NEUROFEEDBACK HEADBAND CONTROLLER BASED ON EEG SIGNAL

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ABSTRACT

Until recently, the dream of being able to control one's environment through thoughts had been in the realm of science fiction. Today, humans can use the electrical signals from brain activity to interact with, influence, or change their environments. The emerging field of EEG signal, technology may allow individuals unable to speak and/or use their limbs to once again communicate or operate assistive devices for walking and manipulating objects. The brain signals used is the essential components of controlling system. This project discussed the potential uses of an EEG signal which can control external devices. The EEG signal of an alpha waves is utilized for controlling external device and displayed in real-time for further analysis. This project also demonstrate the capability in detecting EEG signal with simple equipment and produce significant results in detecting signal movement. Further processing via Matlab software would unlocked other potential in controlling device using the EEG signal obtained from the sensor.

ABSTRAK

Sejak kebelakangan ini, impian untuk mengawal kondisi seseorang melalui pemikiran bukan lagi berada di alam fiksyen sains. Hari ini, manusia boleh menggunakan elektrik hasil daripada aktiviti otak manusia untuk berinteraksi, atau mengawal persekitaran mereka. EEG adalah teknologi yang boleh membenarkan Individu kurang upaya menggunakan anggota badan mereka untuk berkomunikasi atau mengendalikan alat-alat bantuan untuk berjalan dan memanipulasi objek sekeliling. Isyarat otak adalah komponen penting dalam sistem kawalan. Kami membincangkan potensi penggunaan isyarat EEG yang mana boleh mengawal peranti luaran. Kami juga mempertimbangkan kemajuan yang boleh dibuat dalam beberapa tahun akan datang. Satu penyampaian terperinci prinsip-prinsip asas, keadaan semasa dan prospek masa depan teknologi EEG baru-baru ini diterbitkan.

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CHAPTER 1

INTRODUCTION

Chapter 1 covers the introduction part of this Final Year Project of Degree. It contains subchapters of objectives, problem statements, scopes of project and methodology.

1.1 Electroencephalogram (EEG)

The success of electronics technology has announced its arrival to control most of the equipment in order to assist human to do some task or even help people with disabilities. Most of the existent basic controller need at least a button to control some movement or do some task to get desire output where robot is being used to get the output. Some type of controller that widely used by many researchers is Human-computer interface and one of it is by using EEG signals.

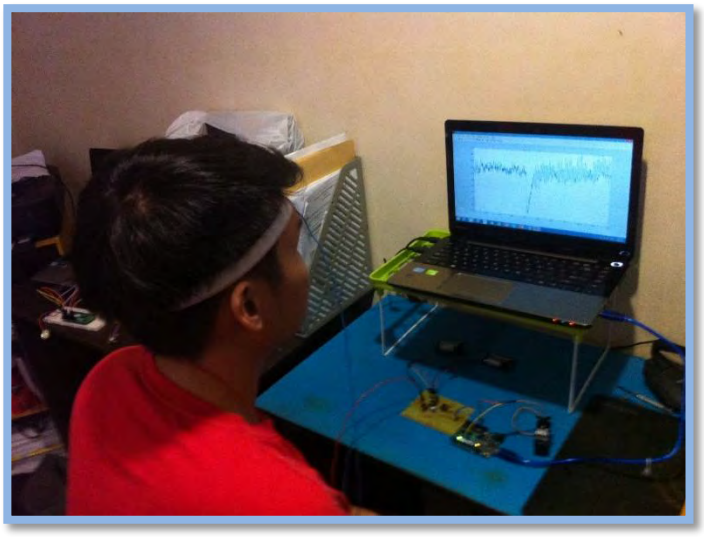

Figure 1.0: The operation and the complete device

With the help of EEG (Electroencephalogram), the controller is at the new kind of technology that have been further study by many researchers. Electroencephalography (EEG) is the recording of electrical activity along human scalp which is brainwave activity that been produce. Inside human brain there are billions of neurons which are electrically charge cell that generate inside. This ability of brain signal is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain that correspond with certain forms of thought.

