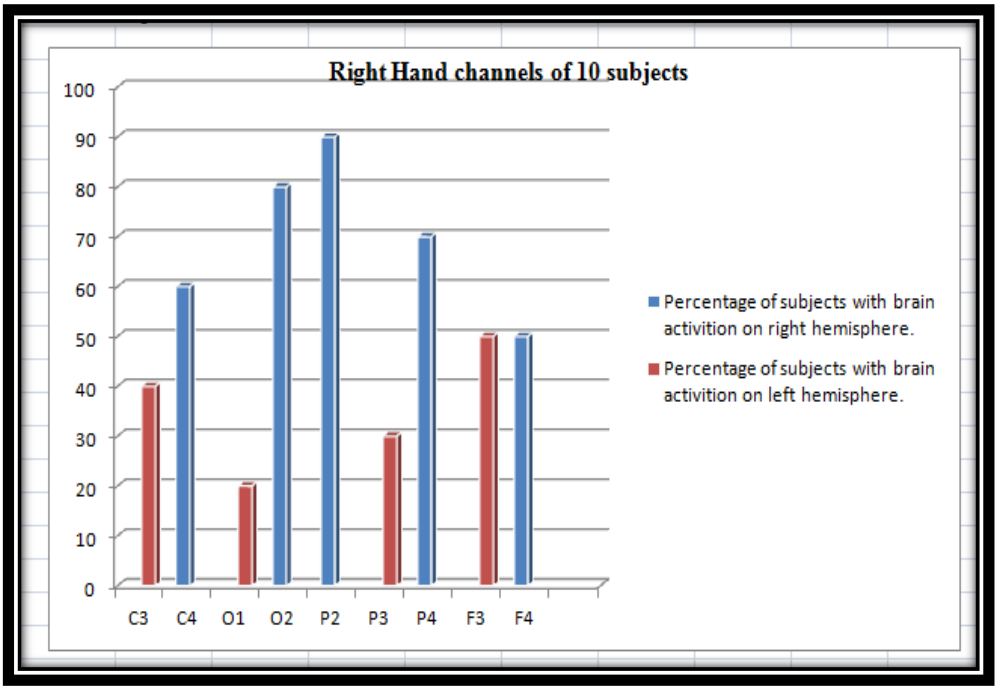


Figure 16:- Right Hand Channels.

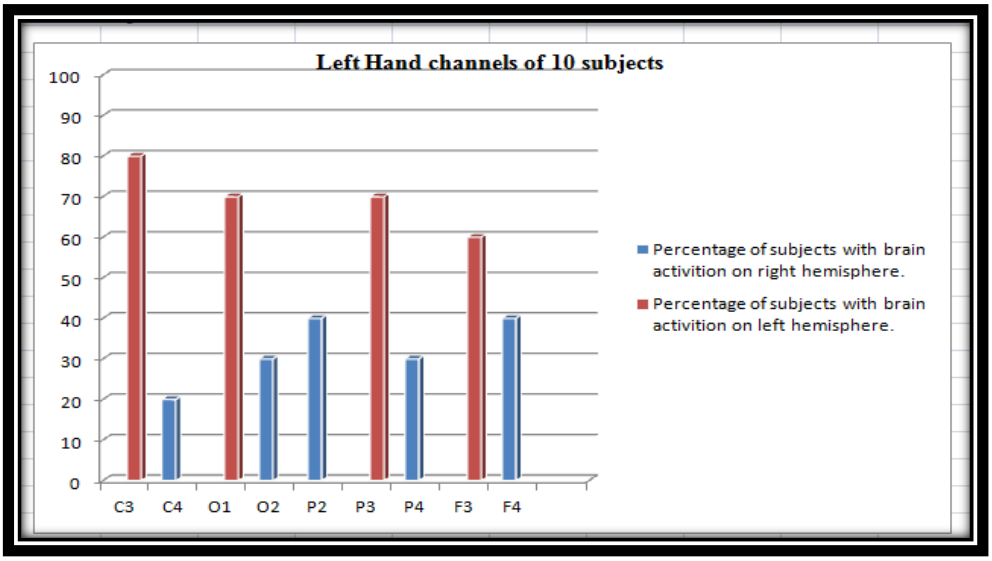


Figure 17:- Left Hand Channels.

