UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ELECTROMYOGRAPHY (EMG) SIGNAL ANALYSIS FOR MANUAL LIFTING IN INDUSTRIAL APPLICATION

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

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DECLARATION

I hereby, declared this report entitled “Electromyography (EMG) Signal Analysis for Manual Lifting In Industrial Application” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor Degree of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

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ABSTRACT

This study discusses about the analysis about Electromyography (EMG) signal from the waist and lower part of the body during manual handling activities. Manual handling is any activity that requires a person to use his own forces to lift, carry, push, pull, move or hold anything. It includes work involving repetitive activities and awkward postures as well. Industry nowadays involves all workers either engineers, technologists or technicians for example handling the machines, loads and things manually. Working out the session with awkward postures or movements through repetitive manual handling may damage to the musculoskeletal system of the body of the workers and may lead to low back pain [1]. In this project, the style of lifting loads such as postures or gestures will be focused in order to obtain the EMG signal accurately. The manual lifting action is basically based on the common lifting involving in the industries. The manipulated variable of this project will be in terms of size and style of subjects in lifting of objects while fixing the gender of the subject as a constant. The subject will be carrying out the experiment for few times by lifting up a load of 5kg, 10kg and 15kg onto a rack of 70cm as well as 140cm, the load will then be lifted back onto the ground by the subject. The EMG signals will be acquired from the waist and lower part of the subjects during the lifting of different weight of the loads [3]. The result of the data will be collected and analyzed in MATLAB by frequency and time domain algorithm in order to get the frequency and time of the data received. The research focuses on the strength applied by the subject by calculating the EMG signal in terms of voltage based on the signal received. The signal collected will be estimated to identify the muscle based on the voltage from the identified phases. The graphical user interface (GUI) for displaying the signal analyzed from the waist and lower part of the body during manual lifting will be built.

ABSTRAK

Projek ini membincangkan tentang analisis berkaitan dengan signal isyarat Electromyography (EMG) dari pinggang dan bahagian bawah badan semasa membuat pengendalian manual. Pengendalian manual adalah aktiviti seperti mengangkat, membawa, menolak atau memegang apa-apa. Ia termasuk juga kerja yang melibatkan pergerakkan badan yang berulang. Pekerja di industri masa kini melibatkan dalam pengendalian mesin secara manual di tempat kerja mereka. Pengendalian manual yang berulang boleh merosakkan system muskuloskeletal badan pekerja dan boleh mengakibatkan sakit pinggang [1]. Dalam projek ini, gaya mengangkat beban akan diutamakan semasa membuat eksperimen pengendalian manual agar isyarat EMG yang tepat dapat didapatkan. Saiz serta bentuk objek untuk diangkat oleh subjek adalah pembolehhubah dimanipulasi manakala jantina subjek akan menjadi malar untuk projek ini. Subjek akan menjalankan eksperimen beberapa kali dengan mengangkat beban 5kg, 10kg dan 15kg ke atas rak 70cm dan 140cm, selepas itu beban akan diangkat kembali ke atas lantai. Isyarat EMG akan diperolehi daripada pinggang dan bahagian bawah badan subjek semasa pengambilan beban yang berbeza beratnya [3]. Hasil data akan dikumpul dan dianalisasikan dalam MATLAB dengan menggunakan algoritma domain masa dan kekerapan. Kajian ini menitikberatkan data dari segi voltan demi mengira kekuatan otot subjek semasa pengendalian manual. GUI akan dibina untuk memaparkan isyarat EMG yang dianalisasikan dari pinggang dan bahagian bawah badan subjek semasa pengendalian manual.

DEDICATION

To my beloved parents who taught me that the best kind of knowledge to have is learned for its own sake. It is also dedicated to my supervisor who taught me that even the largest task can be accomplished if it is done one step at a time.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

EMG	-	Electromyography
LBP	-	Low Back Pain
GUI	-	Graphical User Interface
DSP	-	Digital Signal Processing
DFT	-	Discrete Fourier Transform
FFT	-	Fast Fourier Transform
STFT	-	Short-Time Fourier Transform
TFR	-	Time-Frequency Representation
RMS	-	Root Mean Square
MatLAB	-	Matrix Laboratory
BMI	-	Body Mass Index
N/A	-	Not Available

CHAPTER 1
INTRODUCTION

1.0 Introduction

Manual lifting occurs in almost all working environments. Operations related to manual handling are including the acts of lifting, holding and so on [1]. The relationship between manual lifting and the risk of low back pain (LBP) has been researched and published by many researchers [1],[2],[3]. There will be potential for injuries to occur when handling and lifting things manually such as strains, spraints, cuts, low back pain, muscle fatigue and musculoskeletal problems affecting the neck, backbone, as well as hands [2]. The examples of gestures during manual lifting are shown in Figure 1.1.