Researchers have used these technologies to build brain computer interfaces (BCIs), communication systems. A BCI is a computer-based system that acquires brain signals, analyses them, and translates them into commands which this commands are used to drive an output device to carry out a desired action. This kind of interface where users can manipulate their brain activity without using any movement of motor like the existent controller have to produce signals that can be used to control robot or computer to do some task that needed by its user. Normally people have normal brain function that can be used to control assistive devices.

The most commonly used to monitor the brain signal is by using non-invasive EEG technique where the electrode sensor are only place on human

scalp without put it inside human brain although it gives the best signal in order to avoid any artificial implementation inside human.

This Headband Controller use the programmable integrated circuit as main part to interface the brain and the robot. With the use of brain signal, a robot can be control where this type of technology is one of the new kind of technology.

1.2 Objective of project

The main objective of this project is to design, develop and implement the use of EEG signal as a controller where the brain signal as input to drive the robot. The project is aimed to meet the following objectives:

1) To develop a single channel EEG device that can acquire brain signal and display in real-time.
2) To use the EEG signal of an alpha waves for controlling external device.

1.3 Problem Statement

Some EEG device are more complex and also much more expensive and only can be found in hospital for medical use only where it comes in multiple channel and measure different part on human scalp. With this kind of complicated system, it would be difficult to be conducted plus it just only for monitoring the seizure of brain from patient and cannot be used as a command to drive some outputs. There are many type of wave need to be measured with a better and high performance of data acquisition device that are high cost devices.

1.4 Scope of project

The aim of this project is to implement on signal processing method and use brainwave to control robot movement. EEG is used to measure the human brainwave activity which basically an electrical impulses that sense by electrode sensor and then the signal is amplified to monitor after that being process before the signal is use to drive the robot. With the use of instrumentation amplifier to amplify signal from brain by the amplification device. MATLAB is use for processing part and ARDUINI UNO for data acquisition and the main controller that send commands to drive the desired output that indicates the use of brainwave signal.

Figure 1.1: ARDUINO and MATLAB software

1.4.1 The Sensor

There are various type of sensor that can be used to get the signal from brain which are electrode sensor wet and dry, active and passive electrode. In this project dry electrode is being used due to high input impedance electrodes to adequately reject noise and interference rather than wet electrode where need to use gel to get contact to scalp that might be sticky on the head and high noise interference.

Figure 1.2: Example of Active electrode sensor

1.4.2 The Headband

Headband is used to wrap the sensor around human head that ensure the fixed position in order to get good quality signal that measure the electrical signal on the human scalp where the position is a t the back of human head know as occipital lobe. Consist of three wire connected to the sensor which are positive and negative input and also ground.

Figure 1.3: EEG Headband

1.4.3 The Circuit Design

The circuitry part is where the main part where the amplification of signal from sensor is needed to get the signal for processing and also give the command to the desire output. The design of this circuit is using PROTEUS software for simulation before proceed to the fabrication of the circuit on PCB board. There are two part of the circuit which are the amplification part and the main control unit is using ARDUINO UNO as a main board which received signal and do some ADC conversion. The design of amplification circuit are shown below.

