Faculty of Electrical Engineering

ANALYSIS OF SPINAL EMG SIGNAL WHEN SWINGING AN OBJECT

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A report submitted in partial fulfill the requirements for the degree of Bachelor of Mechatronic Engineering

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DECLARATION

"I declare that the report entitles "**Analysis of Spinal EMG Signal When Swinging an Object**" is the result of my own research except as cited in the references. The report has not been accepted for any degree and it is not concurrently submitted in candidature of other degree."

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APPROVAL

"I hereby declare that I have read this report entitles "**Analysis of Spinal EMG Signal When Swinging an Object**" and in my opinion this report is sufficient in terms of scope and quality for the award of degree in Bachelor of Mechatronic Engineering."

Signature :

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Date :

DEDICATION

Specially dedicated to

My beloved mother,

To my family and friends

Thank you for all the encouragement and support

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ABSTRACT

Electromyography (EMG) is a bio signal record the electricity generated by muscles during muscle contraction. Due to lack of research that emphasis on the recognition of EMG signal at spinal muscle, robotic or rehabilitation studies faces difficulties in designing the best response to overcome spinal injuries. Moreover, the surface EMG is affected by the noise environment, inconsistent due to bodily fatigue and inaccuracy of surface EMG pattern recognition. For data gathering, the MVC normalization method is applied to determine the spinal EMG signal on lumbar multifidus muscle when swinging an object. The MVC test shows that a higher percentage of MVC resulted in higher normalized amplitude. In order to analyse the identical and recognition of spinal EMG signal, three statistical analyses are done. One-way ANOVA analysis shows that the means value among all 15 subjects are different in the % MVC test. In addition, RMS analysis indicates that the muscle activity is increased when the muscle contraction is increased. In boxplot analysis, it shows that the increment of percentage MVC resulted in greater median, normalized amplitude and the interquartile range. Besides, this paper presents a further investigation on determining the average median and interquartile range difference from 0% until 100% MVC by applied 8^{th} order Gaussian function in curve fitting and exponential weight moving average filter in boxplot analysis. The 8^{th} order Gaussian function shows the greatest difference in median and lowest difference in interquartile range when there is an increment on the percentage of MVC, thus it produces more identical and consistent data after go through boxplot analysis. Furthermore, the median is the best feature in the boxplot analysis to show the difference in increment of %MVC. Additionally, this works also found that the thicker fat layer affects the strength of the signal received from the muscle.

