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FINAL YEAR PROJECT II

AUTONOMOUS WHEELCHAIR (MOBILE ROBOT) VIA EOG SIGNAL RECOGNITION

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“I hereby declare that I have read through this report entitle “Autonomous Wheelchair (Mobile Robot) Via EOG Signal Recognition” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”

Signature	:	………………………………………….
Supervisor’s Name	:	………………………………………….
Date	:	………………………………………….

AUTONOMOUS WHEELCHAIR (MOBILE ROBOT) VIA EOG SIGNAL RECOGNITION

WONG CHUI YEE

A report submitted in partial fulfilment of requirements for the degree of Bachelor in Electrical Engineering (Control, Instrumentation And Automation) with Honors

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report “Autonomous Wheelchair (Mobile Robot) Via EOG Signal Recognition” is the result of my own research except as cite in the reference. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………………………..

Name : ……………………………………………...

Date : ……………………………………………..

To my beloved mother and father

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ABSTRACT

The purpose of this study is to use electrooculography (EOG) signal as an alternative controlled technique for wheelchair direction control. The main result for this project is the corneal-retinal potential obtained from the electrodes. Corneal-retinal potential (CRP) is the result of hyperpolarization and depolarization existing between retina and cornea. The amplitude of CRP for this project was collected from 5 volunteers. The CRP was obtained from the electrodes and the signal was then transferred to the Matlab. Three electrodes were attached on skin near eyes region to obtain EOG signal. In Matlab, signal analysis was carried out to attain some information about the signals such as maximum and minimum value of the amplitude of the corneal-retinal potential (CRP). Threshold level is determined based on the features of the signal. Threshold level is used to determine the direction of the wheelchair prototype. The overall of this study is to implement the threshold level set using the CRP collected onto the wheelchair prototype. At the end of this project, a comprehensive report about analysis and discussion made based on the results obtained from experiment is produced.

ABSTRAK

Tujuan kajian ini adalah menggunakan *electrooculography* (EOG) sebagai teknik alternatif untuk mengawal pergerakan kerusi roda. Dapatan kajian utama untuk projek ini adalah potensi kornea-retina yang diperolehi dari elektrod. Potensi kornea-retina (CRP) adalah hasil daripada hyperpolarization dan depolarization antara retina dan kornea. Amplitud CRP untuk projek ini telah diambil dari 5 peserta. CRP itu telah diperoleh dari elektrod pakai buang dan isyarat itu kemudian dipindahkan ke perisian Matlab. Tiga elektrod akan ditampal di muka untuk mendapatkan EOG signal. Dalam Matlab, analisis isyarat telah dijalankan untuk mencapai beberapa maklumat mengenai isyarat seperti nilai maksimum dan minimum ampiltud potensi kornea-retina (CRP). *"Threshold level"* ditentukan berdasarkan ciri-ciri isyarat. *"Threshold level"* digunakan untuk menentukan hala tuju prototaip kerusi roda. Keseluruhan kajian ini ialah untuk menentukan *"threshold level"* CRP yang akan digunakan bagi mengawal prototaip kerusi roda. Pada akhir projek ini, satu laporan komprehensif tentang analisis dan perbincangan dibuat berdasarkan keputusan yang diperolehi daripada eksperimen yang telah dijalankan.

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LIST OF GLOSSARY

JKM	Social Welfare Department
PWD	People With Disabilities
EPW	Electrical Powered Wheelchair
EEG	Electroencephalography
EMG	Electromyography
ECG	Electrocardiography
EOG	Electrooculography
CRP	Corneal-retinal Potential
Mm	milimetre
mV	milivolt
dB	decibel
Hz	Hertz
PA system	Public Address System
IC	Integrated Circuit
BCI	Brain Computer Interface
ERD/ERS	Desynchronization-synchronization
PSD	Power Spectral Density
HHT	Hilbert Huang Transform
FFT	Fast Fourier Transform
ANN	Artificial Neural Network
RMS	Root Mean Square
AC	Alternating Current
DC	Direct Current
USB	Universal Serial Bus
PWM	Pulse Width Modulation

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CHAPTER 1

INTRODUCTION

1.1 Overview

The Person with Disabilities Act (2008, art. 2) defines people with disabilities are person who have long term physical, mental, intellectual or sensory impairments which prevent them from participating the social activities effectively.

