SURFACE ELECTROMYOGRAPHY FEATURES EXTRACTION FOR PROSTHESIS CONTROL PURPOSES

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"I hereby declare that I have read through this report entitle "SEMG Features Extraction For Prosthesis Control Purposes" 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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I declare that this report entitle "SEMG Features Extraction for Prosthesis Control Purposes" 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 : ……

Date : ……

To my beloved mother and father

For their endless love, support and encouragement

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ABSTRACT

Daily routine can be so much different for amputees as they having hard time to balance their movement. As the technology went advance day by day, an amount of research has been pursued to overcome this matter. The study of pattern recognition of hand movement for prosthesis control purpose has aim to contribute in improvise the amputee‟s life after undergoing such unfortunate experiences in life. With hope that the device will more similarly function like a normal people‟s movement, plenty of method were discovered in order to enhance any possibility that might achieved. This study ensures two main objectives which are to extract the features of hand movement for surface electromyography (sEMG) in time domain and frequency domain. It is also to analysis and evaluate the features extracted using Wavelet Analysis. The focus for this bio signal approach is using the low density surface electromyography (sEMG) is more suitable to analyze the muscle bio potentials over an entire muscle belly. Throughout the processes, the subjects will be taken amongst three healthy men with same age but different body weight. The experiment will be conducted with several movements with three times of repetition. So, the first step will be to identify the suitable sensing element to gain the signal from the muscle activity. After that, implementation on the data acquisition by transmitting the data obtained to the computer‟s software MATLAB in order to display the signal outcomes. This study is generally more to analysis research where the feature signal obtained will be extracted in desired features and to be analyzing with suitable Wavelet Analysis. Finally, by selecting the applicable method, this study may leads to improvement at same field in future as well as helping the amputee‟s life in a better way.

ABSTRAK

Rutin harian boleh menjadi begitu banyak yang berbeza untuk orang yang kurang upaya kerana mereka mengalami kesukaran untuk mengimbangi pergerakan mereka. Dengan kemajuan teknologi pada masa kini, sebanyak penyelidikan telah dilaksanakan untuk mengatasi permasalahan ini. Analisis mengenai pengiktirafan corak pergerakan tangan untuk tujuan kawalan prostesis telah berhasrat untuk menyumbang dalam menambah baik kehidupan amputee selepas menjalani pengalaman malang seperti itu dalam kehidupan. Dengan harapan bahawa peranti tersebut akan dapat menyerupai pergerakan manusia, pelbagai kaedah telah ditemui untuk meningkatkan sebarang kemungkinan yang boleh dicapai. Kajian ini berpaksikan dua objektif utama iaitu untuk mendapatkan ciri-ciri pergerakan tangan untuk Electromyography permukaan (sEMG) dalam domain masa dan domain frekuensi. Ia juga untuk analisis dan menilai ciri-ciri yang diekstrak menggunakan Analisis *Wavelet*. Daripada tajuk, menyatakan bahawa pengiktirafan corak untuk berketumpatan rendah sEMG, ia adalah kerana bahawa ketumpatan yang rendah sEMG lebih sesuai untuk menganalisis potensi bio otot lebih perut otot keseluruhan. Sepanjang proses, mata pelajaran yang akan diambil di kalangan tiga lelaki yang sihat dengan umur sama tetapi berat badan yang berbeza. Eksperimen akan dijalankan dengan beberapa gerakan dengan tiga kali pengulangan. Jadi, langkah pertama adalah untuk mengenal pasti elemen penderiaan yang sesuai untuk mendapatkan isyarat daripada aktiviti otot. Selepas itu, pelaksanaan pengambilalihan data dengan menghantar data yang diperolehi kepada perisian MATLAB komputer untuk memaparkan hasil isyarat. Kajian ini secara umumnya lebih kepada penyelidikan analisis di mana isyarat ciri yang diperolehi akan dikeluarkan dalam ciri-ciri yang diingini dan untuk menganalisis dengan Analisis wavelet sesuai. Akhir sekali, dengan memilih kaedah yang terpakai, kajian ini boleh membawa kepada peningkatan di bidang yang sama pada masa akan datang serta membantu kehidupan amputee dengan cara yang lebih baik.