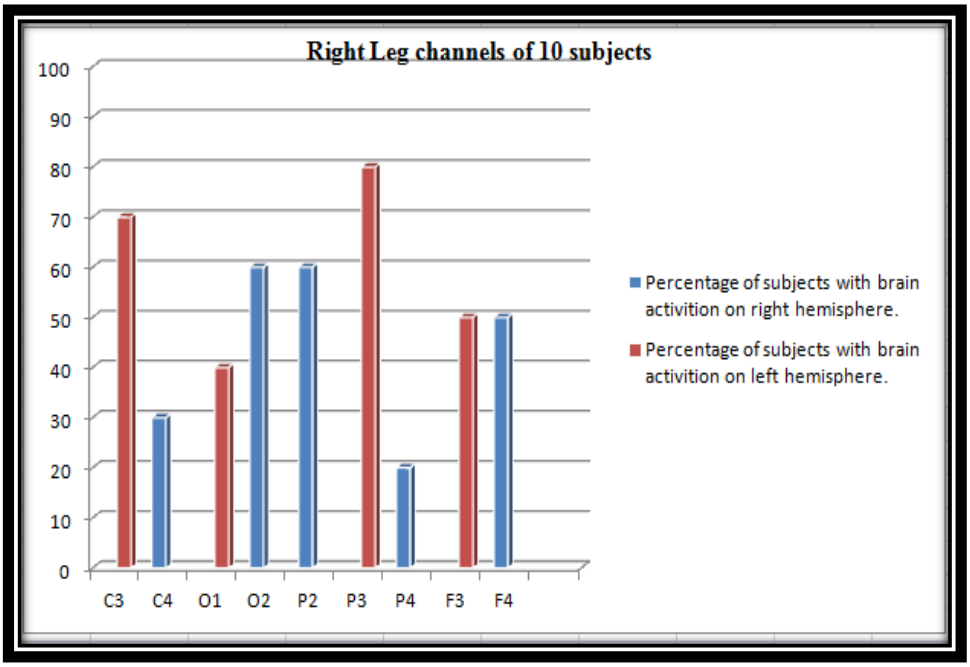


Figure 18:- Right Leg Channels.

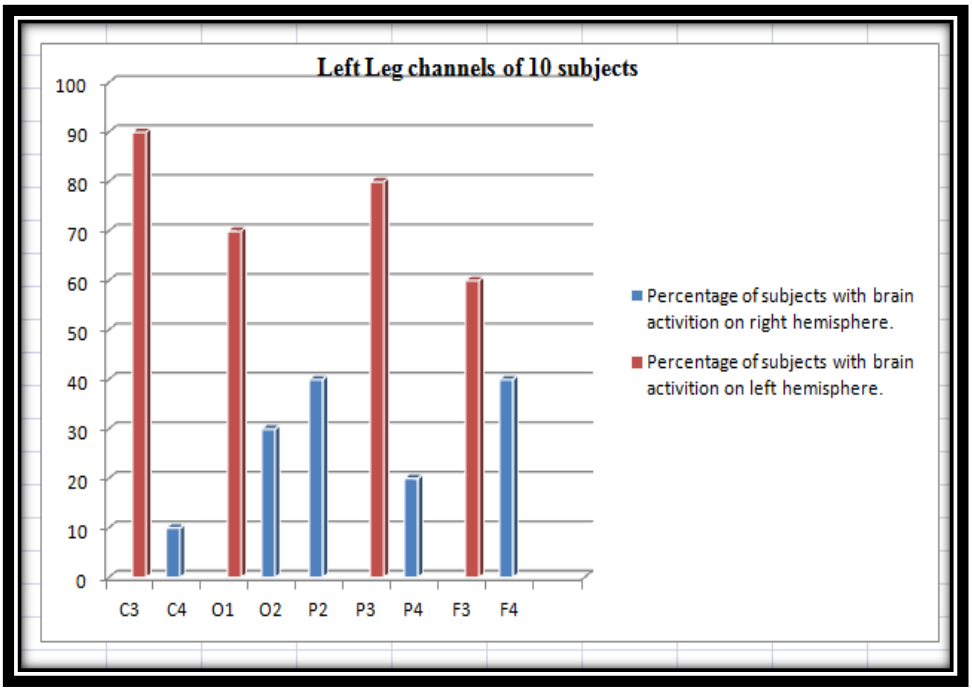


Figure 19:- Left Leg Channels.