Figure 1.1: Examples of gestures during manual lifting. [2]

Electromyogram (EMG) is a signal or small electrical currents that are generated by muscle fibres. These currents are generated by the exchange of ions from one muscle fibre membrane to another. Thus, electromyography is often used as a measure of muscle activity since there has no any direct means exist to examine the force emitted by a muscle tissue under lifting conditions [4]. EMG activity assessment of muscle tissue during motion is difficult to be examined. However, if the velocity of a muscle increases during the increased loading of muscle, the EMG activity will be increasing as well [4]. The example of simple setup of EMG is shown in Figure 1.2.

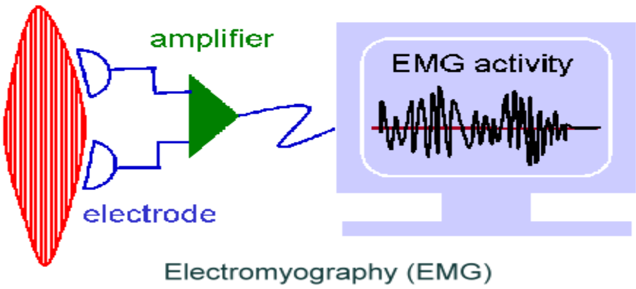

Figure 1.2: The example of simple setup of EMG. [3]

The objective of this study is to investigate how the gestures of workers during manual lifting that will bring bad side effects on the waist and also the lower part of the body. The result of this study is expected to provide information of how the gestures during manual lifting of students should be adjusted to reduce the risk of low back pain.

1.1 Problem Statement

Manual handling involves muscular work such as static work and dynamic work. In general, static means where a muscle remains contracted or stationary for a period of time but there is no any movement, for example carrying a big box, which means our arm muscles are doing work, without moving. While for dynamic work, it means there are both contraction and relaxation of a muscle from a movement, for example walking up stairs. Industry nowadays involves a lot of manual lifting. Industry workers are basically exposed to various physical hazards at the working place. The engineers, technologists or technicians have to involve in handling the machines, loads and things manually. Working out in the industry with awkward postures or movements through repetitive manual handling may bring bad side effect to the waist and also the lower part of the body of the workers and thus may lead to low back pain [3].

1.2 Objectives

There are several objectives that will be achieved in this study

i. To identify the EMG signal from the waist and lower part of the body during manual lifting activities
ii. To analyse the EMG signal by using frequency and time domain algorithms
iii. To build a graphical user interface (GUI) to display the EMG signal of the waist and lower part of the body during manual lifting

1.3 Scopes of the Project

To ensure the objectives are achieved, some of important elements must be considered. They are:

i. The study concerned with the male subjects of age between 20-24, height between 170-180cm and weight between 50-70kg. The subjects with these criteria are selected as these criteria are the average criteria commonly available in the industries [5].
ii. The weight of the load will be fixed at 5kg and 10kg as the constant variable of this project.
iii. The manual lifting is based on the common lifting involving in the industries.
iv. The study analyses the repeating actions of lower part of the body in contribution to injury from the data of EMG signal measured and calculated from frequency and time domain algorithm.
v. The data signal will be stored in Visual Basic.
vi. The analysing of the study will be done by using MATLAB.

1.4 Outlines of the Project

This research consists of 5 chapters. In the first chapter, the study begins with introduction of the study accompanied with the problem statement, objective and working scope for this project.

The literature review in chapter 2 discusses about manual lifting, electromyography and methods used to analyze the EMG signals. Finally the chapter shows the summary and reviews from the table comparison based on the previous journals.

The research methodology in chapter 3 explains the method that will be used to collect the data and shows how the analysis of the data will be made.