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CHAPTER 1

INTRODUCTION

This chapter will give a brief explanation of the theory and application of the surface electromyography (sEMG) signal. Other than that, this chapter will show the purpose of this study and the problem that can be solved from this study. Lastly, the objective was set to ensure that this research will fulfil its target while the scope will explain on the limitation as well as to ensure that this research will always be on track based on the criteria chosen.

1.1 Research Background

The prosthesis may be referring as a device designed to replace a missing part of the body or to make part of the body work better. Diseased or missing eyes, arms, hands, legs, or joints are commonly replaced by prosthetic devices. The evolution of prosthetics is a long and storied history, from its primitive beginnings to its sophisticated present, to the exciting visions of the future. Times flown away as the development in other areas, numerous ideas and inventions have worked and been expanded upon, such as the fixed-position foot, while others have fallen by the wayside or become obsolete, such as the use of iron in prosthesis. Since 1500 B.C. until now, this prosthesis leg has been evolving through such a long and winding path for better outcomes. There have been many refinements to the first peg legs and hand hooks that have led to the highly individualized

fitting and casting of today's devices. Throughout all the efforts of the improvement, the Egyptians were the early pioneers in this field. But way different than now, back then their determination on installing the prosthesis was only for completion form of their body but not the mere function. Mostly, the materials were made of fibre with the similarly design.

For every plight, man seeks solutions by moving toward modern times. Today's devices are much lighter, made of plastic, aluminium and composite materials to provide amputees with the most functional devices. In addition to lighter, patient-moulded devices, the advent of microprocessors, computer chips and robotics in today's devices are designed to return amputees to the lifestyle they were accustomed to, rather than to simply provide basic functionality or a more pleasing appearance. Prostheses are more realistic with silicone covers and are able to mimic the function of a natural limb more now than at any time before. Mentioned by Scott Summit in an article, “Designer limbs must represent personality as well as physicality” [1]. This clearly stated that a prosthesis device for upper or lower limb should be synchronizing with the amputees in terms of function, comfort and movement.

The low density electromyography (EMG) with high surface area is suitable for muscle bio potentials analysis mostly over an entire muscle belly; by that mean it will be able to provide the ultimate response from the muscle activity. Muscle activity are one of the bio signal that generated by human body which will yield information that might be useful for healthcare purposes. Different characteristics were studied based on time and frequency, and were subsequently combined into pairs with fractal analysis, used for low level schemes [2]. As the electrical activity converted to signal where it will be amplify and altered into a signal that is free from any noise. After that, the pattern recognition will classify the data based on statistical information extracted from the patterns. Through the pattern recognition strategies, patterns are transformed into commands that run the device where adaptability, portability and a better response time are wished. In order to find a suitable set of features extracted from the surface electromyography (sEMG) signal, there are plenty of methods based on its energy and complexity rather in time or frequency domain or even time-frequency domain such as Wavelet Analysis.

This study will be focus on the features extraction from the raw signals obtained. The features extracted will be interpreted in time and frequency domain such as the Root Mean Square (RMS) and Standard Deviation (SD). The Wavelet Analysis will be applied

in order to analyse and evaluate the signals collected. In some researches done previously, it illustrated that when combined decoding with a high degree of accuracy, the intention of the motion generated by the subject can interact with the device, using least amount of information, low computational cost, high sensitivity, specificity and high recognition rate in a short response time [3]. Development related to this field were done and has been proposed which entails obtaining a system that can allow the recognition of hand gestures when executed simultaneously by the subject, without any noticeable delay for the user. Subsequently, a new system is expected to obtain a similar recognition level with surface electromyography (sEMG) signals captured from amputees. Finally, once the complete system is obtained, different studies on cognitive learning for healthy people and amputees can be carried out using a real prosthetic hand.