As we mention before in literature review chapter, the central, parietal and occipital parts of the brain has direct affect in the thinking function, so C3, C4, F3,F4,O1,O2,P2,P4 and F4 have been chosen to analyze the more power activated channels during the thinking function.

According to the figures above we can say that the channels of right hemisphere which are C4, O2, P2, P4 and F4 have the higher percentage of subjects for Right Hand movement. In another hand, the channels of left hemisphere which are C3, O1, P3 and F3 have the higher percentage of subjects for Left Hand movement. For Right Leg movement C3, O2, P3 and P2 channels are more activated power. But, for Left Leg movement C3, O1,P3 and F3 channels are more activated power.

4.2 Feature Extraction and classification MVAAR, LDA.

Refer to the analysis of the channels that I have mentioned in channels classification part. We have used MVAAR MATLAB code to apply it on each class with specific channels that have more activated power in each class for every subject. We choose only 4 model orders. The output of Feature extraction couldn't be showing in figures.

For classification part, LDA classification method can only classify between two classes.

So we choose to do the classification between

1- Right Hand- Left Hand.
2- Right Hand –Right Leg.
3- Right Hand – Left Leg.
4- Left Hand –Left Leg.
5- Left Hand –Right Leg.
6- Right Leg – Left Leg.

Figure 20 shows 2 classes Right Hand and Left Hand.

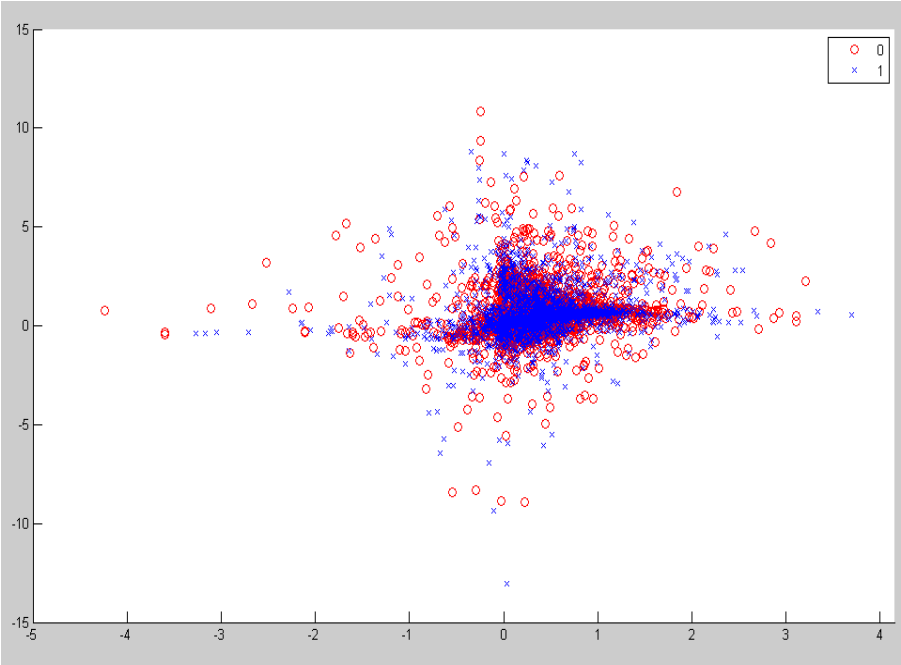


Figure 20:- 2 classes of Right Hand and Left Hand.

after we have got the output data of feature extraction we choose 2 classes to apply the feature classification method on it, But the feature classification fail to classify between the 2 classes for all the data that's because MVAAR is approved that it's not a good method to use in Feature extraction. As we can say from figure 18 that there's no way to do any classification because there's no separation between the classes which shows us that MVAAR method is not good enough for my dataset.

