SIMULTANEOUS ASSESSMENT SYSTEM OF WORK POSTURE AND MUSCLE ACTIVITY FOR MANUAL MATERIALS HANDLING TASKS

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons)

by

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DECLARATION

I hereby, declared this report entitled "Simultaneous Assessment System of Work Posture and Muscle Activity for Manual Materials Handling Tasks" is the results of my own research except as cited in reference.

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Date : 9 JANUARY 2019

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).
The member of the supervisory committee is as follow:

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(DR. ISA BIN HALIM)

ABSTRAK

Pengendalian bahan secara manual adalah salah satu aktiviti yang biasanya terdapat dalam sektor industri perkilangan. Teknik-teknik yang salah ketika melaksanakan tugas ini boleh membawa kepada kecederaan dan ketegangan otot di kalangan pekerja industri. Pengamal ergonomik dan jurutera memerlukan satu sistem penilaian ergonomik yang membolehkan mereka mengkaji interaksi antara postur kerja dan aktiviti otot seseorang pekerja ketika melaksanakan tugas tersebut. Oleh itu, sistem penilaian ergonomik sepatutnya boleh mengukur sudut postur kerja dan data "electromyography" (EMG) secara serentak. Sistem penilaian yang sedia ada tidak memenuhi syarat-syarat ini kerana pengamal ergonomik perlu menjalankan penilaian dengan menggunakan sistem yang berasingan. Tujuan kajian ini adalah untuk menghasilkan dan mengesahkan satu prototaip sistem penilaian ergonomik yang beroperasi secara serentak untuk mengukur sudut postur kerja dan data EMG sesesorang pekerja yang melakukan tugas pengendalian bahan secara manual. Satu soal selidik telah dijalankan di kalangan 30 responden untuk mengenal pasti faktor-faktor yang boleh mempengaruhi postur kerja dan aktiviti otot. Perisian Microsoft Visual Studio, kamera 3D, sensor otot dan pengawal mikro telah digunakan untuk menghasilkan sistem penilaian ergonomik. Selain itu, satu antara muka pengguna grafik telah dibangunkan dalam sistem tersebut untuk membolehkan pengamal ergonomik melaksanakan penilaian secara serentak. Hasil daripada soal selidik mendapati bahawa gerakan mengangkat, membawa dan pergerakan yang berulang adalah faktor utama dalam mempengaruhi postur kerja dan aktiviti otot. Kajian ini menyimpulkan bahawa sistem penilaian postur kerja telah menunjukkan hasil ketepatan yang baik dalam mengukur sudut lengan dan bahagian atas siku. Manakala sistem pengukuran EMG dapat menghasilkan corak data EMG yang sama dengan sistem EMG yang terdapat di pasaran. Kajian lanjut diperlukan untuk meningkatkan kesahihan, kebolehpercayaan dan kebolehgunaan prototaip ini supaya dapat memudahkan pengamal ergonomik dan jurutera untuk menilai postur kerja dan aktiviti otot ketika melakukan tugas pengendalian bahan secara manual.

ABSTRACT

Manual material handling (MMH) is one of the common activities in many industrial sectors such as manufacturing industry. Improper techniques in performing MMH tasks can lead to muscle's sprain and strain among industrial workers. Ergonomics practitioners and engineers require an assessment system which allows them to investigate the interaction of work posture and muscle activity of a worker when executing MMH tasks so that muscle's sprain and strain can be avoided. Hence, the assessment system should allow a simultaneous measurement of work posture angles and electromyography (EMG) signals and low cost. The existing assessment system did not meet these requirements as the ergonomics practitioners have to carry out the assessment of work posture and muscle activity using a discrete system. The aim of this study was to develop and validate a prototype of simultaneous assessment system for measuring work posture angles and EMG signals of a worker who doing MMH tasks. A questionnaire survey was conducted among 30 respondents to identify factors that affect work posture and muscle activity in MMH tasks. The Microsoft Visual Studio software, a 3D camera (Microsoft Kinect), Advancer Technologies muscle sensors and a microcontroller (NI DAQ USB-6000) were applied to develop the work postural angles and EMG signals measurement system. Additionally, a graphical user interface was created in the system to enable ergonomics practitioners to perform work posture and muscle activity assessment simultaneously. Results of the questionnaire survey found that lifting, carrying and repetitive movements are common factors that affecting work posture and muscle activity. Based on the validation results, this study concluded that the work posture assessment system has shown a good accuracy in measuring upper arm and elbow angles. Meanwhile, the EMG measurement system was able to generate a same pattern of electromyography data with a commercial EMG system. Further study is required to enhance the validity, reliability and usability of the prototype so that it may facilitate ergonomics practitioners and engineers to assess work posture and muscle activity in MMH task.