ABSTRAK

Electromyography (EMG) adalah satu rekod isyarat bio elektrik yang dihasilkan oleh otot semasa penguncupan otot. Kerana kekurangan penyelidikan yang menekankan pengiktirafan isyarat EMG pada otot tulang belakang, kajian robotik atau pemulihan menghadapi kesukaran dalam mereka bentuk jawapan yang terbaik untuk mengatasi kecederaan tulang belakang. Selain itu, EMG dipengaruhi oleh persekitaran bunyi bising, tidak konsisten akibat keletihan badan dan ketidaktepatan pengiktirafan corak permukaan EMG. Untuk pengumpulan data, kaedah normalisasi MVC digunakan untuk menentukan isyarat EMG tunjang pada otot multifidus lumbar apabila manghayon objek. Ujian MVC menunjukkan bahawa peratusan yang lebih tinggi MVC menghasilkan amplitud normal lebih tinggi. Dalam usaha untuk menganalisis pengiktirafan serupa dan isyarat EMG tulang belakang, tiga analisis statistik telah dilakukan. ANOVA sehala analisis menunjukkan bahawa nilai cara di kalangan semua 15 subjek adalah berbeza dalam% ujian MVC. Di samping itu, analisis RMS menunjukkan bahawa aktiviti otot bertambah apabila pengecutan otot bertambah. Dalam analisis boxplot, ia menunjukkan bahawa kenaikan peratusan MVC menghasilkan median, amplitud pulih dan julat antara kuartil yang lebih besar. Selain itu, kertas kerja ini membentangkan siasatan lanjut untuk menentukan median dan perbezaan julat antara kuartil dari 0% hingga 100% MVC dengan menggunakan 8^{th} order Gaussian function dan exponential weight moving average filter dalam analisis boxplot. 8^{th} order Gaussian function menunjukkan perbezaan yang paling besar dalam median. Apabila terdapat kenaikan pada peratusan MVC, ia menghasilkan data yang lebih sama selepas melalui analisis boxplot. Tambahan pula, median adalah ciri terbaik dalam analisis boxplot untuk menunjukkan perbezaan dalam kenaikan %MVC. Tambahan lagi, kerja ini juga menunjukkan lapisan lemak tebal memberi kesan kepada kekuatan isyarat yang diterima daripada otot.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The purpose of this report is to analyze the EMG pattern recognition in spinal muscular. Electromyography (EMG) is defined as an evaluation and recording of the myoelectric signal from the skin surface. Myoelectric signal is a signal that generated by muscle electrical activity [1]. Almost 85% of the caregivers are experienced in lower back pain and the prevalence of low back pain shows an increment in the point prevalence of 57.9%, 49.5%, and 35.1 % in 12 months, one month, and in 7 days respectively among automotive industry worker. The overall number of humans who had gait disabilities risen together with the needs of appropriated rehabilitation treatment. In the past 100 years, a lot of rehabilitation treatment had been proposed. With EMG, patients with spinal control injury were able to recover their sensory motor function [2]. Recently, there were a lot of robots involve with EMG pattern recognition such as robotic arms and a wheelchair controlled by human brains. So, EMG pattern recognition has the ability to mimic human. But there were a lot of researchers reported of having difficulties to achieve high accuracy signal due to noise environment and robustness of EMG pattern recognition [3], [4].

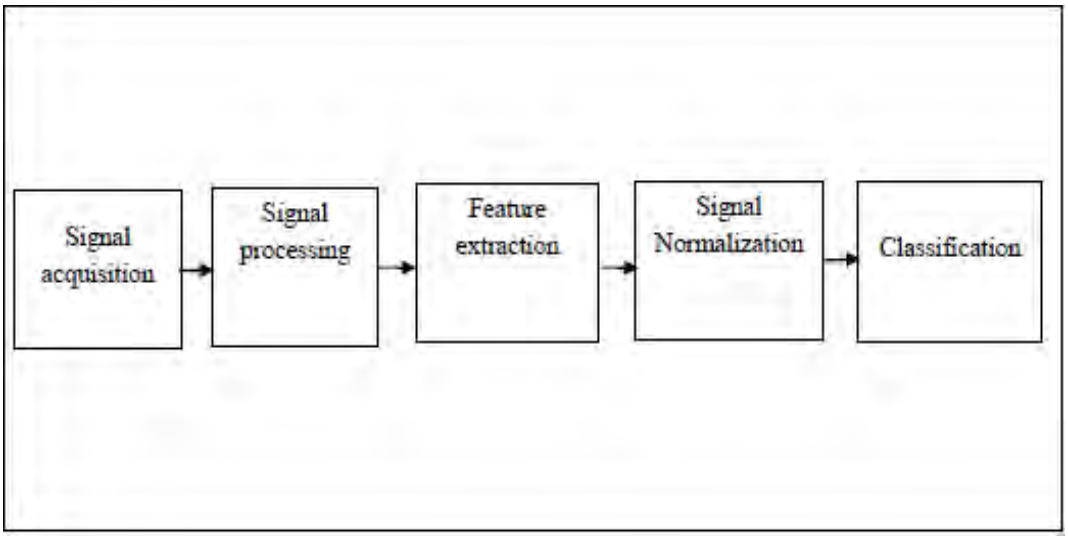

Figure 1. 1: Block diagram of electromyography pattern recognition [5]

By referring the block diagram in Figure 1. 1 , signal acquisition is a process to measure the EMG signal. Signal processing is a process of transferring of the EMG signal. Feature extraction is an important in extracting the valuable information from EMG signal. Normally, feature extraction will easily affect the accuracy of the result due to error and noise. Lastly, signal normalization is another challenge process and it is important in generalized all EMG data acquired from inter and intra samples [5].

