CLASSIFICATIONS OF THE VERTICAL AND HORIZONTAL MOVEMENTS OF ELECTROOCULOGRAPHY (EOG) SIGNALS USING NEURAL NETWORK

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"I hereby declare that I have read through this report entitle "Classification of the Vertical and Horizontal Movements of Electrooculography (EOG) Signals Using Neural Network" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)."

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor in Electrical Engineering (Control, Instrumentation and Automation) with Honours

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle “Classification of the Vertical and Horizontal Movements of Electrooculography (EOG) Signals Using Neural Network” is the result of my own research except as citied in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : Siti Aishah binti Haji Zainal

Date : _____

To my beloved mother and father

ACKNOWLEDGEMENT

First of all, I want to thank to Allah S.W.T for giving me the chance of completing my Final Year Project successfully just in time. I had to face some challenges and problems throughout this final two semesters in completing this subject due to lack of knowledge and information between friends and lecturers about electrooculography, because it is a quite limited field and not everyone knows about it.

Luckily, my supervisor guides me throughout this final two semesters until the end and I would like to give my fullest gratitude and thank you to him, Mr. Wan Mohd Bukhari bin Wan Daud. Thousands of thanks to him for giving me support, assisted me when I'm having problem with Matlab software, explained and suggested to me his opinions on some of the problems that I faced, until I manage to finish this project smoothly.

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And lastly, I am hoping that this project can be helpful to the next researchers in upgrading all the lacks that I did and help disabled people to have a more comfortable and easier life.

ABSTRACT

The study of Artificial Neural Network (ANN) in classifying electrooculography (EOG) signals for the vertical and horizontal movement purpose is mainly to validate that ANN is good in classifying data. Hoping that this study can contribute in helping other researchers in choosing the best classifier for their experiment or project in helping the community of an extreme disable society's life. Also, maybe that someday that this study can help other developer's project to function smoothly and comfortably in order to give a great service not just for disable users, but also to people that have the interest in trying something new. The two main objectives of this study are to classify the features of EOG specifically on cornea-retinal potential and also to evaluate and validate the features extracted using Neural Network. There are a few steps needed to be completed throughout this study before the ANN can be validated as the best classifier. These steps included the study on ANN, extracting the EOG signals on a few subjects, extracting the features of the signals, testing and training the network, and lastly analyze the results. There will be some hardware used in this study, which are NI MyRIO 1900, Muscle Sensor V3 kit and disposable electrodes. Mostly this study focuses more on analysis research on how the feature signal will be classified and analyzed. There are many methods that can be used in classifying EOG signals, but ANN is the simplest yet can give an excellent classification result.

ABSTRAK

Tujuan utama kajian tentang *Artificial Neural Network* (ANN) dalam mengkelaskan isyarat *electrooculography* (EOG) untuk pergerakan menegak dan mendatar adalah untuk mengesahkan bahawa ANN merupakan pengkelasan data yang baik. Dengan harapan bahawa kajian ini dapat menyumbang dalam membantu penyelidik-penyilidik untuk memilih pengkelasan terbaik yang boleh dipakai untuk eksperimen atau projek mereka dalam membantu kehidupan komuniti orang kurang upaya. Dan juga mungkin suatu hari nanti kajian ini boleh membantu pengkaji lain dalam mengembangkan projek mereka bukan sahaja untuk memberi keselesaan kepada orang kurang upaya, malahan juga untuk pengguna yang berminat untuk mencuba sesuatu yang baru. Terdapat dua objektif utama di dalam kajian ini iaitu untuk mengkelasifikasikan ciri-ciri EOG terutamanya pada potensi kornea-retina, dan juga untuk membuat penilaian dan pengesahan terhadap ciri-ciri yang telah dicapai dengan menggunakan ANN. Terdapat beberapa langkah yang perlu diambil sepanjang kajian ini sebelum ANN boleh disahkan sebagai pengkelasifikasi terbaik. Langkah-langkah ini adalah dengan membuat kajian tentang ANN, mengeluarkan isyarat EOG terhadap beberapa orang, mengeluarkan ciri-ciri isyarat, ujian dan latihan terhadap rangkaian, and akhirnya menganalisis keputusan. Terdapat juga beberapa perkakasan yang diguna pakai di dalam kajian ini, seperti NI MyRIO, *Muscle Sensor V3 kit* dan juga elektrod pakai buang. Sebahagian besar tumpuan kajian ini adalah pada kajian analisis tentang bagaimana ciri-ciri isyarat yang didapati kemudiannya dikategorikan dan dianalisis. Terdapat pelbagai cara yang boleh digunakan untuk mengklasifikasikan isyarat EOG, tetapi ANN merupakan yang termudah tetapi dapat memberi keputusan pengkelasifikasi yang terbaik.

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CHAPTER 1

INTRODUCTION

1.1 Overview

According to the Social Welfare Department, the number of registered disabled people in Malaysia had around 445,006 only in the year 2012 alone, but the number could be more than recorded nowadays since the registration is voluntary.

