MIND CONTROLLED COMPUTER GAME USING EEG SIGNALS

LIEW WAI CHUN

This Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor Degree in Electronic Engineering (Wireless Communication)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer

Universiti Teknikal Malaysia Melaka

June 2016

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **MIND-CONTROLLED COMPUTER GAME USING EEG SIGNALS**

Sesi Pengajian :

1	**5**	**/**	**1**	**6**

LIEW WAI CHUN

Saya ……

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐ **SULIT*** *(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD**** **(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ **TIDAK TERHAD**

Disahkan oleh:

_____ (TANDATANGAN PENULIS)

_____ (COP DAN TANDATANGAN PENYELIA)

Tarikh: ……..

Tarikh: ……..

"I hereby declare that the work in this project is my own except for summaries and quotations which have been duly acknowledge."

Signature : .....

Student's name : **LIEW WAI CHUN**

Date : **15 JUNE 2016**

"I acknowledge that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics/ Computer Engineering/ Electronic Telecommunication/ Wireless Communication)* with Honours."

Signature : .....

Supervisor's Name : **DR. LOW YIN FEN**

Date : **15 JUNE 2016**

To my family for nursing me with their love and dedicated for success in my life.

ACKNOWLEDGEMENT

I, Liew Wai Chun, am very thankful to everyone who supported me throughout the project and helped me in completing my report effectively and moreover, on time. It would not have been possible without the kind support and help of them.

I am using this opportunity to express my deepest gratitude and special thanks to my supervisor, Dr. Low Yin Fen who in spite of being extraordinarily busy with her duties, took time out to guide, give necessary advices and keep me on the correct path, as well as for provide necessary information for my project.

Also, I am highly indebted to my friends for their careful and precious guidance which were extremely valuable for my project both theoretically and practically.

Last, but not least, I would like to thank my parents and family for supporting financially and emotionally.

ABSTRACT

The aim of this thesis is to develop a mind-controlled computer game using electroencephalogram (EEG) signals. EEG signals were used to trigger the command to control the game instead of using keyboard or joystick. In the first part of this project, a suitable game which is Space Plane (Stellaria) game was developed using MATLAB software. In this game, player control the space plane and has to destroy the enemies to survive until the end. Then, ENOBIO20 device was used to acquire the EEG signals from the human scalp. EEG signals acquired from ENOBIO20 device were sent to the computer and analyzed using the NIC software via Bluetooth. Filter process was done using the NIC software to remove unwanted signal. Training process has been done to select suitable channels. 3 channels (F7, F8 and F3) were selected to acquire the EEG signals through the user eyes blinking and moving the eyebrows. Besides that, TCP/IP connection was created using MATLAB software to interface between the Neuroelectrics Instrument Controller (NIC) and MATLAB software. Then, feature extraction and classification of the EEG signals acquired in MATLAB software had performed to acquire the desired output to trigger the command to control the game. Lastly, the desired outputs were used to interface with the game as a trigger to trigger the command to control the game. In conclusion, a mind-controlled computer game using EEG signals has been successfully designed and developed. This project is essential for the disabilities user, sustainable and able to improve human living lifestyle. This technology can be extended to industries and applications or systems such as medical industry, game industry and Smart Home System.

ABSTRAK

Projek ini bertujuan untuk membina satu permainan komputer kawalan otak dengan meggunakan isyarat "electroencephalogram (EEG)". Isyarat EEG digunakan untuk mengawal permainan tersebut sebagai ganti dengan "keyboard" dan "joystick". Pertama, permainan computer yang sesuai iaitu "Space Plane (Stellaria)" telah dibina dengan memggunakan perisian MATLAB. Dalam permainan tersebut, pemain mengawal kapal angkasa dan menyerang musuh untuk bertahan sampai akhir. Seterusnya, alat "ENOBIO20" digunakan untuk memperoleh isyarat EEG. Isyarat EEG yang diperolehi dari alat ENOBIO20 telah dihantar ke komputer dan dianalisis dengan perisian NIC melalui "Bluetooth". Proses penapisan telah dibuat untuk menapis isyarat EEG daripada isyarat yang tidak digunakan. Proses latihan telah dibuat untuk memilih saluran yang sesuai. 3 saluran (F7, F8 and F3) telah dipilih untuk meperolehi isyarat EEG melalui kelipan mata dan pergerakkan kening daripada pengguna. Selain itu, sambungan TCP/IP telah dicipta dengan menggunakan perisian MATLAB untuk menghubungkan NIC dan perisian MATLAB. Ekstrak cirri dan klasifikasi isyarat EEG di perisian MATLAB telah dilaksanakan untuk mendapatkan output yang dikehendaki dan menhubungkan dengan permainan untuk mencetus arahan untuk mengawal permainan tersebut. Kesimpulannnya, komputer kawalan otak dengan meggunakan isyarat telah berjaya dibina. Projek ini penting untuk orang kuran upaya, mampan dan boleh meningkatkan gaya hidup manusia. Teknologi ini boleh dilanjutkan ke industri, aplikasi dan system seperti industri perubatan, industri permainan dan system "Smart Home".