1.2 Motivation and Significant of Study

Every year, there will be 12 to 53 humans with new spinal injury over the million populations and there was a monthly case of spinal injury occurred at Sarawak General Hospital. The ratio of men with spinal injury is higher than women and most of the patients are still young. The spinal cord is important to control the movement of the body. Therefore, the EMG is developed in order to help the patient with spinal injuries in physiotherapy. This research will contribute the method for data acquisition and analysis of the EMG signal. Besides, develop a feature which was more robust to noise in order to achieve high accuracy of the EMG signal. Moreover, with the involvement of EMG in robotic, robot has the ability to mimic human especially in motion. Lastly, the robot was able to use more effectively in rehabilitation, therapy, and medical test.

Recently, researcher was focused on the development of an upper limb rehabilitation training system [6], the relation between surface EMG signal and ideal motor muscle [7]. Besides, some of them focus on improving the process speed and response of EMG device [8], [9]. In addition, the investigation on the performance with the implement of two electrode system in electromyogram detection was also done[10]. Due to lack of research that emphasis on the recognition of EMG signal at spinal muscle, robotic or rehabilitation studies faces difficulties in designing the best response to overcome spinal injuries.

1.3 Problem Statement

This section contains an elaboration of the problem on surface EMG when applied to human motion. The surface EMG is affected by the noise environment and its feature was not robust. The robust feature of EMG signal determines the noise depend on the strength of the signal. According to Thongpanja et al., 2016, the transformation of measure EMG signals into a reduced set of features is normally extracted in time domain and frequency domain [4]. However, the robust features of surface EMG still didn't meet the expectation until today.

Furthermore, inconsistent due to bodily fatigue affected the capability of the surface EMG pattern recognition. Fatigue inconsistency happened at different times due to different subjects. In addition, environmental issues such as temperature and humidity result in inconsistency fatigue. Thus, the time taken for a resting period between each %MVC test must be taken into consideration.

Lastly, the inaccuracy of surface EMG pattern recognition affected the results. The review shows that a lot of researchers having difficulties in getting high accuracy of surface EMG pattern recognition [4], [11], [12].

1.4 Objectives of Research

From the research questions in the problem statement and in order to achieve the aim, two objectives were highlighted.

1. To implement 8^{th} order Gaussian function in Curve Fitting and Exponential Weight Moving Average Filter to the spinal EMG signal.
2. To analyze the spinal EMG signal using statistical analysis methods which are one-way ANOVA, RMS and boxplot analysis.

1.5 Scope of Research

The following are the list of scopes:

1. The experiment was done in the laboratory.
2. Subjects of experiment were between 20 to 30 years old and they must be healthy males.
3. All subjects must not have any accident history on their spinal.
4. Experiments only focus on lumbar multifidus muscles located at spine.
5. Bipolar electrode was used to collect the EMG data.
6. The analysis was done by using Matlab.
7. The experiment focuses on swinging.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the description on EMG system overview which consists of the theoretical background of EMG, muscle organization, surface electromyography and lumbar multifidus muscle. The review presents the experiment methodology on surface EMG testing and muscle identification. Besides, the robust feature of surface EMG is clearly shown. Lastly, it discusses on factor affects and influence the EMG signal. Research shows that mostly the factor affects the results of the surface EMG experiment is the accuracy pattern recognition of the EMG signal. At the end of this chapter, the method of surface EMG experiment and knowledge are presented.

2.2 Theoretical background

In this subchapter, the theory and principle of electromyogram (EMG), muscle organization and human spinal anatomy are reviewed.