The Minister for Women, Family and Community Development, Datuk Seri Shahrizat Abdul Jalil did said that the needs of the disabled people must be fulfilled and supplied by the authorized department in order to make them feel comfortable to move anywhere and interact with other people freely.

Other than the disabled people, there are people who suffered not just with amputees, but also patients with extreme disability from muscular and neurological disorder like amyotrophic lateral sclerosis (ALS) and spinal cord injury. Even though most of the extreme disability patients can't move half or more of their bodies, but they can still make eye movements and some even interact with their families with just blinking their eyes.

Hence, there are several inventors and researchers starting to develop methods and set up applications that can be used by these patients to communicate with others comfortably without even using too much effort, by just moving their eyes. There are several methods that were developed in order to help these patients' life more independently by using signals from human body, such as electrooculography, electrocardiography (ECG), electroencephalography (EEG), and electromyography (EMG).

1.2 The Study Motivation

There are some people in this world with an extreme disability such as severe cerebral palsy or amyotrophic sclerosis (ALS) patients strip them of the use of their limbs and facial muscles except the eye. Electrooculography (EOG) interfaces let users who cannot move their body, mainly because of their extreme disabilities move a cursor on a computer screen or control the direction of their wheelchair just by moving the eyes and many more.

There are several studies before did a pattern recognition and classification of the EOG signals in order to detect the eye movement, this study will show how much the accuracy in percentage of the EOG signal classifications can get by placing electrodes around the eyes. Usually the electrodes were placed both above and below the eyes or on the left and right sides of the eyes.

The voltage difference is measured between the cornea and the retina and it is due to the large presence of electrically active nerves in retinal compared to the front of the eye. With the cornea acted as positive charged and retina as a negative charged show that the eye acts as a dipole that will result in a negative or positive signal.

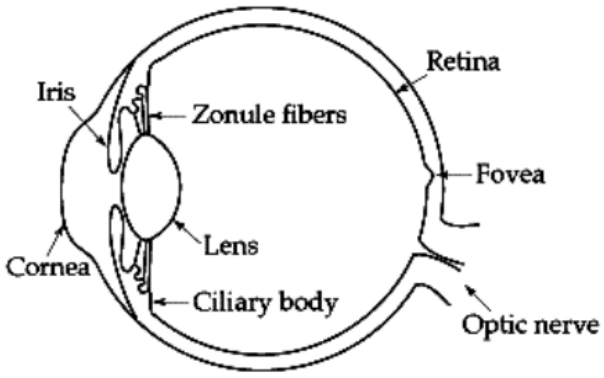

Figure 1.1: Structure of the eye (adapted from Google Images)

For this study, a Neural Network system will be proposed in order to classify the EOG signal gain from the movement of the eyes such as rolling upward, downward, left and right.

1.3 Problem Statement

Some researchers said that eyes are the organ of visions of sense the light and convert it into electro-chemical impulses in neurons and EOG is a very useful system in detecting the eye signal made by the movement of the eyes. Eye motions are sensitive and needs less utilization of physical strength. Specifically, for patients with extreme physical handicaps, eye movement is the last spontaneous movement for them to make a reaction.

Hence, in order to make their life more comfortable, many researchers and scientist shows their interest in recognition of eye motions in years. Hence, there are many methods that can be used to recognize eye motions such as Corneal Reflection Method [1], Limbus Tracking Method [2], Search Coil Method [3] and VTR Method [4]. Before they can recognize the eye motions, the signals must be validate and classified first.

When the eyes move, a potential difference will be generated that can be known as corneal-retinal potential (CRP) and most of the time, the polarity obtained is different for each different directions. To collect the data and record the signals can be quite challenging due to a very small range of the signal amplitude.

The neural network system used for validation and classifications after the features extracted from the obtained signals. In order to classify it, the data obtained must be arrange carefully because it can affect the accuracy percentage of the signals in order to know if the system were suitable or not in classifying the data.

1.4 Objectives

This study embarks on the following objectives:

- To classify the features of EOG specifically on cornea-retinal potential.
- To evaluate and validate the features extracted using Neural Network system.

For the first objective, the features of the EOG signals extracted by using MATLAB software. While for the second objective also using MATLAB software, but by using the neural network toolbox.

1.5 Scope of Work

This study used five subjects with three men and two women, respectively with healthy conditions, and their range of age between 22 to 24, and each subject were tested for five times but only the best signal out of five times of the test were recorded. While for the sensing element a Muscle V3 sensor will be used in order to sense the eye movements from up to down and left to right. To obtain the data, an equipment which is called NI MyRIO 1900 and LabView will be used as an interface to collect the data before it can be plotted as a signal by using MATLAB. And finally, in order to classify the data, the neural network toolbox (nnstart) were used.

1.6 Report Outline

For this study's report, there are five chapters included in order to explain everything. For Chapter 1 is introduction, shows the general information included in every other reports, such as introduction of the studies, problem statements, objectives and scopes.

While for Chapter 2 is the literature review, this chapter will share some previous studies that some are related about the classifications of EOG signals. In this chapter also explain the materials used to detect the eye movement.