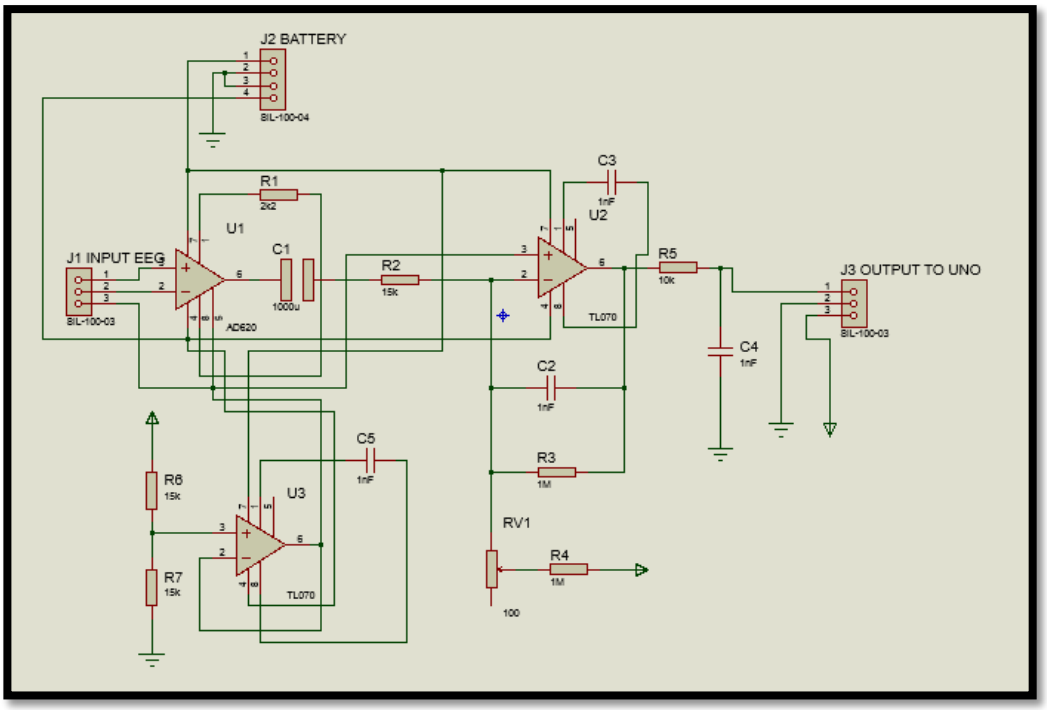

Figure 1.4: EEG Amplifier signal Circuit Design

The AD620 is used as instrumentation amplifier for amplify signal direct from the scalp before drive it to the operational amplifier that sense by electrode. This type of instrumentation amplifier are commonly used in bio-signal amplification.

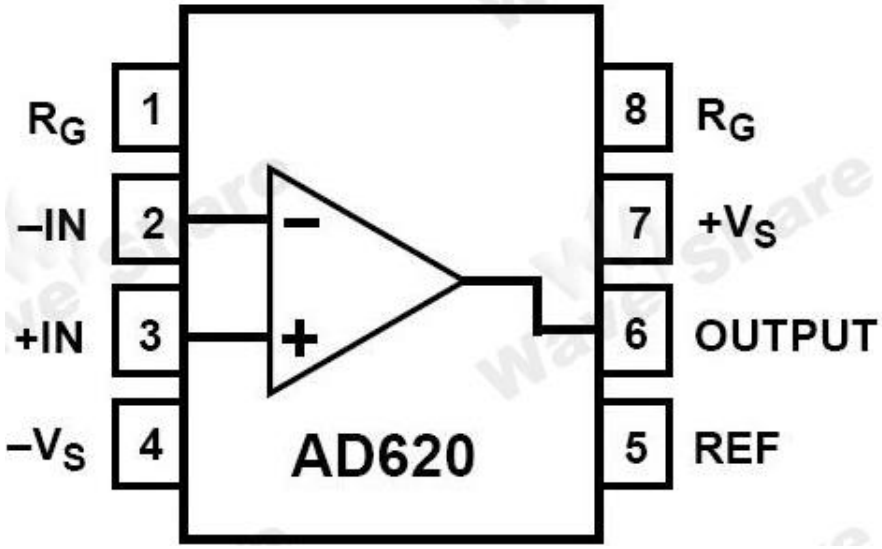

Figure 1.5: AD620 Instrumentation amplifier

1.4.4 The Software Design

For this project there are two main part of software include where the processing part and the main control part which interpret those commands. For signal processing and data acquisition, MATLAB is required to monitor the brain wave activity and the pattern produce by brain. After the signal from brain being translate to some commands, the ARDUINO will sends the commands to drive the robot as desired.

