VALIDATION OF KINECT-RULA SYSTEM FOR WORKSTATIONS ASSESSMENT

This report submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

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DECLARATION

I hereby, declared this project entitled “Validation of Kinect-RULA system for workstations assessment” is the results of my own research except as cited in reference.

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APPROVAL

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

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(Dr. Radin Zaid bin Radin Umar)

ABSTRAK

"Rapid Upper Limb Assessment (RULA)" adalah salah satu instrumen penilaian postur badan di tempat kerja. Antara isu-isu yang timbul dalam penggunaan kaedah manual RULA ialah penilaian yang memakan masa, kemungkinan untuk melakukan kesilapan dalam pengiraan markah dan sensitiviti yang rendah disebabkan oleh pemerhatian postur menggunakan mata kasar. Kajian ini bertujuan untuk membuat pengesahan (validation) kepada sistem penilaian postur baru (Kinect-RULA) yang menggunapakai sensor Microsoft Kinect Xbox. Tiga fasa analisis dilakukan untuk membandingkan diantara kaedah penilaian RULA secara manual dan system Kinect-RULA. Fasa pertama melibatkan penilaian postur daripada sepuluh penilai novis untuk membandingkan skor RULA untuk sembilan stesen kerja menggunakan kaedah manual dengan sistem Kinect-RULA. Fasa kedua ialah penilaian postur yang dijalankan oleh lima pakar ergonomik untuk membandingkan skor RULA untuk dua stesen kerja menggunakan kaedah manual dengan sistem Kinect-RULA. Fasa ketiga ialah mengambil maklumbalas pakar ergonomic berkenaan sistem Kinect_RULA. Analisis deskriptif, statistik dan kandungan telah dijalankan untuk membandingkan kaedah penilaian RULA secara manual dengan sistem Kinect-RULA. Hasil kajian "T-test" menunjukkan tiada perbezaan antara skor RULA di dalam dalam fasa satu; manakala fasa kedua menunjukkan terdapat perbezaan dalam skor RULA daripada "T-test" yang dijalankan. Dalam fasa ketiga, pakar-pakar memberi maklum balas perbandingan antara kaedah penilaian RULA secara manual dan Kinect-RULA. Beberapa kelemahan dalam sistem Kinect-RULA termasuk sensitiviti untuk mengesan bahagian badan yang berpusing dan sedikit bongkok, hadangan objek yang mempengaruhi proses penilaian dan sebagainya. Kesimpulannya, sistem Kinect-RULA ini boleh digunakan dalam menilai postur bekerja di stesen kerja, namun skor akhir masih memerlukan input dan pemantauan daripada pakar.

ABSTRACT

Rapid upper body assessment (RULA) is one of the postural assessment tools in identifying awkward posture and is suitable to use in assessing the posture of upper body. Issues regarding manual assessment of RULA are time-consuming, potential errors in calculation of scores and low sensitivity due to naked eye observation. This study of newly developed system (Kinect-RULA) under short term PJP/2015/FKP(2D)/S01393 has the primary purpose to improve the current manual assessment method of RULA. Microsoft Kinect Xbox sensor was integrated with traditional RULA assessment system to capture RULA scores. There are three phases involved in comparing the results between the manual and Kinect-RULA assessments. First phase is comparing the RULA score of manual assessment for all nine workstations carried out by ten novice evaluators with Kinect-RULA assessment. Second phase involves comparison between manual assessments conducted by five experts in ergonomics field with the RULA scores of Kinect-RULA system for two selected workstations. In the third phase, experts were interviewed to get their opinion on the Kinect-RULA system. In comparing the results of RULA score between both assessment methods, descriptive, statistical and content analyses were conducted. T-test for phase one shows there is no difference between the mean scores; phase two demonstrates there is statistical difference in t-test result for mean RULA score comparison. In phase three, experts gave feedback and opinions when comparing between manual and Kinect-RULA assessment methods. Few limitations of the newly developed system were identified, for example, limited detection of twisting and slight bending of body parts, obstruction that influences the assessment process, etc. All in all, the newly developed system can be used in assessing the working postures at workstations in laboratories and industries. However, the RULA scores generated from the Kinect-RULA system still require inputs and monitoring from experts.