The result, analysis and discussion in chapter 4 present the findings, results of the study which will be presented in tables and figures. Several observations are projected from the findings.

The conclusion and recommendation in chapter 5 summarizes the outcomes of the study. The objective of this project will be achieved. This chapter outlines several recommendations for the further development and improvement on the method use for the analysis. Suggestions for future researchers will be also provided within this chapter.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter provides the literature review based on the previous researches as well as theoretical readings based on manual lifting and also electromyography analysis. The literature review done based on the previous researches will help improving the methodology of this project and the result will be recorded successfully.

2.1 Manual Lifting

According to the U.S. Department of Labor, handling is defined as working out such as grasping, holding and so on either with hand or with both hands. Manual lifting is an action of manually grasping an object of definable size and mass with one or two hands and vertically moving the objects without the help of mechanical tools. It is commonly practiced by workers in industrial workplace to move or transport things to a desired place [3]. In industrial workplaces, manual lifting is an unavoidable choice and way to perform material handling task even if automated instruments or equipment are provided. Improper lifting can contribute to occupational injuries such as back pain [3]. Operations related to manual handling include the acts of lifting, lowering, carrying, pushing, pulling, and holding items. When lifting items manually, there is potential for injuries such as strains, spraints, fractures, cuts and bruises, low back pain, awkward postures, muscles fatigue and musculoskeletal problems affecting the back, neck, shoulders, elbows and hands [4].

Changes in body postures are likely to have significant impacts on the synergism of muscular activity [6].

2.2 Electromyography (EMG)

Electromyography (EMG) signal is a complex bioelectricity process that produces by muscle excitation or activity. Electromyography is the study of muscle function through the analysis of the electrical signals emitted during muscular contractions. The electromyography was originally developed for investigating muscular disorder. The EMG recording is used to study the functional state of the muscle during various motions [4]. For detection, processing and classification of the signal, it requires the advanced methods for the EMG signal analysis. The method provides efficient and effective way to understand the signal and nature [7]. EMG also known as electrical signals that representing the contraction of the muscle in human body. EMG is not a stationary signal. It is basically acquired in two ways which are by using surface EMG or needle electrodes [8]. Computer and software becoming more powerful tools which are able to process complex algorithm on numerous data at high speed and advance in digital signal processing (DSP) applied to bio-signals [11].

The EMG signal from the muscle is collected by using EMG detector or the EMG electrodes [8]. There are two types of electrodes, the invasive as well as the non-invasive electrodes. The invasive electrodes are the needle electrodes which are inserted directly into the muscle in order to measure and collect the electrical activity signal of the muscle. This method is basically conducted by the electro-diagnostic medical consultant who interprets the study in actual procedure, means that good muscle selectivity and signal to noise ratio can be obtained through this method [9]. The non-invasive electrodes are the electrodes which are attached at the skin surface. This method is also easier to use, safe and has effective cost [3],[9],[10]. Figure 2.1 shows the example of invasive electrodes while Figure 2.2 shows the example of non-invasive electrodes.

Figure 2.1: The example of invasive electrodes. [4]

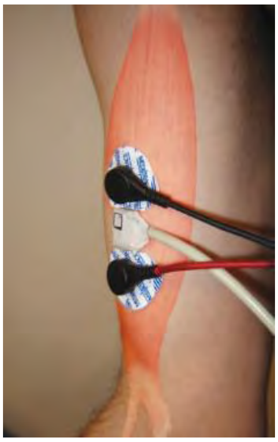

Figure 2.2: The example of non-invasive electrodes. [4]

2.3 Fast Fourier Transform (FFT)

A fast fourier transform algorithm computes the discrete fourier transform (DFT) of a line of transmission, either in ascending or descending order. It converts the signal from time domain to the frequency domain and can be doing in the opposite way as well. Fast Fourier Transforms are widely used in engineering, science and mathematics applications. The basic ideas were familiarized in 1965 yet algorithms were derived in early of 1805 [12]. The FFT is a complicated algorithm and one of the most important algorithms in signal processing and data analysis. It can be defined as:

$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-2\pi f t} dt \quad \text{--(2.1)}$$

where X(f) is the signal in frequency domain, x(t) is the signal of interest. However, if the signal is moving, the frequency of the signal is hardly to be measured and detected. As stated in the journal written by J. Kilby and K. Prasad [12], FFT is a simple technique which suitable for stationary signals only [17]. It provides accurate frequency resolutions as well. FFT does not provide temporal information and is only providing the frequency information and power spectrum. The accurate frequency resolution is unable to be provided through this method [16]. Figure 2.3 shows an example of FFT signal in MATLAB.