1.2 Project Motivation

As it well-known, amputation in the term of medicine is a process of removal any part of the body as to be exact the removal of a part of or an entire limb, either upper or lower extremity. Nowadays, the reasons for this surgical step are injury, infection, tumour, diabetes or insufficient blood supply. At the earliest amputations, were performed mainly to remove dead tissue which for some reason of unable to control the blood loss only due to the limitation of surgical techniques. In order to let the amputees experiences lives like a normal person, the prosthesis devices are quite important. As the time flies, the evolution of these prosthesis devices has been enhancing to ensure that the application may able to imitate the movement of a person. Therefore, the surface electromyography signal plays an important role in gaining the activity of the muscle. The pattern recognition is a branch of artificial intelligence concerned with the classification or description of observations. Technically, it will aim to classify data based on the movement of the muscle‟s extraction or extension. The analysis technique used is the Wavelet analysis which each of the signals from the muscle activity will be divided into different frequency components and each of it will be match with resolution. Generally, the signal will be shifted and scaled. Each of the

movement will be tested several times to ensure its characteristic precisely. Hence, the motivation of this project is to decide the best method to analyse the pattern of the hand movement. In addition, determination of the movement also can be one of the motivations of this study. Lastly, the motivation of this study is also related to how the surface electromyography (sEMG) can contribute its function in designing prosthesis equipment.

1.3 Problem Statement

The human history has been accompanied by accidental trauma, war, and congenital anomalies. Consequently, amputation and deformity have been dealt with, one way or another, throughout the ages. This study related to the identification of different hand gestures from electromyography (EMG) signals from rearm muscle, to be used as human machine interface system in hand prosthesis which is the ultimate solution in bringing a new form of hope to the amputees. Though, in all efforts the prosthetic arm could not achieve the target to become as complete as human normal hand. This has limited their life capabilities and may cause troublesome to another person to help them to live as a normal person. Therefore, a proper analysis of muscle behaviour is necessary.\

This study will be specific the process of electromyography (EMG) which measures muscle response or electrical activity in response to a nerve‟s stimulation of the muscle. The electromyography (EMG) signal based reliable and efficient hand gesture identification can help to develop good human computer interface which in turn will also increase the quality of life of the disabled people. Studies has shown that the importance of the electromyography (EMG) in the ability in diagnose muscle disorder and the rehabilitation in people especially to those who experiences the traumatic amputation.

Hence, the use of surface electromyography (sEMG) is to do the analysis of the behaviour of muscle when force is applied to it. The surface electromyography (sEMG) signal will be extracted to obtain the characteristic of the muscle and will be evaluated by using statistical analysis, such as scatter plots to produce information for the other

researcher to develop a better prosthetic arm. From the previous researches, the data collected which was the electromyography (EMG) has quite small amplitudes level. This might also become errors during the experiment. Besides, the subjects may also have the different bio signal produced by the body. Not only have that, the factors like the noise interference, skinned preparation, and muscle exhaustion and the placement for the sensors will also effect the signals efficiency. So, attention must be stress out during the data collection.

1.4 Objectives

This study stated the following objectives to be achieve:

- To extract the features of hand movement for surface electromyography (sEMG) in time domain and frequency domain.
- To analysis and evaluate the features extracted using Wavelet Algorithm.

1.5 Scope of Work

This study will mainly focus on the feature of hand movement for surface electromyography. The experiment will be performed on 3 male subjects with a healthy condition without any amputation. Each subject will undergo the same activities for three times for comparison purpose. Next, the sensors will be placed at the muscle involved which are the flexor carpi radialis muscle and the extensor carpi radialis muscle. Some delay time will be allowed to avoid any muscle fatigue. After the data is collected, the signals will be transmitted to the software to display the graph in MATLAB. As the

objectives, the features extractions are in time domain and frequency domain. All the results will be listed at the end of this study.