- Discussion

  At the end of my result I can't achieve my third scope of study which is feature classification

  These some reasons could be caused of this:-

  1- MVAAR feature extraction method is not matching with LDA feature classification methods.
  2- MVAAR couldn't extract the actual features.
  3- Numbers of participants are not enough for giving a good result.
  4- Need more training data for each movement from one participant.

I have thought in the previous reasons and I come out with some recommendation may be if we follow it we can achieve the feature classification part.

The recommendation:-

1- Increase the number of participants.
2- Increase the time of thinking for each class of motor movement during the experiment.
3- Use neuro guide to calculate the power absolute to differentiate the proper channel of each class because neure guide result is more accurate.
4- Use another method for feature extraction such as common spatial pattern Because It is the popular method for feature extraction, attempt to projects multichannel of EEG to subspace, also it Plan to design spatial filter which converts the input to output data with optimal variance for following discrimination, the spatial filter could affect the CSP performance, Appropriate for non stationary signals and it suitable for synchronous BCI which it gives a very good result.

Chapter 5

CONCLUSION

5.1 The conclusion

As a conclusion, this project is more related to the biomedical and neural engineering field which seeks to close the gap between the engineering and medicine, since it is related to work with paralyzed people. We designed an experiment depending on the earlier studies with a lot modification and managed to recruit ten subjects to be a part of this research depending on preliminarily questionnaire. The experiments have been conducted for 2 weeks, After using Net Station for data acquisition. We extracted the data and then started analysis by using MATLAB) to meet our objectives.

EEG lab software helps us to do the analysis for the data to plot the time frequency for each channel, and also to plot the channels spectrum and maps. We used PSD to know which area is more activated power in the brain for each subjects and then choose the proper channel that will be use in feature extraction part. The Feature extraction method MVAAR can't give as a good result to use it in the next stage which it Feature classification, thus we can't proceed with the next objective.

Unfortunately, I couldn't achieve all my objectives because of the timeframe and some problems have been faced during my work. Also because we have conducted the experiment so late, so I wasn't able to change the method of Feature extraction with another method could give us a good result to do the classification.

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APPENDICES

Appendix A {CONSENT FORM}

Research Title: - **Brain Computer Interface for Movement Control**

Researcher's Name: - **Wafaa ELsayed Elbasty**

INTRODUCTION:-

Brain computer interface is direct communication between brain and external devices without depending in muscles or nerves. So the experiment is depending in your imagination.
The recording session will take 114 seconds. This experiment will be repeated for 2 times per session.
The first 10 seconds, you are going to perform close and open right hands test. Then you have to follow the images that will be shown in the screen. You will be asked to imagine that you are moving your right hand, left hand, right foot and left foot. We will show you the images of the experiment before the experiment starts.

Subject Information and Consent Form
(Signature Page)

To become a part this study, you or your legal representative must sign this page. By signing this page, I am confirming the following:

I have read all of the information in the is consent form.

I voluntarily agree to be part of this research study, to follow the study procedures and to provide necessary information to the researcher.

_____

Subject Name (print or type) **Subject Initials** and **Number**

_____

Subject I.C No (New) **Subject I.C** NO. (Old)

_____

Signature of Subject or legal Representative **Date (**dd/MM/yy)

Wafaa ELsayed Elbasty

Name of Individual

Note: all subject/subjects who are involved in this study will not be covered by insurance.