Wheelchair is an important communication tool for those who are handicapped and suffered from diseases such as paralysis, Parkinson's disease and Lou Gehrig's disease. With the wheelchair, patients are able to move around and interact with other people. Wheelchairs help people with moving disabilities to help them in sustainable into environment. There are many types of techniques have been applied to the wheelchair in order to ease the patients. The most commonly used technique is controlling the wheelchair by using joysticks or tactile screen. However this technique (using joystick or tactile) cannot satisfy the demands of elderly or patients who have restricted limb movement [1].

Controlling wheelchair by using joysticks requires excellent control from the user [2]. Some users especially those users who suffer from Parkinson's disease or Lou Gehrig's disease face difficulty in controlling wheelchair by using joystick. Patients who suffer from these diseases have difficulty in controlling their limb movement. They have little or no control to their muscle. These patients unable to control their limb motion and hence cannot control the wheelchair by using traditional method which is joystick or tactile screen. Good motor functionality of hand muscle is needed to handle the surrounding region when controlling the wheelchair using joysticks.

1.2 Project Motivation

Patients who suffer from paralysis, Parkinson's disease and Lou Gehrig's disease make them facing difficulties in mobility issues. According to Social Welfare Department (JKM) statistics in August 2010, showed that there are 313685 people with disabilities (PWD) are registered. According to Malaysian Parkinson's Disease Association, it is approximated that about 15000 to 20000 patients suffer from Parkinson's disease in Malaysia. All these patients rely on wheelchair to enable them to interact with environment [1].

The number of people with disabilities (PWD) has an increasing trend in Malaysia, demands for wheelchairs is also increasing. The common type controlled wheelchair is electrical powered wheelchair (EPW). This electrical powered wheelchair (EPW) is controlled by using a joystick. Joystick is the common instrument in controlling electrical powered wheelchair (EPW). User can move to the targeted location by controlling the joystick as shown in Figure 1.1. However, controlling technique using joystick as shown in Figure 1.2 is not convenient for other disabled people such as those who suffer from paralysis, Parkinson's disease and Lou Gehrig's disease. They have difficulties in controlling the joystick because they do not have good motor functionality of hand muscle.

Figure 1.1: Joystick controller [21]

Figure 1.2: Electrical powered wheelchair using joystick controller

Existing hands-free controlled wheelchairs in the market are costly which encourage the development of an alternative method to substitute currently hands-free controlled wheelchairs that are available in the market. EOG signal recognition technique can be developed in a low cost method. Implementation of EOG signal recognition in navigating the wheelchair can help to reduce the cost of the wheelchair and thus it is affordable by many disabled people.

1.3 Hypotheses

Hypothesis is used to determine reason on method selection. Two hypotheses have been made for this project. The first hypothesis for this project is majority of people who suffer muscular and neurological disorders still have the ability to move their eyes. The second hypothesis is shifting of gaze will result a potential and negative potential voltage respectively. Based on these two hypotheses, electrooculography (EOG) signal recognition is proposed.

1.4 Problem Statements

Wheelchair is the common tool for disabled people. The conventional wheelchair (hands-rim controlled wheelchair) and electrical powered wheelchair (EPW) which is controlled by a joystick are not suitable for all types of disabilities for example people who suffer Parkinson’s disease because they do not able to control their hand coordination well thus cannot control the wheelchair using joystick. People with muscular and neurological disorder still have the ability to move their eyes. Therefore, EOG signal recognition technique is developed to help those disabled people with Parkinson’s disease.

When eyes are moving, they will generate a potential difference, known as corneal-retinal potential (CRP). The polarity for this voltage potential obtained is different for different directions. The polarity is positive for right and upward eyes movement while the polarity is negative for left and downward eyes movement.