CHAPTER 2

LITERATURE REVIEW

This chapter will elaborate about the theory and basic principles about the project. At first, this chapter will briefly explain regarding each main topics of the title given such as the pattern recognition to surface electromyography in term of their function and the relation to prosthesis application. In this chapter, some explanation related to the muscle involved, electrodes, sensors and so on. Later on, the chapter will also describe about several author‟s articles form the previous study about the similar subject.

2.1 Theory and Basic Principles

2.1.1 Pattern Recognition

Pattern recognition is familiar to everyone, it has a long history. Pattern recognition is a subject researching object description and classification method, it is also a collection of mathematical, statistical, heuristic and inductive techniques of fundamental role in executing the tasks like human being on computers. In a sense, pattern recognition is figuring out actual problems via mathematical methods. Based on the research, pattern

recognition undergoes an important developing for many years. It is include a lot of methods which impelling the development of numerous applications in different filed. The practicability of these methods is intelligent emulation. Relate in this matter, stated that the design of surface electromyography (sEMG) pattern recognition system undergo few levels which are the sensing element of the signals, pattern of the movement classes, feature extraction, classification method and any errors encountered during the data collection [4].

2.1.2 Electromyography (EMG)

Electromyography (EMG) signal is a bio medical signal derived from neuromuscular activities of skeletal muscle [5]. This bio signal has been contributing information regarding human body conditions which are quite useful for clinical purposes and engineering applications [6]. In biological term, electromyography (EMG) is a form of signals measured from the muscle electricity which generated by the activation of the muscle motor units. Technically, electromyography (EMG) is a complicated signal that may confront noises while travelling through tissues under the skins [7]. The nervous system controlled the electromyography signal which is completely the muscle bodily property. Hence, whenever the muscle tissues strike an electrical current, those activities were called as the muscle action potential.

Meanwhile, in this study the use of surface electromyography (sEMG) was applied during the data collection. In order to approach those potential, this surface electromyography is a way of collecting the muscle action potential as it is the summation to Muscle Action Unit Potential (MUAP). This surface electromyography (sEMG) is widely used in many other applications, including other clinical biofeedback applications such as surface electromyography (sEMG) biofeedback in physical rehabilitation. This surface electromyography (sEMG) is basically a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. The main contributor to this bio-signal from body movement was related to motor unit which consists of motor neuron and muscle fibre. Human body has a build-in low pass filter

which consists of connective tissue and skin layers. The phenomena cause the surface electromyography (sEMG) to cause the firing frequency to produce the non-originality to electromyography (EMG) signal firing and amplitude signal characteristic.

The useful side of using this surface electromyography (sEMG) is that it able to measure a large are of the depolarization [8]. Based on what Peter Konrad wrote [8], there two types of electromyography (EMG) signal the non-invasive and the invasive electromyography. From that, the non-invasive is known as surface electromyography where an electrode placed on the skin. While the invasive or intramuscular requires needle as the electrodes that being inserted into the muscle. It was explained by Gregory S. Rash that, surface electromyography (sEMG) only applies at superficial muscles and indwelling paste on profound muscles [9]. Another opinion from previous study stated that, this technique is less harmful compared to the intramuscular [10]. After several surveys, it is clearly that numerous scholars has been conducting experiments with surface electromyography (sEMG) as it causes no harm on patients, flexible signal processing, effective bionic control and highly potential application [11]. Studies have been made related to this surface electromyography recording for further improvisations. This matter was proved by the previous case where it shows that new approach has been gathered in attempts to understand surface electromyography (sEMG) such as AR Modelling, Statistical Pattern Recognition techniques, Discrete Wavelet Transform and Artificial Neural Network [4].

2.1.3 Features Extraction

Features extraction is a method to obtain information from the collected data which is the raw signals. It is always been the first step before performing an analysis or classification stage. In the processes, this features extraction will eliminates the unwanted noise or disturbances and store the desired information. The signals gathered can be represented in three ways of domain which are time, frequency or time-frequency domain [12]. For time domain, it can be defined as the signal‟s amplitude versus time. While