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LIST OF ABBREVIATIONS

WMSDs	-	Work-related musculoskeletal disorders
RULA	-	Rapid upper limb assessment
MSDs	-	Musculoskeletal disorders
SOCSO	-	Social Security Organization
NIOSH	-	National Institute of Occupational Safety and Health
HSE	-	Health and Safety Executive
OCRA	-	Occupational repetitive actions
REBA	-	Rapid entire body assessment
SI	-	Strain index
CF	-	Action frequency factor
Ff	-	Force factor
Fp	-	Postural factor
Fc	-	Additional factor
Fr	-	Recovery periods factor
Fd	-	Duration factor
SKD	-	Software development kit
RGB	-	Red, green, blue
IEA	-	International Ergonomics Association
ASEAN	-	Association of Southeast Asian Nations

CHAPTER 1

INTRODUCTION

This chapter describes the background, problem statement, objectives of this project, scope and significant of study. The overall flow of the project is presented in a flow chat and embedded in the subtopic of this chapter. In addition, the organization of final year project is also included.

1.1 Background

Work-related musculoskeletal disorders (WMSDs) have become common place in many working environments due to incompatible workplace settings that have resulted in employees developing WMSDs. WMSDs development are mostly due to physical causes (lifting heavy items repetitively in severe or awkward postures), characteristics of the organization work, individual, psychosocial and sociocultural (Anderson et al., 1997). National Institute of Occupational Safety and Health (NIOSH) stated that in the year of 2013 alone, there were 694 ergonomics related cases out of 2630 cases of the disease. This means that on every four cases reported to SOCSO, one of them was related to musculoskeletal disorders (Borneo Post online, 2016). A research carried out in automotive manufacturing industry in Malaysia, a high occurrence of MSDs on the neck was 49.3%, hand, and wrist for 48.0% and shoulder for 46.7%. This proved that WMSDs often lead to upper limb musculoskeletal disorders (Nur et al., 2014). In addition, major WMSD on back pain was experienced by electronic workers (Aziza et al., 2015).

In Malaysia, all of the employees and workers are under the protection of Employee Social Security Act 1969 and Employee Social Security General Rules 1971 enforced by Social Security Organization (SOCSO). The Employment injury scheme provides coverage and protection to employees that suffer from employment injuries, where the coverage might come from industrial accidents while workers are carrying out their duties and accidents while traveling or during an emergency (Social Security Organization, 2016).

Malaysian Employment Act defines working weeks for employees as 48 hours, where maximum working hours per day is 8 hours and 6 working days for one week (Law of Malaysia, 2012). However, fatigue of industrial workers causes them to develop various WMSDs due to the characteristics of task activities. Dimensions of human performance of muscle activity and fatigue are able to indicate the temporal organization of work such as duration of a task, work pace, rest breaks patterns and more for employees (Dempsey et al., 2010). The design of occupational setting for workers is also one of the crucial factors in reducing the percentage of WMSDs that happen that would contribute to the development of WMSDs for workers. In Iran, the design of sewing workstations that are not compatible for sewing operation caused the Iranian operators to experience MSDs after the bending posture of neck and reflexion of the trunk over a long period of time (Dianat et al., 2015). Thus, working condition is the paramount influence for the working postures.

Various assessment tools are available for use in assessing the postures for workstations, for example, NIOSH Lifting Equation, Rapid Upper Limb Assessment (RULA) and others. Although there are a few tools that can be used are available at the moment, a system still needs to be developed for comparing and checking of any mismatch of the tools selected. Furthermore, there are problems associated with the use of these tools and therefore continual research in validating these tools need to be carried out.

The method of identifying the risk factors that contribute to the development of various disorders of body parts can be investigated using the existing ergonomic assessment tools (David, 2005). Most assessment for upper part of the body is the neck, back, shoulder, arms, and wrists (Beek&Dressen, 1998). Rapid upper limb assessment (RULA) tool is used in this project for identifying the exposure of workers during their daily working task at their workstations to risk factors associated with WMSDs. RULA assessment method uses diagrams illustrating body postures and scoring tables in evaluating the exposure to risk factors (McAtamney&Corlett, 1993).