To navigate the wheelchair using EOG signal, the threshold level of the corneal-retinal potential (CRP) has to be determined accurately. Threshold level is determined through the features of EOG signal obtained. Threshold level can be the maximum, minimum, mean or root mean square (RMS) values of the signal obtained. It has to be very critical in selecting the threshold level. If the selected threshold level is too high, it is very hard to achieve, meanwhile if the selected threshold level is too low, then it will be very sensitive. Any eyes movement will lead to changing in motor direction. Thus, threshold level has to be determined precisely and accurately.

1.5 Objectives

Following are the objectives for this project:

1.) To classify features of electrooculography (EOG) signal.
2.) To develop a controlled wheelchair prototype using electrooculography (EOG) technique.

In order to achieve the first objectives, experiments have to be conducted to obtain EOG signal and analysis has be done to classify the features of EOG signal. A motor based with PIC microcontroller is used to develop a wheelchair prototype. The features extracted from EOG signal is used to control the wheelchair prototype.

1.6 Scope

This project is basically focussing on develop a hands-free controlled wheelchair prototype which is suitable for patients with severe motor disabilities using electrooculography (EOG). Dimension for the wheelchair prototype is 200mm×110mm×120mm (length × width × height). This project proposes the used of wheelchair for those who are paralyse but having the ability for eyes coordination. Movement of eyes produces EOG signal which is then read by EOG kit (Shield EKG-EMG board). These EOG signals are used to control the directions of the wheelchair which are left, right, forward and reverse direction. For those who are motor disabilities that do not have ability for eye coordination will not be covered in this project. Matlab Simulink is the software used to obtain and process the EOG signal. PIC microcontroller is used to program the direction control for wheelchair prototype. Besides, factors such as light intensity colour in surrounding environment and personal conditions for example tiredness, sleepiness and stressed condition will not be included in the consideration in EOG method. The experiment will be carried out in indoor. Place such as laboratory and lecture room to avoid disturbance to the signal. The experiment should be conducted in a silent situation. For volunteers who take part in the testing cannot be colour blindness and night blindness and their age is in the range from 20 to 24 years old.

1.7 Report Outline

The report starts with understanding the motivation of the project, determines the objectives of carrying out this project and then followed by defining the scope of the project. Literature part consists of reading some journals about this topic to gain a rough idea on the method to carry out the experiment. By reading journals, it provides many related information about the project and acts as a guideline to conduct the experiments. The next step is to propose a suitable method to conduct the experiment after reading the journals. The methodology part describes the procedures to obtain results. Results obtained are tabulated. Discussions are made based on the results obtained. In conclusion, it concludes all the results and discussions. Hence it is the part to determine whether the objectives are achieved or not. Suggestions for future work are also included in this report.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Topologies

In this section, simple concept about electrooculography (EOG) will be introduced such as the EOG background, types of EOG signal, and basic components used in obtaining EOG signal will be explained.

2.1.1 Electrooculography (EOG) Background

Electrooculography is a bio-signal which is produced by eye-movements. It is a test to measure the electrical response of the light-sensitive cells (rods and cones) and motor nerve components of the eyes [3]. It is the simplest and the weakest bio-signal that can be obtained from human body. The signal pattern is not quite complex [4]. EOG is the most effective test for the study of the functioning of the vestibular system [5].

EOG is the electrical signal obtained by the potential difference between the cornea and retina of the eyes. It is produced inside the eyeball by the metabolically active retinal epithelium [6]. Electrooculography (EOG) observes the eye-movements [7]. The movements of the eyes can be considered as steady-electrical dipoles which are anterior pole and posterior pole. Anterior pole is cornea which is positive pole while posterior pole is retina which is negative pole [8]. The larger amount of electrically active nerve present in the retina compared to the cornea. This difference leads to the potential difference between cornea and retina which is known as corneal-retinal potential (CRP) [9]. As eyeballs rotate, CRP is produced.

Corneal-retinal potential (CRP) is a result from depolarization and hyperpolarisation existing between the retina and cornea [7].