Meanwhile in Methodology for Chapter 3 of this studies will explain the procedures from taking the signals of the eye movements, until classifying the data and finally analyze the performance of the classifications. This chapter is important in order to make sure that the work flow is accurate in order to bring out the expected outcome.

In chapter 4 cover the analysis and discussion of this study, and also shows the results obtained from classifying the data and shows some signals from the movement of the eyes.

Last but not least Chapter 5 that discuss about the conclusion for this study. Here, the conclusion was made based on the results obtained and some suggestion for references in the future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Topologies

For this chapter, some explanations about the theory and basic principles about this study will be given, especially about electrooculography, basic components used in obtaining the data, and some about neural network system. Lastly, this this chapter will make a review on some articles and journals of previous study on a similar subject.

2.1.1 Electrooculography (EOG)

Electrooculography is a new technology that record the eye movements by placing electrodes on user's forehead around eyes and the technology's principle are based on corneal-retinal potential (CRP). In a simple term, it is the resting potential between the cornea and retina also known as electrooculogram. An EOG detects eye movement when electrodes placed on the face and it measures the voltage between the electrodes.

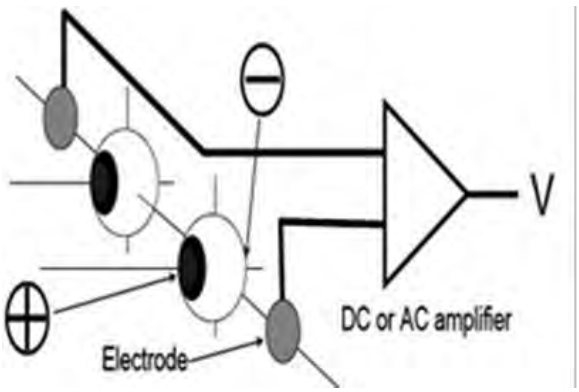

Figure 2.1: Principle of EOG

The electrical signal generate inside the eyeball by the metabolically active retinal epithelium, while the EOG monitor the movement of the eyes and the movement can be expressed as steady-electrical dipoles which are anterior and posterior pole. Anterior pole is the positive pole which is the cornea, while the posterior pole is the negative pole which is the retina.

Between the retina and cornea, there are a large amount of electrically active nerves present in the retina and this difference that people known ad CRP. The CRP produced when the eyeballs rotate, and the potential happened from hyperpolarization and depolarization between the retina and cornea [5].

In the past study, there are researchers did some similar study in developing the help system for people with extreme disabilities increased. Some of their systems are using the videooculography system (VOG) or infrared oculography (IROG) by detecting eye positions using a camera.

Also there is a voice recognition, simply give commands in order to control instruments or robots and the most popular methods is by using joystick to control different applications but it limited to upper body only and it is difficult to accomplish because it needs a fine control [6].

EOG interface has its own advantages because of its simple configuration, being inexpensive, easy to use, reliable and also let users handle it easier and more efficient. And there have been research groups developing and implementing eye gaze interfaces using various methods since 1980's such as IROG, VOG and the limbus tracker.

Normally, EOG signals have the amplitude of 15 to 200uV and the waveform is easy to detect because of the linearity relationship between eye movements and EOG. In order to measure the EOG signal, there will be 4 electrodes placed around the eyes; above, below, right and left of the eye.

2.1.1.1 Hyperpolarization

Hyperpolarization happened when there are lights, then photons will strike the pigment molecules that will eventually cause photoreceptors to hyperpolarize. Hyperpolarize happens when the photoreceptors receive a photon of light that later causing the sodium gates in the membranes of the cell close. The bipolar cell eventually depolarize when photoreceptors get hyperpolarize and release a less inhibitory neurotransmitters. The number of calcium ion channels open is low when light is present causing the decreasing rate of neurotransmitter. An action potential is generated when bipolar cells depolarizing and this causes the ganglion cells to depolarize. [19].

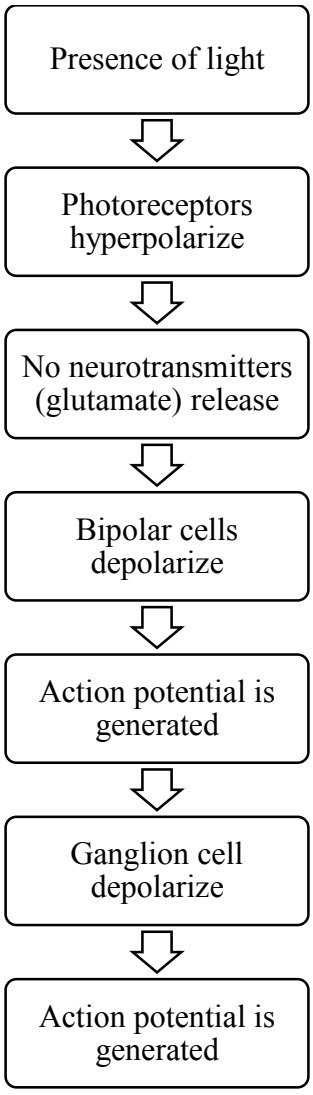

Figure 2.2: Hyperpolarization process