The direct method that relies on sensors attaching to a worker's body for the collection of data in assessing the worker's posture has been widely used (David, 2005). Development of Kinect sensor by Microsoft company (Microsoft) enables various users to make good use of it in various fields. This device has low-cost depth camera with markerless motion caption, calibration free alternatives where it is used for the recognition of real-time human posture (Shotton et al., 2011). With Kinect system, Pierre Plantard et al. (2015) did a study on the estimation of posture using Kinect and acquired the results of a virtual mannequin which is in conformity to the poses from the real subject.

With the accordance of RULA assessment method, under short term PJP/2015/FKP(2D)/S01393 system that uses Kinect software has been developed in investigating the posture of workers. This system is able to shorten the assessment process in detecting awkward postures, keeping a record of the workers' working process and make the evaluation of RULA easier. Validation, however, is needed for verifying the system. Since 1978, the concept of validation has been developing in the United States and its purpose is to ensure the particular conditions for the specified plans are achieved with the assurance of examination and provision of objective evidence (Patil, 2010). The aim of this study is to validate the developed system.

1.2 Problem statement

RULA assessment using worksheet is a common tool in assessing working postures for upper body of the workers. However, current postural assessment tools are time-consuming at entering postural data, manual calculations of scores may lead to errors, low sensitivity due to naked eye observation and limited data points for capturing the working postures. A new system integrating RULA and Kinect has been developed to address these problems, but has not been validated. Hence, this study focuses on validating the newly developed system for the assessment of workstations design in the industries.

1.3 Objective

The objectives of this project are:

- To explore the existing postural assessment tools used in industry.
- To explore the Kinect technology and its applications in industry.
- To understand the newly developed system under short-term PJP/2015FKP(2D)/S01393 that integrates RULA and Kinect.
- To compare RULA assessment method with the newly developed system integrating RULA and Kinect.

1.4 Scope

This is a validation study where a system is developed. This system uses Kinect technology and investigation is limited to Malaysia's population, where the subjects are of the standard height and size of the local population. The RULA evaluators are also from local based. Evaluators of RULA assessment consist of ten novice evaluators and five experts. In addition, from the nine workstations selected for this validation, four are from laboratories located inside the campus UTeM and the five are from real workplace in industries. The workplaces in industries comprises of the categories of material handling, maintenance and machining processes.

1.5 Significance of study

Validation of the newly developed system that integrates RULA and Kinect is important in order to enable the system to have sufficient trust to be used by users in ergonomics field. This system is compulsory to go through the confirmation process through various comparison with the traditional assessment method of RULA using the assessment worksheet and by expertise in ergonomics field for the purpose of meeting the standard. Validation is needed for this newly developed system to get assurance through the results itself, and also the expertise.

1.6 Overall project flow

This project of validating the developed system of Kinect-RULA covers the processes of identifying the problem statement of postural assessment tools. Then, the exploration of posture assessment tool and understanding the method of using the Kinect software for RULA evaluation on workers' postures were done. The next step is to assess the workplace of workers and evaluate the postures using both manual and automatic methods. Comparison of both of the methods is carried out and the data collected and analysed. Feedback was recorded down from the expert practitioners in the ergonomic field. Then, discussion was made based on the results taken and the conclusion was made. The overall project flow is shown in Figure 1.1 below.

