UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NEURO – ASSISTED EXOSKELETON FOR FINGER USING BRAIN CONTROL

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours.

by

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This report is submitted to the Faculty of Electric and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours. The lecture of the supervisory is as follow:

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ABSTRAK

Maklumat daripada *Global Burden of Diseases, Injuries and Risk Factor Study (GBD)* menyatakan, strok adalah tempat ketiga daripada penyebab utama tahun kecenderungan kecacatan diselaraskan (DALYs). Salah satu kecacatan ialah hilang kawalan, lemah atau sakit pada beberapa otot dan sendi seperti tangan dan jari. Pakar perubatan memperkenalkan antara kaedah penyelesaian yang boleh diamalkan ialah fisioterapi yang merupakan sistem perubatan merangkumi pemeriksaan dan rawatan. Salah satu rawatan menggunakan tangan exoskeleton untuk menyokong tangan pesakit untuk membuka dan menggenggam. Pada masa ini, gabungan teknologi antara kejuruteraan dan perubatan berkembang pesat dan menghasilkan banyak peranti berteknologi tinggi yang telah dicipta seperti peranti Electroencephalography (EEG). Peranti EEG adalah pembangunan berdasarkan isyarat EEG yang dihasilkan oleh Neuron dalam sel otak dan peranti EEG ini telah digunakan untuk menggantikan arahan manusia sebagai peranti untuk mengawal alatan seperti motor. Tujuan projek ini adalah untuk membangunkan *Neuro-Assisted Exoskeleton* untuk jari menggunakan kawalan otak dengan mengabungkan teknologi peranti EEG dan exoskeleton. Bentuk gelombang dan isyarat frekuensi EEG dianalisis untuk ditetapkan sebagai isyarat masukan dan dilaksanakan oleh mikropengawal dan maklumat yang diperoleh digunakan untuk mengaktifkan keluaran iaitu motor pada exoskeleton.

ABSTRACT

From the Global Burden of Diseases, Injuries and Risk Factor Study (GBD) the third most cause of disability-adjusted life-year (DALYs) was stroke. One of the disabilities is lost control, weak or even pain at several muscles and joint such as hand and finger. Medical expert came out with solution which is physiotherapy which is medicine system such as examination and treatment. One of the treatments is using exoskeleton hand to support patient hand in order to open and grasping. Currently, advance combination between engineering and medical is expanding rapidly and resulting many high technology devices that have been created such as Electroencephalography (EEG) device. EEG device is a development based on EEG signal that produces by Neuron in brain cell and this EEG device has been used to replacing human command as a device to controlling hardware such as motor. The purpose of this project is to develop Neuro-Assisted Exoskeleton for Finger Using Brain Control by implemented EEG device technology and exoskeleton. The EEG signal pattern and frequency analyzed to set as a input command and executed by microcontroller and the information used to active the output which is motor at the exoskeleton.

DEDICATION

I dedicate this project to Allah Almighty my creator, my strong pillar, my wellspring of motivation, shrewdness, learning and comprehension. He has been wellspring of my quality all through this program and on His wings just have I taken off. I also dedicate this project to my family who has supported me the distance and whose consolation has ensured that I give it everything necessary to complete what I have begun. This project also is particularly committed to my supervisor and co-supervisor, for his ability to manage me to the accomplishment of undertaking for my degree.

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F - Force

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EEG	Electroencephalography
BMI	Brain Machine Interface
BCI	Brain Computer Interface

CHAPTER 1

INTRODUCTION

1.0 Overview

Chapter 1 provides information about introduction of the project. Including research background, problems statement, objective and scope explained in detail to give best over view of the project.

1.1 Introduction of Project

The purpose of this project to developed an exoskeleton that can be control by using brain. Electroencephalography (EEG) used to detect Neurons signal in brain and send the data through wireless device to microcontroller. Next, microcontroller processed and transmitted the data to motor that attached at the finger exoskeleton. These would help certain people how loss their ability to do physiotherapy. Usually finger physiotherapy device used materials that have physical momentum movement such as spring and rubber to help user open or grasp their hand. Furthermore, user needs to force (F) and move a lot their muscle and joint. By implement the EEG device technology, open and grasp hand will be easy as thinking.

1.2 Project Background

The technology of bio-signals such as Electroencephalography (EEG) senses electrical impulses that created by Neuron in brain cell transmit whether it send or receive information to other nerve cells referred as a postsynaptic potential[1]. Billions of Neuron cell communicated to each other in our nerve system. All electrical impulses send along Axon has specific pattern and frequency. This specific pattern and frequency are very useful signal that can be used as input signal and processed by control device such as computer to perform a specific output task.

EEG was use replacing human command as a device to controlling tools such as machine developed by researcher. This technology is a direct communication between the user brains with external devices that allows the user performs a specific task in multi situation without physical command. The combination of science and medical created an advance technology and dramatically increase together with requirement and demand towards future investment Science purpose especially medical rapidly uses this technology to help certain people to do physiotherapy exercise. It is very important for most people that have arthritis to get physiotherapy treatment. Arthritis cause hurt in some specific body part or more general joint and muscle pain. Helped by physiotherapists, professionals healthcare team to guide patient. However, overdoing this exercise can increase the pain at joint or muscle.

Therefore, with all information about brain control technology, exoskeleton and physiotherapy treatment, developing the neuro – assisted exoskeleton for finger using brain control is the solution. The project designed to allow the exoskeleton support the hand to open and grasp. This project used only brain wave as an input to rotate the motor attached at the exoskeleton and prevent the muscle for overdo or forced. An arduino used as a microcontroller to be a main processor between input and output. By implementing wireless communication, Bluetooth module HC-05 used to transmit the signal from EEG device to processor.

