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LAPORAN PROJECT SARJANA MUDA

DESIGN AND DEVELOPMENT OF MOTOR CONTROL USING EMG-FORCE SIGNAL

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Bachelor of Mechatronics Engineering

May 2014

“ I hereby declare that I have read through this report entitle “Design and development of motor control using EMG-force signal” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Mechatronics Engineering)”

Signature : ....

Supervisor’s Name : ....

Date : ....

DESIGN AND DEVELOPMENT OF MOTOR CONTROL USING EMG-FORCE SIGNAL

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle "Design and development of motor control using EMG-force signal" is the result of my own research except as cited 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 : ....

Date : ....

To my beloved mother and father

ACKNOWLEDGEMENT

In preparing this report, besides searching for related article and journal, I also get in contact with many people inside my University, including lecturers, researchers and colleagues. I have learned many knowledge and they have greatly contributed to me by triggering the new ideas. I wish to express my sincere appreciation to my main project supervisor, Dr. Muhammad Fahmi bin Miskon and my friend Mohammad Ihsan bin Sabri. They has helps me a lot by giving me suggestion, opinion and guidance, helping me finish this report..

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ABSTRACT

Electromyography signal also called EMG signal, it is generated in our muscle when our muscle unit is contract or expand. The high speed progression in technology has made us possible to detect the EMG signal and use it as the control signal for other applications. This report describes the development of position control of DC motor with encoder by using EMG signal from biceps brachii muscle. EMG signal is received by using sensor, sending it into microcontroller for feature extraction and classification process. Elbow joint angle is mapped with the EMG signal and the rotation angle of DC motor is synchronized with joint angle. Experiments were conducted to analyze the relationship between joint angle, torque and EMG signal. Results showed that additional torque can increase the signal to noise ration in the equipment. For the relationship between joint angle and EMG signal, it exists 2 type of shape and the mathematics model between each respondent is different. A new mapping method has been designed in this project. It map the EMG signal to joint angle by identify the closest EMG value that represent respective joint angle. Result shows that it can classify the EMG signal but calibration needs to be done to counter the fatigue factor.

ABSTRAK

Isyarat Electromyography juga dipannggil isyarat EMG, ia dihasil dalam otot kita apabila otat kita kembang atau kontrak. Teknologi yang semakin memaju telah membuatkan kita dapat mengesan isyarat EMG dan menggunakan ia untuk aplikasi yang lain. Laporan ini menceritakan kawalan DC motor pengekod dengan mengunakan isyarat EMG dari otot bicep lengan kita. Isyarat EMG akan direkodkan mengunakan sensor, hantar ia ke mikropengawal untuk ekstrak ciri-ciri yang terdapat dalam isyarat dan klasifikasi proses. Sudut siku akan dipetakan dengan isyarat EMG dan sudut pusingan DC motor akan menyegerakan dengan sudut siku. Eksperimen akan dijalankan untuk menganalisis hubungan antara isyarat EMG, tork dan sudut siku. Keputusan menunjukkan bahawa tork akan meningkatkan nisbah isyarat kepada bunyi. Bagi hubungan antara isyarat EMG dan sudut siku, ia didapati terdapat 2 bentuk graf dan model matematik antara responden adalah berbeza. Permetaan yang baru telah dicipta dalam projek ini. Ia mempetakan isyarat EMG kepada sudut siku dengan mengklasifikasi isyarat EMG yang terdekat yang mewakili sudut siku. Keputusan menunjukkan ia boleh mengklasifikasi sudut siku tetapi penentukuran perlu dijalankan untuk menyelesaikan isu keletihan.

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LIST OF SYMBOLS

N	-	Sample size
V_T	-	Terminal voltage
E_A	-	Induced voltage
I_A	-	Armature current
R_A	-	Armature resistance
k	-	Constant
ω	-	Angular velocity
ϕ	-	Magnetic flux
τ	-	Torque
F	-	Force
r	-	Radius
m	-	Mass
g	-	Gravitational force, 9.81 m/s
Θ	-	Angle (degree)

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Stroke is a kind of brain attack that occurs when there is a disrupt in the blood supply to the brain. According to National Stroke Association of Malaysia (NASAM), stroke is the third largest cause of death in Malaysia[1]. Every year, there is estimate 40000 people suffer from stroke. One of the effects of stroke is the disability of certain part of body and it depends on which part of the brain is damaged. Based on the stroke statistics from University hospital, New Jersey, stroke is the main cause of disability among adults in US[2]. Rehabilitation needed to be done to improve patient's body function so that they can become independent to the other. Nowadays, therapist can get help from artificial device in rehabilitation process. Human exoskeleton interaction can be done in 3 methods. The first method is by brain activity or Electroencephalography (EEG), the second method is using muscle signal or Electromyography (EMG). The last method is generation of the assisting exoskeleton movements.