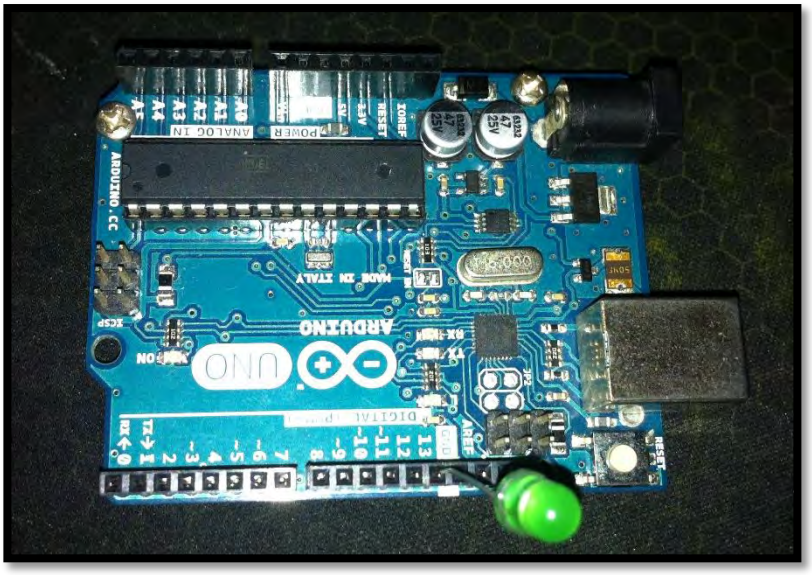

Figure 1.6: ARDUINO UNO

1.5 Project Significant

This project will provide an important new communication and control option for those who have disabilities and might also give those without disabilities a supplementary control channel in special circumstances.

In future, the use of EEG signal with further investigation and research will be more in various application such as to control car movement, have blind people to gain mobility and also to communicate between human through brain.

1.6 Thesis Outline

This report is consists of five parts. For chapter one section concentrates on the project background, problem statement, objectives, scope of project and thesis outline. Chapter two will discuss on the literature review which related in study background. In Chapter three, the discussion will be on the methodology in conducting this project which includes the methods and techniques used. In Chapter four, the results and the discussion will be discussed. Finally, conclusion and recommendation are presented in Chapter five. For the project to be successfully implemented, there are several areas to look in to. The following are the main chapters:

(a) **Chapter I: Study the objectives and scope of work on the project.**
The aim of this project is to design and develop and implement the use of EEG signal as a headband controller where the brain signal as input to drive the robot.

(b) **Chapter II: Literature review in important components and relevant hardware.** Research and read up relevant topics from sources such as reference book, internet and journal will enable to gain more understanding and information for project. Research on similar system in the market and knowing what are the features and capabilities of current products will also provide more information and understanding on the project.

(c) **Chapter III: Project methodology includes the planning, the development of the design and the management of the project.**

This chapter will explain more about the project methodology used in the project. This part will explain more about the project path from the beginning until it is completed. Every work flow that has been done in this project should be explained step by step.

(d) **Chapter IV: Implementation, problems faced and the solution.**

The fourth chapter should focus on hardware and simulation of the design circuit. This chapter also shows about testing process. Testing will be performed on each individual module on both hardware and software of the system.

(e) **Chapter V: Conclusions and recommendations on the project**.

The last chapter will review on the project, whether the implemented solution meet the objective of the project. Discussion on problems encountered, conclusions and suggestions will be included for the future improvements on this project.

CHAPTER 2

LITERATURE REVIEW

Overview of the related works on EEG signal is shown in this chapter.

2.1 Thought Controlled Wheelchair Using EEG Acquisition Device

A wheelchair is designed using BCI technique so that a person with any extent of disability can operate the wheel chair to attain self-independence at least in activities of daily life.