2.2.1 Electromyogram (EMG)

Electromyogram (EMG) is a bio signals that recorded the electrical activity produced by muscles at rest and during muscle contraction. When there is an exchange of ions pass through the muscle fibre membrane, an electrical current is generated. Generally, the electrical current generated by active muscles usually proportional to the level of muscle activity. Electromyography is a method used to evaluate and record electromyogram signal. Simplest way to understand EMG signal is the way muscles generated bioelectric signal, spinal cord and muscle anatomy [3], [13], [14].

2.2.2 Surface Electromyography

Surface electromyography is a technique used for electrical recording and analyzing of muscle activity from the skin surface. Besides, surface EMG is the most common method of measurement and it is non-invasive electrical recording that recorded procedure obviates the need to infiltrate the skin. Superposition of the large number of transients having semi-random temporal and spatial separation is the results from surface EMG. For surface EMG, the electrodes and EMG sensors are attached to the user skin and the detection of abnormalities and activation level of human development is done by analyzing the shape, size and frequency of motor unit potential produced by muscle fiber [1], [15].

2.2.3 Muscle and Motor Units

Motor units (MUs) are a group of muscle, which consist a large number of muscle fibers. It is known as the basic level of the neuro motor system of motor and they are controlled by a single motor neuron. The electrical stimulus travels down the motor neuron to activate the muscle fiber by the change in polarity travels down neuron and liberate neurotransmitter from terminal [1].

Muscle contractions cause by motor neuron simulations. Muscle contractions divided into three categories which are isometric, concentric and accentric. Isometric contraction happened when muscle contractions attend upon muscle length. Concentric contraction results in muscle shortening. Muscle lengthens take place during accentric contraction. Isometric contraction is different compared to concentric and accentric contractions thus they are known as un-isometric contractions [1], [16].

Process that motor units selected to take part in muscle contraction is known as recruitment process. It is a process that motor units build up a small number of muscle fibers are engaged and larger levels of contraction necessitates involvement of motor units incorporating an ample number of muscle fibers [1], [7].

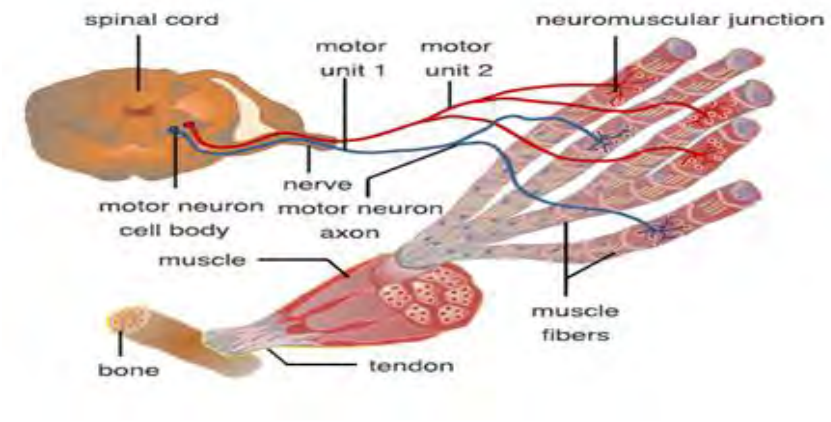

Figure 2. 1: Motor neuron and motor units [1]

2.2.4 Lumbar Multifidus Muscle

Lumbar multifidus muscle is one of the back muscles. The most outstanding superficial back muscles are latissimus dorsi and trapezius and they are related to upper limb movements. Lumbar Multifidus Muscle is a small and powerful muscle and it provides support to the spine. The adjacent vertebrae are connected to each other from the cervical to the lumbar region by multifidus muscles. Besides, multifidus muscle begins to contract prior to actual movement before an action is performed [17], [18]. As the result, lumbar multifidus muscle is suitable for surface EMG.