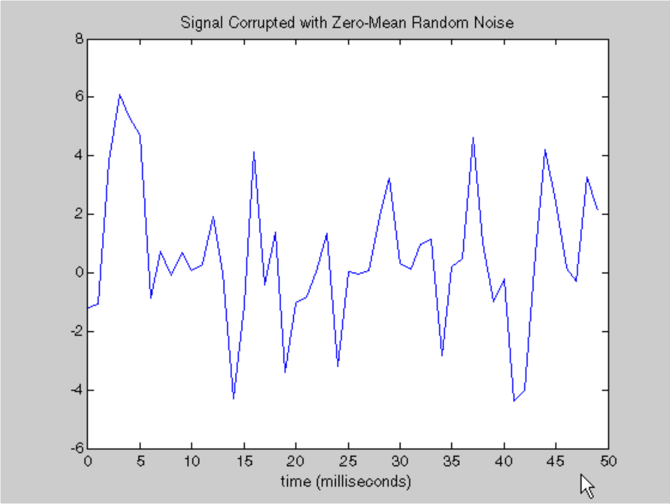

Figure 2.3: The example of FFT signal in MATLAB. [14]

2.4 Short-time Fourier Transform (STFT)

The short-time fourier transform (STFT), is a fourier-related transform used to determine the sinusoidal frequency as well as the phase of a signal with respect to time [13]. It divides a longer time signal into shorter sections of equal length and size then computes the fourier transform separately on each of the divided section.

$$STFT\ (t', u) = \int_{t}^{\infty} [f(t) \cdot W(t - t')] \cdot e^{-j2\pi ut} dt \quad \text{---------------------- (2.2)}$$

where t' is the time parameter, u is the frequency parameter, f(t) is the signal to be analyzed, W is windowing function, (t-t') is the center of t = t'. However, the very low frequency component will not be able to be detected. STFT is a transform which has both time and frequency information with fixed width. The time and frequency resolutions are inversely proportional, which means higher time resolution brings lower frequency resolution and vice versa [14]. The STFT which provides temporal and spectral information that represent signal with TFR (time-frequency representation) can overcome the FFT limitation [17]. Figure 2.4 shows the example of a STFT graph.

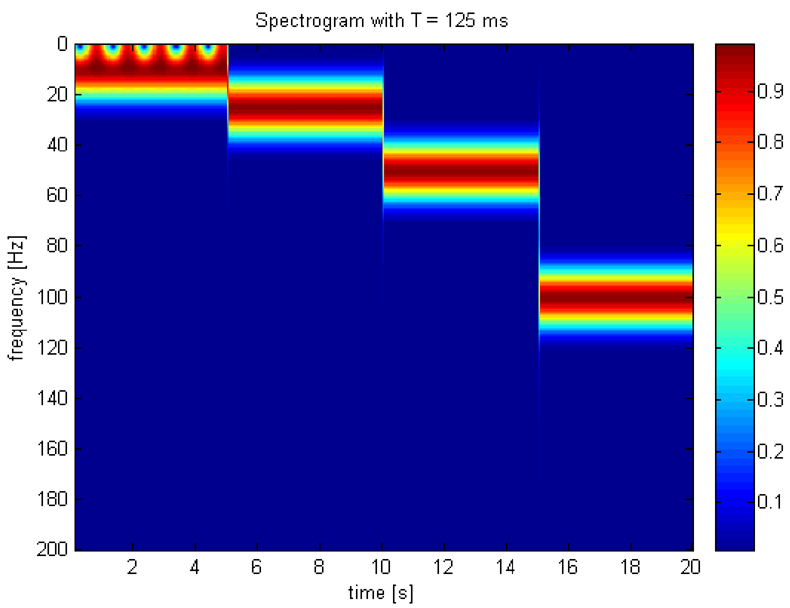

Figure 2.4: The example of a STFT graph. [16]