Appendix B {Requirement Data}

1	First Name
2	Last Name
3	Gender
4	E mail
5	Age
6	Phone no.
7	Handedness
8	Nationality
9	Race
10	Right hand Sight (Y/N) if ‘y’ state the power
11	Daily Medication (Y/N)
12	Smoking
13	Neurological disease Epilepsy Seizures or migraine (Y/N)
14	Systemic Problem Asthma, Blood pressure, hyper tension or diabetes (Y/N)
15	Right hand Disease or surgery (Y/N)
16	EAR problem or surgery (Y/N)
17	Semester

Appendix C {Experiment Photos}

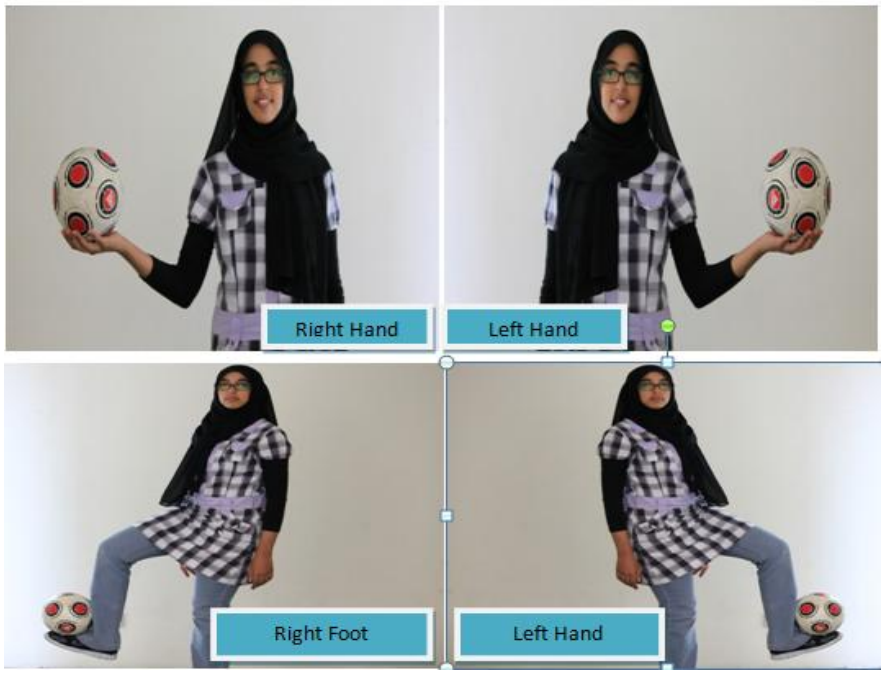

Figure 6: - Hand and Foot Movement.

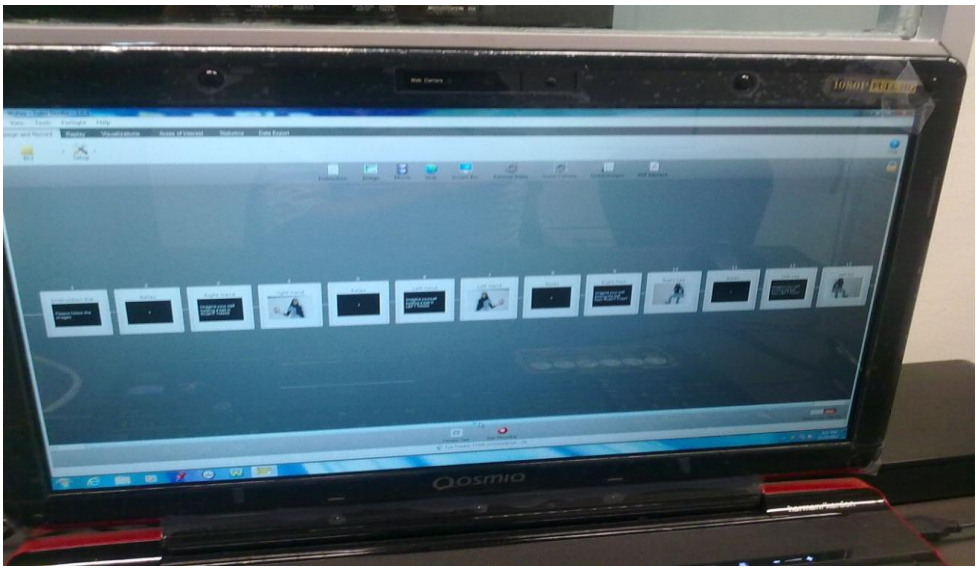

Figure 7: - Experiment video using prime software.