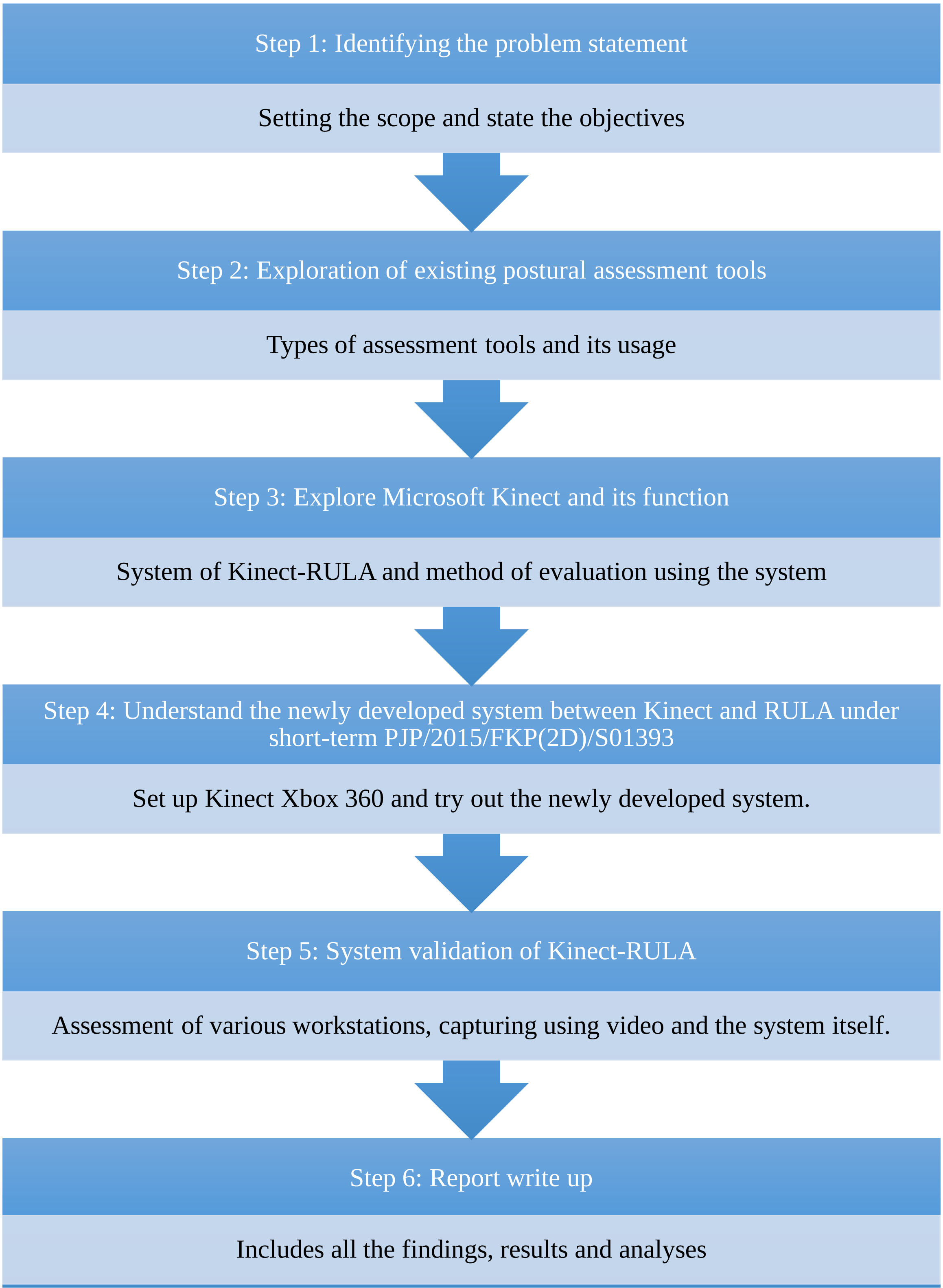

Figure 1.1: Flow chart of the overall project

1.7 Organization of final year project

The organization of this project starts with Chapter 1 that includes the background study of the project research, problem statement, objectives, scopes and significance of study. Chapter 2 is the literature review conducted through online research, reviews from electronic books, articles and journals on the topic of WMSDs and workstation design, postural assessment tools, Kinect technology, development of system that integrates between Kinect and RULA and finally is the validation study. Chapter 3 describes the overall project flow, Gantt chart for the timeline completion of the project and project methodology. Chapter 4 shows the results for the validation of the system, analysis and discussion based on the results collected. Lastly in Chapter 5 is the conclusion and recommendation of the project.

CHAPTER 2

LITERATURE REVIEW

This chapter describes about the theories and researches found or done by the other researchers. The information found was cited, discussed and put as reference. Topics included in this chapter are WMSDs that occur in industry, workstation design, postural assessment tools, the use of Kinect technology and its applications, development of system integrating Kinect and RULA and lastly is the validation study.