TABLE OF CONTENT

LIST OF FIGURES

LIST OF ABBREVIATION

EEG	-	Electroencephalogram
NIC	-	Neuroelectrics Instrument Controller
F7	-	Frontal Lobe 7
F8	-	Frontal Lobe 8
F3	-	Frontal Lobe 3
TCP/IP	-	Transmission Control Protocol/Internet Protocol

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Mind controlled computer game using electroencephalogram (EEG) signal is one of the main technologies that has been discussed recently. The meaning of mind controlled computer game is by sending subject's intention through human brain wave signal to the computer and translates the signal to a command to control the game. Many research related to the usage of EEG signal to control external system especially mind game have been done.

Basically, this EEG technology is able to apply to some applications, field or industry such as educational field, medical industry and game application. It is able to help users who suffer from disabilities to communicate with outside environment by converting brain signals into machine commands for the devices. Besides that, mind controlled computer games are able to create different type of entertainment for the player to play the games. While playing the game, the user have to focus on their brain or perform some action to generate EEG signals to control the game for example by imagining moving left arm or right arm and eyes blinking to produce brain signals needed. This technology is believed to be able to have high sustainability as this technology is based on wireless technology and it is improving. Therefore, this technology will has high demand in the future.

Electrical brain activities or EEG signals can be recorded and translate the features of the EEG signals to a command that able to be read by computer. An EGG signal is an electrical brain activity that can be detected using electrodes that attached to the user scalp. An electroencephalogram is a system use to measure and records the human brain activity. It shows the signal of brain over time and it able to evaluate the state of the user brain such as relax, drowsiness, excited and so on.

In this project, it involved four steps which are design a game, signal acquisition, signal processing and game implementation. Firstly, a computer game will be developed using MATLAB software. Secondly, ENOBIO20 will be used as an EEG headset to acquire the EEG signals from human brain through the scalp. The EEG signals will be produced when the subject perform some actions such as look to the left or right, smile, smirk, eye blinking and laugh. Then, EEG signals that produced from those actions will be analyzed and extract the suitable features of signal as a command to the game. Filter is essential and has to be applied as the signal acquired included noise interference which produced distortion in the signal. Lastly, the extracted features of signal will be used to interface with the game by a suitable algorithm developed in MATLAB software. Besides that, an interface between NIC and MATLAB software is developed using MATLAB software to import the EEG signals data.

1.1 Problem Statement

There are humans who are suffering from disabilities such as speaking and mobility issues, especially caused by neuromuscular injuries that striped their muscular tissues. These have lead to difficulty in communication and performing their daily activities. The aim of this project is to develop a new technology to provide an alternative communication by using brain signals for the disabled users as well as general medical application. However, there will be some constraints such as difficulty in maintaining and identifying the brain signals due to interference (power-line noise and electromagnetic) that can affect the brain waves (EEG signals)

acquired [1.2]. Besides that, EEG sensors have poor conductivity and users perform in a noisy environment can affect the performance of the signal [2]. Therefore, applying filter and increase the usage of electrodes can help to reduce the interference (power-line noise and electromagnetic) [1.2]. Then, a conductive gel can be applied on the sensors to increase the sensitivity and users have to relax and perform in quite condition to acquire high and stable performance of signals [2].

1.2 Objectives

The main objective of this project is to develop a mind game using EEG signals. There are few sub-objectives have to be achieved which are:

i. To design a computer game using MATLAB software
ii. To acquire and analyze EEG signal using NIC and MATLAB software
iii. To interface EEG signals between NIC and MATLAB software and the game developed

1.3 Scope of Work

In this project, it focuses on developing a computer game that can be played or controlled by using brain signals or EEG signals. EEG signals will be acquired using ENOBIO20 device and NIC software through the scalp. Then, signal processing methods which are feature extraction, classification and filter to acquire the desired output to trigger the command to control the game. Lastly, MATLAB software will be used to create an interfacing between the NIC software and the game.

CHAPTER II

LITERATURE REVIEW

In this chapter, Electroencephalogram (EEG) and the brain activity are discussed. Many researches have been done on the journals regarding the brain activity and the EEG signals that can be acquired through the human scalp. Besides that, it also discuss the EEG signals apply to the game.

2.1 Electroencephalogram (EEG)

Electroencephalogram is a technique that uses to detect the electrical brain activity using electrodes that attached to the human scalp [3]. Brain activity produces when the brain cells communicate with each other via the electrical impulses. Brain activities are active all the time therefore, EEG recording shows wavy lines. Besides that, this technique is also use to detect the problems of brain disorder. For instances, head injury, memory problems, stroke, sleep disorder, brain tumour and so on. All these diseases can be identified through the abnormal pattern of the brain electrical activity [4].

Then, history of EEG is also discussed. Hans Berger (1873-1941), a German psychiatrist from the University of Jena in Germany, is known as the father of EEG. He had a deep interest in psychophysiology (the study of the relationship between mental processes and the brain). Berger began his exploration by conducting experiments on dogs. Later, he tried on humans such as himself and patients who had lost some of their skull bones in surgery by placing needle electrodes under the scalp. He also experimented on his son, Karl, by using a non-invasive (non-surgical) method. The German term "elektrenkephalogramm" is used to describe the graphical representation of the electric currents generated in the brain. Berger had found that correlation exists between electrical activity of human brain waves and the feelings or emotions (state of mind).