Robot is suitable to be used in rehabilitation because it can provide precise movement, able to collect data from the user performance[3]. Recent technologies have made it possible to use robot as the assistant to the therapist. It can assist therapist to conduct rehabilitation programs without monitored by therapist and can work for a long time. One of the example is rehabilitation robot which named PolyJBot from Tong and Hu [4]. It was developed to assist stroke subjects to actively train their wrist, elbow and ankle using their EMG signal as the intention driven signal. Figure 1 shows the exoskeleton robotics training device from Hong Kong Polytechnics University. It is targeted for stroke patients and allows them control the robotics fingers by using their own surface EMG signal.

Figure 1: Exoskeleton robot training device

1.2 Problem Statement

The characteristic of EMG signal should be studied before it could be applied to control the rotation of a motor. Information like joint angle and torque can be obtained in EMG signal. However different people will have different muscle firing frequency, ratio of slow to fast-switch fibre, fatigue status and muscle unit, hence the EMG signal can't directly compare across the subjects. To control the position of the motor, the relationship between the EMG signal, torque and position have to be study before using it to control the motor actuator.

Researched questions are described as below:

a) What are the available features that could provide the most accurate and easiest mapping between EMG-force signal and joint angle?

b) What is the relationship or mathematic model between EMG signal and joint angle?

c) How to map the EMG-force signal to the arm's joint angle in real time for different user?

d) How to synchronize the motion of motor actuator to our arm by minimum error and smoothly?

1.3 Project Objectives

The objectives of this project are defined as below:

a) To study the relationship between joint angle, torque and EMG-force signal

b) To synchronize the rotation angle of motor and elbow joint angle by mapping EMG-force signal from biceps brachii muscle.

1.4 Scope of the Project

The scopes of works are described as below

a) 4 respondents are selected for experiment 2 and 3. All EMG signal are retracted from biceps brachii muscle in right arm by using disposable surface electrode.

b) All experiments are carried under minimum fatigue condition. The experiments are focused on isometric contraction (static position).

c) The rotation angle of DC motor actuator and elbow joint angle is limit from 0 to 90 degree only.

1.5 List of Contribution

The contribution of this thesis is:

a) Development of a new mapping method that can accurate synchronizes and maps the joint angle and EMG signal in real time and suitable for different user.

b) Development of a new method to control a DC motor by using human arm motion.

1.6 Outline of Dissertation

This report contains detail information of the methodology of the project and the material we using in this project. Chapter 2 is literature review. It contains background theory and some result that related to this project by other researcher. In chapter 3, research methodology, experiment setup, the feature and characteristic of material used will be showed. The detail procedure about the conduction of experiment will also discussed in chapter 3. Chapter 4 shows the results that have been generated. Any analysis, discussion or calculation that involved will be present here. Conclusion of the result will showed in chapter 5. The list of item used, programming coding and its flow chart will be attached in appendix.

CHAPTER 2

THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Theory of motor control using EMG-force signal

This section introduces the EMG signal, signal processing, Surface EMG (SEMG) collection, feature extraction, pattern classification and model of human upper limb. Figure 2 shows the block diagram of actuator control system using EMG-force signal.

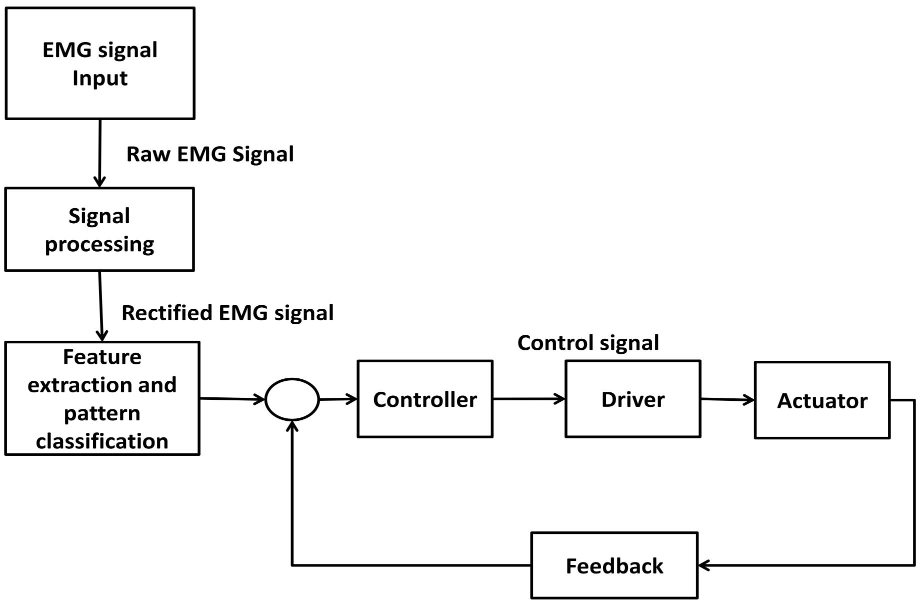

Figure 2: Block diagram of motor control using EMG-Force signal

2.1.1 Electromyography (EMG) signal

Electromyography (EMG) refers to recording of muscle's electric activities [5]. It also is an experimental technique concerned with the development, recording and analysis of myoelectric signals. Figure 3 shows the raw EMG signal during muscle contraction.