DEDICATION

I dedicate this report to only
my beloved father, Abullais bin Murtuza
my appreciated mother, Fatimah binti Aziz
my adored brother and sister, Faris and Asnie
for giving me moral support, cooperation, encouragement and also understandings
Thank You so Much & Love You All Forever

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In the name of Allah, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete this final year project successfully without difficulty.

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Last but not least, I would like to give special thanks to my friends, classmates and some supporting UTeM staffs who gave me much motivation and cooperation mentally in completing this report especially to, Mr Zahar for permissions using laboratory and equipment's. They had given their critical suggestion and comments throughout my research. Thanks for the great friendship.

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LIST OF ABBREVIATIONS

MMH	-	Manual material handling
SOCSO	-	Social Security Organisation
RULA	-	Rapid Upper Limb Assessment
Kinect	-	Microsoft Kinect Sensor
EMG	-	Electromyography
REBA	-	Rapid Entire Body Assessment
OWAS	-	Ovako Working Posture Analysing System
IR	-	Infrared
SDK	-	Software Development Kit
MVC	-	Maximum voluntary contraction
MUAP	-	Motor Unit Action Potential
sEMG	-	Surface Electromyography
CMRR	-	Common Mode Rejection Ratio
ISB	-	International Society of Biomechanics
RGB	-	Red, green and blue
GUI	-	Graphical User Interface
PDF	-	Portable Document Format
NI	-	National Instruments
DAQ	-	Data accquistion
USB	-	Universal Serial Bus
LiPO	-	Lithium-ion polymer
LED	-	Light emit detector
AI	-	Analogue Input
GND	-	Ground
SIG	-	Signal
SOP	-	Standard Operating Procedure
Opamp	-	Operational amplifier

LIST OF SYMBOLS

D	-	Dimensional
™	-	Trademark
a	-	Alpha
Hz	-	Hertz
%	-	Percentage
cm	-	Centimetre
V	-	Volt
etc	-	Etcetera
μF	-	Micro Faraj
kΩ	-	kilo-ohm
kg	-	kilogram

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CHAPTER 1
INTRODUCTION

This chapter introduces the background of study which focuses to the work posture and muscle activity in manual materials handling tasks and their assessment system. In addition, this chapter also will cover the problem statements, objective of study, scope and limitations of study as well as significance of study.

1.1 Background of Study

Manpower contribution as manual work asset is still overwhelming in current manufacturing activities. Manual Material Handling (MMH) activities or tasks are the common term used to describe the activities. MMH utilization was favoured over automation because of its high adaptability and being generally low in cost. MMH holds advantage in its adaptability to maneuver amid basic and light material transfer, in the event that compared to perform the same action utilizing mechanical aids (Deros et al., 2015).

A MMH task is the process of moving or supporting an object by using physical strength of the human. Examples of manual handling tasks are pushing, pulling, lifting, holding, and carrying activities. These activities can be found in many working environments such as manufacturing industry, office, farm, and construction industry. Figure 1.1 shows two workers performing MMH task in an industry. If the MMH are performed erroneously or improperly, this task may contribute to physical discomfort and injuries to the workers.

Figure 1.1 Two workers are lifting an aircraft parts in an awkward posture

MMH activities are frequently of concern when surveying work activities for dangers that have the potential to lead to musculoskeletal disorders. Musculoskeletal disorders include strains and sprains to the lower back, shoulders and upper limbs. Possibly damaging work practices may include awkward posture such as twisting and bending, high repetitive works, overexertion of muscles, contact stress on body parts and sustaining static posture for a long duration. Improper design of MMH tasks is one of the root causes of musculoskeletal disorders associated with sprain and strain.

In the past three years, Social Security Organization (SOCSO) of Malaysia reported total of 20440 sprain and strain cases in workplaces (SOCSO Annual Reports 2016, 2015 and 2014). In order to prevent and reduce the occurrence of sprain and strain among industrial workers, there are many ways and methods that been used by ergonomics practitioners to assess work posture and muscle activity. For example, a previous study applied Rapid Upper Limb Assessment (RULA) and Microsoft Kinect Sensor (Kinect) to assess work posture during MMH tasks in a manufacturing industry (Jiang et al., 2017). Figure 1.2 shows one of the methods used by the ergonomic practitioner to assess work posture.

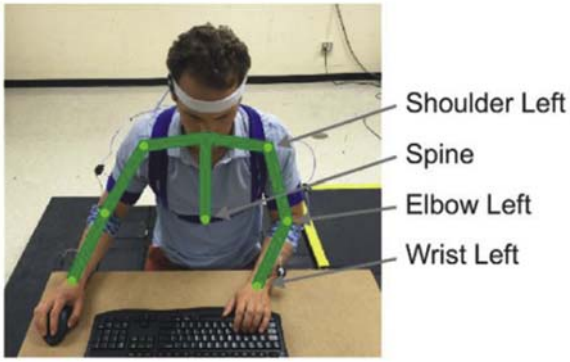

Figure 1.2: Assessment work posture using Kinect sensor
(Source: Xu et al., 2017)

A neutral work posture is a combination of balanced strength and flexibility in the skeletal muscles, enabling workers to perform MMH tasks in a healthy manner. To ensure the muscles are not exposed to any strenuous contraction during MMH tasks, electromyography (EMG) can be used to quantify the muscle activity. EMG is a demonstrative step which assesses the well-being condition of muscles and nerve cells that control them. These nerve cells are known as motor neurons. They transmit electrical signals that cause the muscles to contract and relax. Muscular motion includes the activity of muscles and nerves which requires an electrical current. This electrical current is much weaker than the one in domestic wiring.