1.3 Problem Statement

From the Global Burden of Diseases, Injuries and Risk Factor Study (GBD) the third most cause of disability-adjusted life-year (DALYs) was stroke[2]. One of the disabilities is lost control, weak or even pain at several muscles and joint such as hand and finger. Medical expert came out with solution which is physiotherapy. Physiotherapy means a physiotherapeutic medicine system that includes examination, treatment, counseling and directions for repairing physical damage by accelerating the healing process and reducing pain and rigidity[3]. But all this treatment involved high cost that should be bore by patient.

By purposing this Neuro-Assisted Exoskeleton for Finger Using Brain Control project, patient will be able to do physiotherapy exercise without human assist at their own home will save a lot of cost and time. Plus, patients only need to think because of this project use brain cell wave to move the exoskeleton hand. In other hand, this activity not only increases the healing of hand muscle but also improve the health of brain cell.

To implement the brain control in a system is not easy, there are five types brainwaves that need to be study. Therefore, this project used EEG device to detect the frequency and the pattern of brainwave. Furthermore, it use microcontroller to synchronous data between the frequency and the output.

1.4 Objectives

There are 3 main objectives that focused in order to achieve this project successfully:

The objective is stated as below:

1) To study the brain frequency and brain wave patterns by using Electroencephalography (EEG) device.
2) To implement EEG device as an input signal for controlling the motor of the exoskeleton finger movement.
3) To analyze the suitable EEG signal values for controlling the motor of the exoskeleton finger.

1.5 Scope

Work scope will focused in implementing the low cost prototype that can be used in medical based. The project will be focusing in controlling the exoskeleton finger in order to open and grasp hand. Plus, transmitting the EEG signal to the microcontroller by wireless system. Furthermore, the purpose is to study the suitable range of brainwave frequency needed for an input signal.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

While the first chapter explained the background of the study, this chapter contain the literature review of the study and upgrading of a control strategy for exoskeleton finger using brain control. Plus, previous, current project and thesis also attached.

2.1 Project Research

2.2 A Wearable Hand Exoskeleton for Activities of Daily Living and Neurorehabilitation

This project joining wearable mechanical exoskeletons and human machine interfaces called MANO and invented to help and rebuild hand functions of disability persons to do activities of daily living (ADL) by providing motor assistance. Next, the project focused on designing light and soft exoskeleton, excluding systems that have bulky, hard and unportable constructions. Plus, with excluding the entire element giving advantages of light and soft exoskeleton arm that comfort the user while wearing. In other hand, all this characteristic causing high cost in designing only for exoskeleton arm excluding other components.

Bowden cable also been used at this project in two different way which is, it used as motion communication and secondly the exoskeleton hand mechanism component. This method gives some advantages such as, it allowed the remote positioning of the actuators with regard to the wearer's arm, to the advantage of lightweight and low-profile constructions on the limbs. Furthermore, user freely can adjust the exoskeleton hand freedom angle

Furthermore, this project actuation control and power supply storage units of this project located inside a chest-pack. This is because to allow user sitting on chair to lay back against the chair and relax their body and muscle. By using a flexible cable such as bowden cable as shown in Figure 2.2, the mechanical energy or force by the movement transmitted from an inner cable relative to a hollow outer cable cover. Bowden cables used to connect between the chest-pack and the exoskeleton. This cables also used as link to the linear servomotors that move the exoskeleton.

Figure 2.2 Bowden Cable

The controller element contains of a microcontroller which is Arduino Mega 2560 R3 that runs the firmware of the system, and of a custom printed-circuit board holding a Bluetooth radio module HC-06, for wireless communication with external devices. The linear actuators provide a standard 3-wired interface for radio-controlled servomotors, allowing the application of closed-loop position control

through the transfer of pulse-width modulated (PWM) references by the microcontroller. The LiPo battery H2B180 used as a power supply for the system that provides autonomy of up to 3 hours in constant process mode (continuous opening and closing of five fingers).

2.3 Development of Hand Rehabilitation System for Paralysis Patient – Universal Design Using Wire-Driven Mechanism

This exoskeleton is a rehabilitation type and suitable for patients who are suffering from contracture and paralysis [4]. There are two main components in this project, first is the hand exoskeleton that move the index finger of the injured hand. The second one is the components act as an input signal for the exoskeleton which is a data glove that is linked to another healthy hand and sends the input data for controlling the hand exoskeleton. This system called "Self-motion control" strategy.

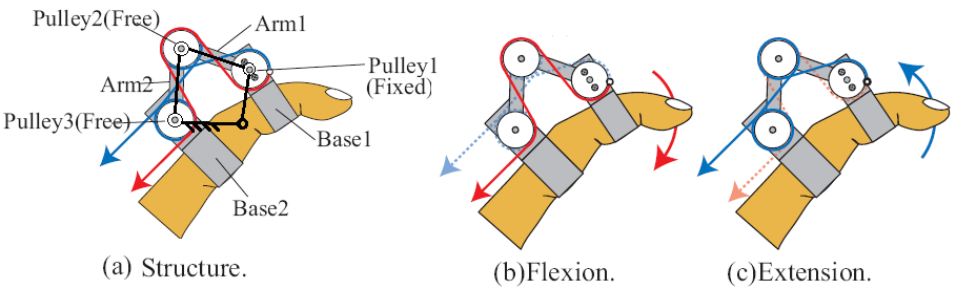

Figure 2.3 The phalanges is based on a four-bar mechanism scheme

All mechanism controlled though a wire-driven directly or indirectly. Motor connected to the actuated pulley by the wire driver mechanism as shown in Figure 2.3. The movement of the cable leads to the turning of the pulley that effects in a rotation of the human finger. Thus, to move three finger joint this project uses two motors.