EOG potential is the resting potential of the retina. The potential is varied proportionally to the displacement of the eyeballs inside the conductive environment of the skull [6]. Depolarization and hyperpolarisation of between retina and corneal produce potential difference across the eyes, which is known as corneal-retinal potential (CRP). In dark condition, photoreceptors are depolarized and continuously active and releasing glutamate to bipolar and horizontal cells. When light arrives, photoreceptors hyperpolarise and amount of glutamate released decreases. Photoreceptors contain light-absorbing pigment molecules. On-centre bipolar cells and off-centre bipolar cells have their own glutamate receptors [17].

i.) Hyperpolarisation

Hyperpolarisation is a process that occurs in the presence of light. When light is present, photons will strike a pigment molecules which causes photoreceptors to hyperpolarise. The photoreceptors receive a photon of light, sodium gates in the membranes of the cell close and neurones become hyperpolarize. When photoreceptors are hyperpolarised, they will release less inhibitory neurotransmitters (glutamate) which then cause the bipolar cell to depolarize. In the presence of light, number of calcium ion channels open is low and thus the rate of neurotransmitter being released is decreased. As bipolar cells are depolarizing, action potential is generated and this in turn causes the ganglion cells to depolarize and generate action potential. Figure 2.1 shows the hyperpolarisation process [20].

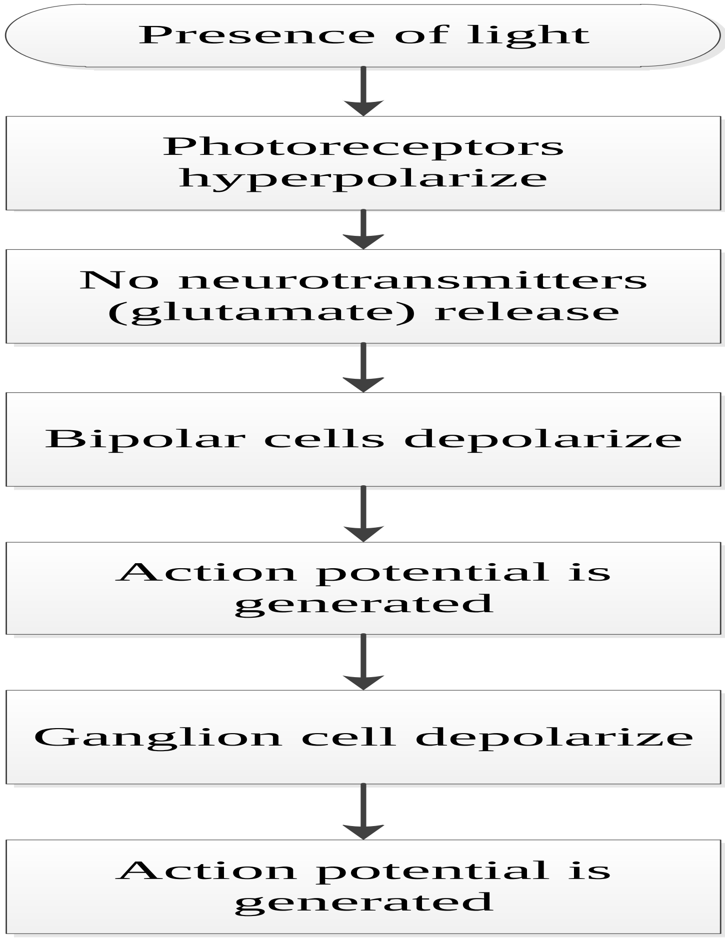

Figure 2.1 Hyperpolarisation process

ii.) Depolarisation

Depolarisation is a process that takes place in the absence of light. In the dark condition, photoreceptors do not receive photon. Under this condition, photoreceptors are depolarized. Depolarization of photoreceptors release inhibitory neurotransmitters (glutamate) which then prevent the bipolar cells from depolarizing. This is because in the dark, numbers of sodium ion channels opened at the synaptic terminal increase which leads to increase in higher neurotransmitters released. Therefore, ganglion cells do not depolarize and hence no action potential is generated. Figure 2.2 shows the process of depolarization [20].