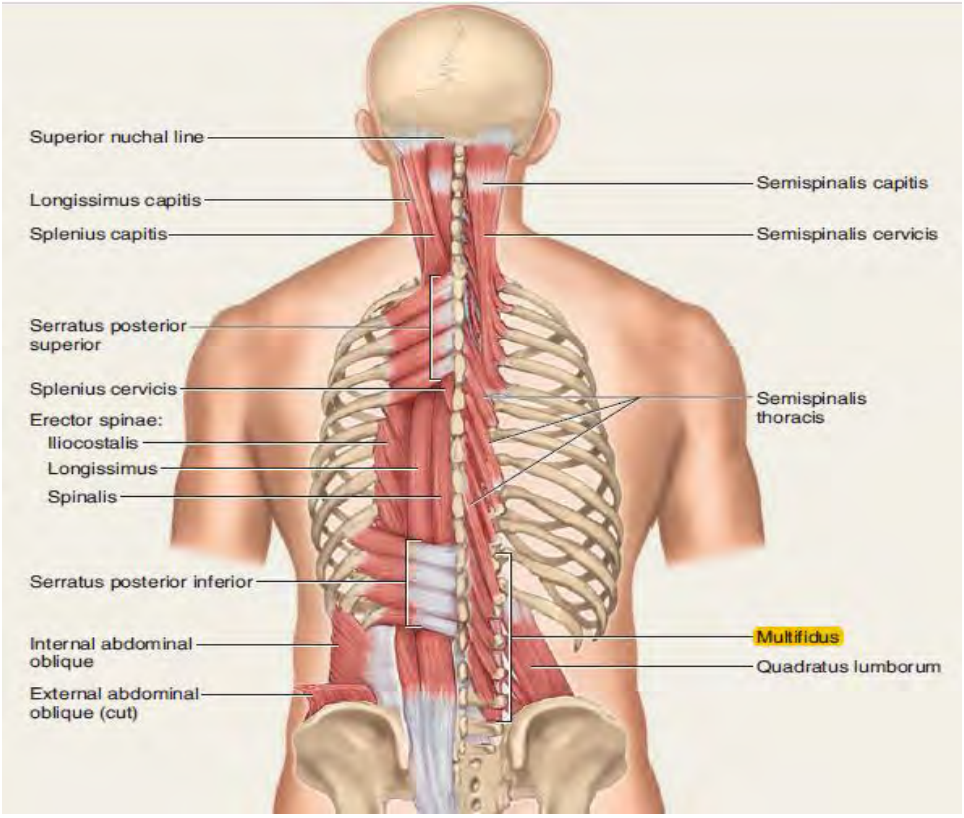

Figure 2. 2: Muscle Acting on the Vertebral Column [18]

2.3 Experiment Methodology

2.3.1 Subject

There are 6 to 14 subjects included males and females are participating in this study. All subjects were provided informal consent before the experiment. All subjects were required to make sure their healthy states were in good condition. Age of subjects should be in the range of 20-30. All the detail such as age, weight, height, gender, perimeter of biceps brachii muscle when contracts, perimeter of biceps brachii muscle when extends, pulse bits and length of the hand from the subject have been recorded [15], [19]–[22]. But the research shows that the number of samples is not sensitive enough, thus the number of sample had to increase for a better result.

2.3.2 Pre-Experiment

All equipment is prepared and placed simultaneously to the subjects. This set-up is able to save the time and avoiding the tiredness of the subject [21]. Devices such as multiple-channel surface EMG system as surface EMG recording of forearm and muscles of subjects. Before electrode placement, subject took several minutes to rest, then put alcohol to shave the skin of a subject, lightly abraded and cleaned it. All the above methods must be conducted to prevent any harm to the skin from rubbing [2], [15]. The time taken for the samples to rest had to be long enough to make sure samples had a good performance on tests and increase the accuracy of data collected.