An EMG device converts these signals into charts or numbers and this EMG will be used if someone is having a sign of illness of the muscle or nerve disorders. Most of the EMG is being used by the doctors in the hospital in order to assist them to make a diagnosis for those are having any muscle and nerve disorders. There also some specialists are using this EMG to observe and evaluate the muscle activity of the workers or operators in manufacturing industry in order to reduce the ergonomic problems faced by them during the MMH activities. Figure 1.3 shows an assessment of muscle activity of worker who performing MMH task.

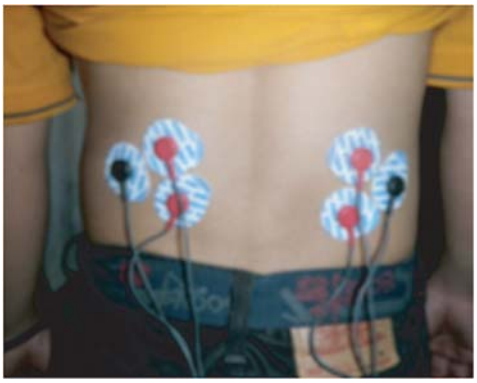

Figure 1.3: Exterior electrodes made up from silver or silver chloride attached to lower back (Source: Halim et al., 2012)

A simultaneous assessment system of work posture and muscle activity will allow the ergonomics practitioners to understand the interaction of postural angle and muscle effort in MMH tasks. For instance, if a worker is bending downward his back 45-degree to lift a sheet metal, an ergonomics practitioner can analyse the effort of muscle of this worker during this bending position through a simultaneous assessment system. Even though the work posture assessment and muscle activity assessment produce different data, however, the data can be used by the ergonomics practitioners to design better MMH tasks by considering postural data and muscle activity simultaneously. An example of simultaneous ergonomics assessment of posture and whole-body vibration been carried out by Hermanns et al., (2008).

Based on the literature, numerous studies have developed the work posture and muscle activity assessment systems. However, the developed systems do not allow the ergonomics practitioners to perform assessment of work posture and muscle activity simultaneously, even though muscle is very crucial to allow human to move and maintain the work posture during manual materials handling task. Due to unavailability of the simultaneous posture and muscle activity assessment system, posture and muscle relationship in manual materials handling task is difficult to examine. As a consequence, the ergonomics practitioners might not be able to investigate the tasks of manual materials handling comprehensively, in which can lead to ineffective ergonomics solution.

In recognition the above-mentioned issue, the aim of this study is to develop a prototype of simultaneous assessment system for assessing work posture and muscle activity in MMH tasks. The assessment system utilises low-cost EMG hardware and 3D camera (Microsoft Kinect sensor) to objectively capture muscle activity and work postural data. The engineers or ergonomics practitioners can utilize this system to screen any mismatches between worker (posture and muscle activity) and MMH tasks; and consequently provide critical forward action data for the purpose of redesigning MMH activities. It is expected that the use of simultaneous system may facilitate the human-system interaction through the optimization of muscle activity and work postures. Hence, better compatibility of task and human maybe achieved resulting in workers' efficiency, productivity and occupational health improvement.

1.2 Problem Statement

Workers in manufacturing who performing MMH tasks are always complaining that they are at high chance to have musculoskeletal disorders such as pain in the back, shoulder, and upper limbs (Akodu & Pt, 2015). Figure 1.4 and 1.5 show two workers performing the MMH tasks that can lead to musculoskeletal disorders.

Figure 1.4 Two workers are holding the aircraft parts in sustained position

Figure 1.5 Two workers carrying the aircraft parts to another station repeatedly

Based on above figures, the workers performing the MMH task in an awkward posture and strenuous muscle efforts. Due to the awkward posture and strenuous muscle, it can lead to strain and sprain in the muscles. The existing work posture and muscle activity assessment tools are in a separate system, which not allow a simultaneous assessment. The engineers and ergonomics practitioners require an integrated system to assess work posture and muscle activity related to MHH tasks. The assessment system should allow simultaneous assessment, portable, low-cost and easy to use. In addition, the system should provide real time data as well as rapid results. The existing assessment system did not meet all these requirements. Thus, a development of an assessment system that meets above requirement is needed.