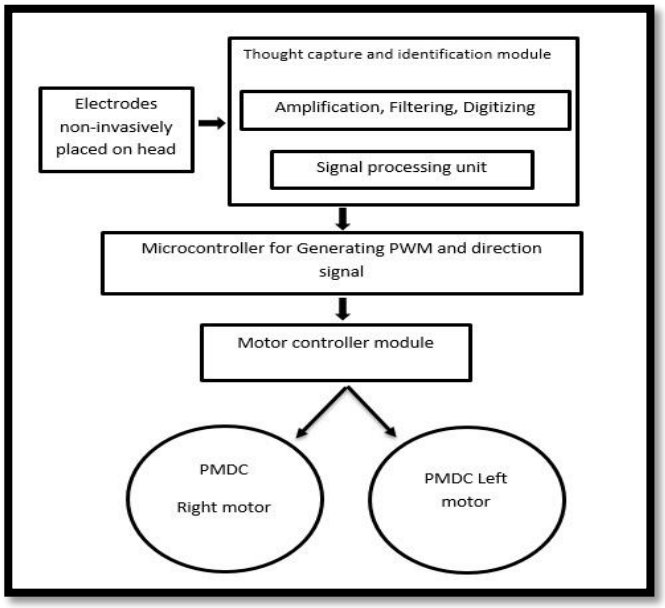

Figure 2.0: Wheelchair system design

The system are divide into four blocks, thought acquisition block, thought transmission block, thought processing block and motor control block. Acquisition of the EEG signal from user scalp and processing it for controlling a wheelchair. EEG scalp potentials obtained are amplified, digitized and transmitted to a processor and after processing the output of the processed signals are used to control the wheelchair.

1) Thought Acquisition Block

This block primarily targets at the careful extraction of the EEG signal from the user scalp. It is made up of different blocks such as instrumentation amplifier, operational amplifier, high pass, low pass and notch filters. The purpose of the instrumentation amplifier is to extract the EEG signal. The extracted EEG

signal is passed through the operational amplifier block for proper amplification. It is then, passed through the high pass, low pass and notch filters. The high pass filter, removes the noise in the signal. Low pass filter extracts the signal frequencies of interest. As DC power supplies are used, one common problem to encounter is the 60 Hz power line signal. This 60 Hz power line signal will distort the EEG scalp potentials. Integration of a notch filter will filter out this undesirable power line signal. This block has been simulated and its details is been explained in the later sections of this paper. One of the disadvantages that can be considered about this system is that users with Slow Cortical Potentials (SCPs) cannot use this system. SCP is a state where the motor reflex of the patient is very slow and hence there is a delay between the mechanical input to the system and thereby a delay in the response of the system.

2) Thought Transmission Block

This block focuses on the transmission of the acquired EEG signal (thought) to a processor. It consists of 12-bit A/D converter for digitizing the EEG signal. The ATMega644 microcontroller is used for UART transmission. This microcontroller is having a 10-bit A/D converter peripheral, which cannot be used because of lesser resolutions. That is the reason we are using an external 12-bit A/D converter. The

FTDI USB RS232 is an Opto-coupler used for electrical isolation to prevent electrical hazards during the transmission of the digitized EEG signal to a DSP as shown in Fig.2.1. It is also used for converting the RS232 signals to USB signals so that this setup can be interfaced to a processor.

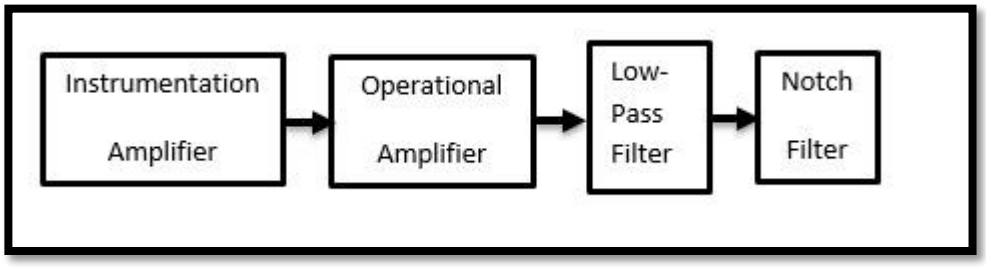

Figure 2.1: Schematic Outlining various stages involved in thought acquisition block