2.1 WMSDs in the industry

Workers normally lack knowledge about health and posture when carrying out all their job-related tasks. Most employees unconsciously or unknowingly move their body parts into various awkward postures such as twisting and bending of the body parts in the process of getting their jobs done. As a result, employees would suffer from muscles pain, tendon and nerve disorders. Bernard et al (1994) and his team carried out a study in identifying risk factors for work-related musculoskeletal disorders among newspaper employees. 41% of musculoskeletal disorder of upper acuteness was identified. Most intermittently are neck symptoms (26%), followed by hand or wrist (22%), shoulder (17%), and elbow (10%) symptoms. Research on the conceptual model prognosis of work-related musculoskeletal disorders include descend posture, its application on body parts, capacity and the effects of the posture and number of times on its application at one level and of the next. Job evaluation and design can be carried out as the knowledge on the common exposure factors and various responses are known (Bureau of Labor Statistic, 2013), for the purpose of minimizing work-related musculoskeletal disorders (Armstrong et. al 1993). Under the Safety and Health topics of United States Department of labour, musculoskeletal disorders are described to affect the body parts such as muscles, nerves, blood vessels, ligaments, and tendons. All of these depend on the type of occupation different workers are exposed to in different industries. Working activities that involve carrying heavy weight, bending and twisting, reaching to the higher place, pulling and pushing heavy loads, repetition of the same tasks for a long period of time are main causes of MSDs. The exposure to these commonly known risk factors for MSDs will increase the risk of injuries to the workers (United States Department of Labor). MSDs resulting from injuries or illness under occupational purposes, and these cases were accounted up to 33% (Bureau of Labor Statistic, 2013).

2.2 Workstation design

Ergonomics for workstation can either be considered as reactive or proactive. One is proactive ergonomic and another is reactive ergonomic. Proactive ergonomic is normally developed before injuries or accidents happen. It is the process of developing the appropriate design of workstation to inculcate the issues for the prevention of hazards, risk factors for WMSDs and more. Reactive ergonomic is changes that need to be changed for improvement in an existing workstation, where it is unsafe for carrying out the task. Corrective action is required for reactive ergonomics. Issues that will look into for improvement are the design of equipment, task, or environment aspects (The International Ergonomics Association (IEA), 2008). Thus, it is important to have the correct ergonomic design of workstation in the beginning so that time, energy and cost can be saved from changing of workstation design for corrective measures.

Workstation design is crucial in industries as it is a workplace for workers to perform their task in an appropriate and comfortable manner, in spite of working effectively. The ergonomic method of designing workstation often involves the aspect of anthropometry of the population of workers and other components related and required by the workstation. It is expedient for the designer to acquire relevant data regarding the performance of job, equiment that will be used, working posture and also the surrounding of the working area in designing workstation. Human factor ergonomic discipline designated through the variables of the genaral system are usually brought into considerations in designing workstations (Meister, 1999). Figure 2.1 below shows the list of the general system of variables.

1. Requirement constraints imposed on the system
2. Resources required by the system
3. Nature of its internal components and processes
4. Functions and missions performed by the system
5. Nature, number, and specificity of goals
6. Structural and organizational characteristics of the system (e.g., its size, number of subsystems and units, communication channels, hierarchical levels, and amount of feedback)
7. Degree of automation
8. Nature of the environment in which the system functions
9. System attributes (e.g., complexity, sensitivity, flexibility, vulnerability, reliability, and determinacy)
10. Number and type of interdependencies (human–machine interactions) within the system and type of interaction (degree of dependency)
11. Nature of the system's terminal output(s) or mission effects

Figure 2.1 Variables of general system for workstation design, taken from Meister (1999)

2.3 Postural Assessment Tools

Postural assessment tools are used for examining the postures of a person, worker or an employee while they are carrying out certain tasks or activities. Exposure assessment of physical posture normally based on whether an ergonomic intervention needed to take place for a certain job. If it is necessary, an assessment will be done to see whether the arbitration is effective. Expert views and practitioners' need suggestions to combine for the purpose of practical and valid for its purposes (Li and Buckle). In assessing the upper limb for the musculoskeletal disorder, several tools can be used. For example, Health and Safety Executive (HSE) upper-limb risk assessment method, Rapid Upper Limb Assessment (RULA), Stetson's checklist for the analysis of hand and wrist, Keyserling's cumulative trauma checklist, Ketola's upper-limb expert tool, strain index, occupational repetitive actions (OCRA), rapid entire body assessment (REBA) and more are frequently used tools (Takala et al., 2010).