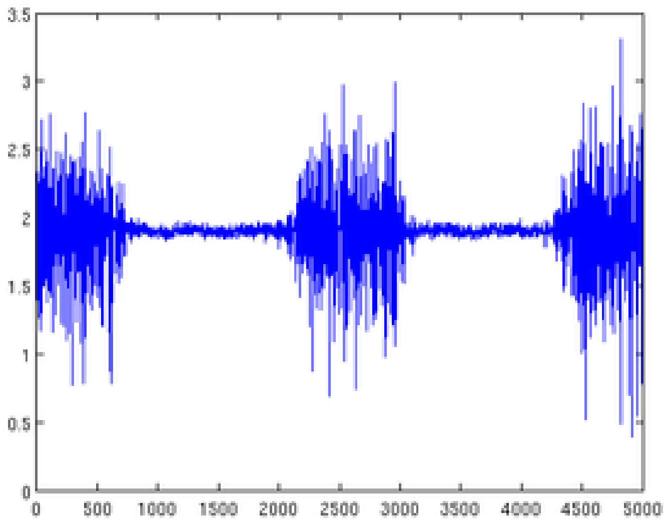

Figure 3: Raw EMG signal

Myoelectric signals are formed by physiological variations in the state of muscle fibre membranes. The amplitude of EMG signal is depends on the muscle contraction. The stronger the contraction of the muscle, the higher the amplitude of EMG produced by that muscle. Dynamic action like rotating joint angle or static action like holding the load can increase our muscle contraction. Other than that, the shape and amplitude of EMG also depends on amount of motor unit and firing rate, hence different people will have different amplitude and shape of EMG signal.

2.1.2 Signal Processing

Since raw EMG signal has very low voltage, typical EMG electric potentials is between 50 µV up to 20 or 30 mV in amplitude[6]. Practical EMG signal contains some noise due to the influence of electronic component and the electric power cable, it has to go through signal processing unit before we can process it. Raw EMG signal has to amplifier, go through band pass filter to filter the noise. Normally frequency of surface EMG ranged from 0-500Hz, but only 50-150Hz is the useable energy[7]. Controller like microcontroller and Arduino can't process negative voltage signal. To easier the analysis process, the entire negative signal have to be eliminated. There are 2 methods to eliminate the negative signal, one is by full rectification process, and the other one is by adding offset voltage into the signal to neutralize the negative signal [8].

2.1.3 Surface EMG data collection

EMG signals are measured within the muscle tissue itself or at the external derma by means of either needle or surface electrodes. Electrodes are sensors that detect electrical potential generated inside the nerves and muscles[9]. Even though EMG signal which recorded by needle is more accurate than surface electrodes, however modern researcher more prefer to surface electrodes as it is more convenient and bring no pain to respondents.

There are 2 types of electrode that can be used to capture the surface EMG signal, unipolar electrode and bipolar electrode. Unipolar electrode is a type of electrode which only requires one electrode to capture the signal. For the bipolar electrode, it requires 2 electrodes, 1 of the electrode placed in the centre of the muscle to capture the muscle signal while another electrode placed in the end of muscle to acts as the reference point. The output is the difference of voltage level between those 2 electrodes.

The high impedance between our skins and surface electrode will weaken the signal received by electrode. To improve the performance of the surface electrode, the skin surface should be watch and cleaned using alcohol. Hair should be shaved to increase the touching area between the surface electrode and our skin.[10] Electrolytic gel like silver chloride gel is used to improve the contact between the electrode and the skin, it act as the medium to easier the transfer of electrons from skin to electrode.

Position of electrode plays a main part in getting an accurate result. Different set of muscle have different locations for the electrode. Figure 4 shows the location for biceps brachii muscle.

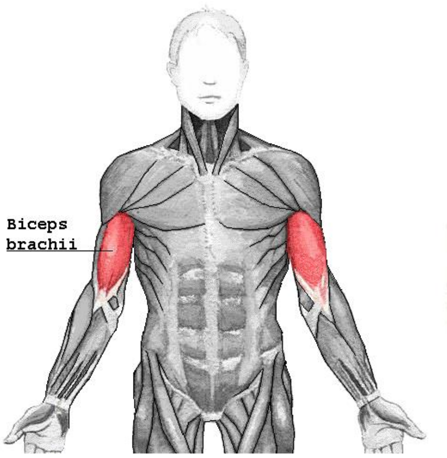

Figure 4: Biceps brachii muscle

Based on recommendation of SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) on biceps brachii, it is recommended that the signal electrodes to be placed on the line between the medial acromion and the fossa cubit at 1/3 from the fossa cubit, while the reference electrode placed on or around the wrist[11]. Figure 5 shows the location of the electrode for biceps bacchii muscle which recommended by SENIAM. Another method is placed the reference electrode 2cm parallel from the signal electrode[12]. This method is applied to decrease the effect of muscle belly dislocation due to the flexion activity. It also act as a standardize method when involves more than 1 respondents.