He published his findings in 1929 but it was largely ignored by the scientific community. Many scientists doubted that activities of a complex organ could be recorded through the skull. His conclusions could only be verified 5 years later after British electro-physiologists Edgar Douglas Adam (1889-1977) and Sir Bryan H C Matthews (1906-1986) carried out experimentation and confirmed Berger's findings. In 1936, W. Gray Walter used this technology to identify brain tumour in humans. Berger gained international reputation for his work. [5.6.7]

The system involves attaching electrodes and wires to the person's scalp using adhesive tape. Electrical signals are picked up and sent from the brain cells to the computer or EEG machine through the electrodes. The machine amplifies the signals and translates them into wave patterns on papers or computer screens that are able to be interpreted. The procedures are safe, non-invasive and do not cause any pain to the subject. Due to competency to reveal both the normal and abnormal electrical activity of the brain, EEG is a very useful tool in the field of neurology and clinical neurophysiology.

2.2 EEG Applications

Nabeel Ahammad, Thasneem Fathima and Paul Joseph stated that EEG plays a very crucial role in the medical field. One of the most common uses of EEG in clinical approach today is to monitor and diagnose seizure disorders as well as epilepsy. Seizures involves sudden abnormal and uncontrollable electrical activity in the brain which affects a person's action or feeling for a short time. Epilepsy, brain disruptions caused by unusual electrical activity in the brain, is now one of the most dominant neurological disorders in human beings. It causes a person to have abnormal behaviour, body convulsion and even lose consciousness. [8]

Y.U. Khan, O. Faroq and P.Sharma stated that the epileptic seizures are caused by disturbed brain activity and this causes the normal EEG reading to change. Hence, EEG test is suitable for diagnosing and analysing the disorder because the everyday brain wave patterns of patients with epilepsy tend to be abnormal. [9]

One of the main EEG-related application fields that have been explored include BCI applications to assist disabled people to communicate with machines, BCI applications for video games as game controllers and Neurofeedback games. [10]

2.3 Human Brain

The brain is a very important organ to the nervous system which consists of about 100 billion nerve cells called neurons. These cells convey signals to each other via synaptic connections. Brain acts as the central regulator of all human activities and it is the centre of all human thought, feeling, emotion, movement, and touch, among other facilities. The main parts of the brain are the prominent cerebrum, the cerebellum, and the medulla oblongata. The highest influence to EEG comes from electric activity of cerebral cortex due to its surface position. [12]

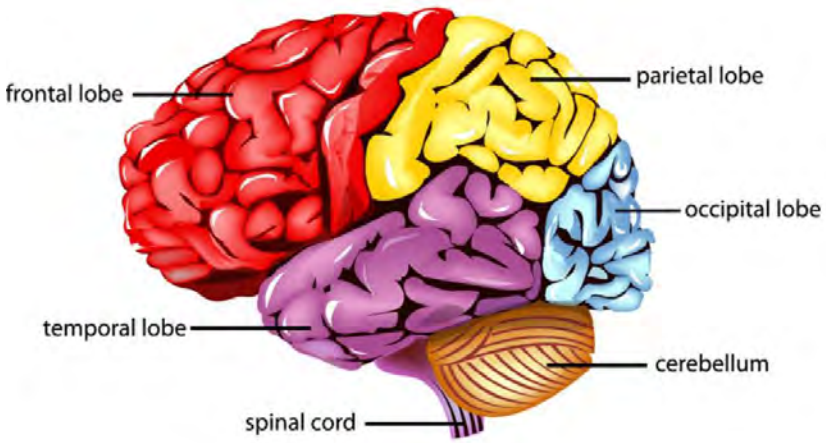

Figure 2.1: Human brain.

Neurons are able to send and accumulate electrochemical signals. A neuron is built like other cells, but the presence of electrochemical enables it to send signals over long distances (up to several meters) and send messages to each other. Neurons are connected to each other through axons, which carry information. [13]

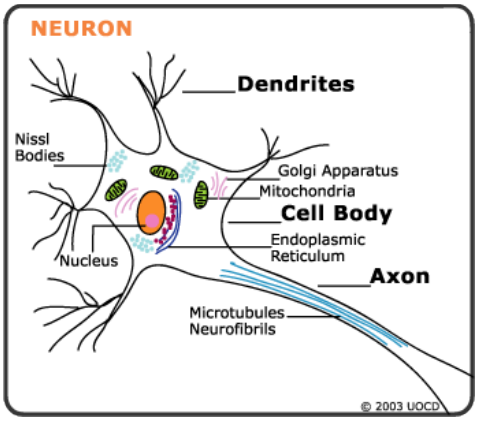

Figure 2.2: Neurons [13].

Local current flows are produced when the brain cells (neurons) are activated during EEG. Using EEG, voltage fluctuations subsequent from ionic current within the neurons of the brain can be measured.