DEVELOPMENT OF VISION BASED MEASUREMENT DEVICE

FOR RAPID UPPER LIMB ASSESSMENT (RULA)

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“ I hereby declare that I have read through this report entitle “Development vision of vision measurement device for rapid upper limb assessment (RULA)” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering with Honors”

Signature : .....

Supervisor’s Name : Dr. Muhammad Fahmi Bin Miskon

Date : .....

I declare that this report entitle “Development vision of vision measurement device for rapid upper limb assessment (RULA)” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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ABSTRACT

Nowadays a lot of factories have been established all around Malaysia. This factory has given big contribution in the development of the country. The main role in the contribution made by this sector is their worker. Without them a factory cannot operate. But these workers are always facing health problems such as bodily injury. To overcome this problem an ergonomic evaluation was being conducted for each of the worker. One of this evaluation is the RULA table. However, these assessments are taken manually. Therefore the reading that being taken are not consistent. Hence a vision system that can solve to this problem was proposed. Besides, these vision system also able to detect the local object. This vision system provides a new ways to collect the RULA data. There will be three main objectives of this project. The first objective is to develop a vision based system that can measure the position of the human body. The second objective is to determine local object, a local object that wanted to be located. And the last is to analysis accuracy and latency of the system. To achieve all three objective additional experiments were conducted. The first experiment is a DC motor with different speed was used to test the latency and a fixed angle was drawn on a paper was used to test the accuracy of the system. The second experiment is, three participants was volunteered to do the experimental test. A yellow ping Pong ball attached to the part of the participant body. They require to make the body posture base of the RULA sheet. Then the vision system detects the yellow pings Pong ball and produce the angle of the posture that being made by the participant. Angle produce by the vision system is the data required. The third experiment is, the color algorithm coding was used in order for the vision system detecting the local colored object. At the end of these projects a vision system manages to measure the position of the human body with the analysis of accuracy with the error 0.933˚ and latency with standard deviation for both speed is 26.939 and 28.907 was successful produced.

ABSTRAK

Pada masa kini banyak kilang-kilang telah diwujudkan di seluruh Malaysia. Kilang ini telah memberikan sumbangan besar dalam pembangunan negara. Peranan utama dalam sumbangan yang dibuat oleh sektor ini adalah pekerja mereka. Tanpa mereka kilang-kilang ini tidak dapat beroperasi. Tetapi golongan pekerja ini sentiasa menghadapi masalah kesihatan seperti kecederaan badan. Untuk mengatasi masalah ini penilaian ergonomik sedang dijalankan bagi setiap pekerja. Salah satu daripada penilaian ini adalah jadual RULA. Walau bagaimanapun, penilaian ini diambil secara manual. Oleh itu bacaan yang diambil adalah tidak konsisten. Oleh itu sistem visi yang dapat menyelesaikan masalah inis diusulkan. Selain itu, sistem penglihatan ini juga dapat mengesan objek setempat. Sistem ini menyediakan cara baru untuk mengumpul data Rula itu. Terdapat tiga objectif utama di dalam projek ini. Objectif yang pertama ialah untuk menghasilakan satu system visi yang mampu untuk megukur kedudukan manusia. Objektif yang kedua adalah untuk mengesan objek yang tertentu sahaja. Objektif yang ketiga adalah menjalan kan analisis ketepatan dan juga kelewatan sistem tersebut. Bagi mencapai kesemua objektif experiment telah dijalankan. Experiment yang pertama adalah, Tiga peserta menjadi sukarelawan untuk melakukan ujian percubaan. Bola ping pong kuning menjadi penanda dan dilekatkan pada bahagian badan peserta. Mereka dikehendaki untuk membuat pergerakan berdasarkan kertas kerja RULA tersebut. Kemudian sistem visi mengesan bola ping pong kuning dan menghasilkan sudut postur yang dibuat oleh peserta. Hasil sudut oleh sistem penglihatan adalah data yang diperlukan. Data ini akan diambil untuk beberapa kali untuk mengesahkan ketekalan data dan ketepatan sistem visi. Experiment yang ke tiga adalah dengan menggunakan motor dc untuk menguji selang masa antara system dan keadaan sebenar dan satu lukisan dengan sudut yang telah ditetap kan telah digunakan bagi menguji ketepatan sistem ini. Experiment ke empat adalah algorithma warna pengekodan telah digunakan supaya sistem penglihatan dapat mengesan objek setempat. Pada akhir projek ini sebuah

sistem penglihatan dengan konsisten data RULA dibina dan juga ketepatan dengan nilai ralat 0.000933 dengan sisihan piawai sebanyak 26.939 dan 28.907

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CHAPTER 1

INTRODUCTION

1.1 Motivation

RULA table is a survey method created for ergonomic investigation of the workplace such as a factory. RULA is stand for Rapid Upper Limb Assessment. This assessment is a tool used to evaluate the exposure of an individual. The observer will use these RULA tables to evaluate the worker. Usually the worker ignores the right position while doing their work. They do not think that wrong of body posture while they working can bring to serious injury to their body. The injury that often occurs due to the wrong body posture while working is MSD or known as musculoskeletal disorder. This disease is injury or pain in the body joint, ligaments, muscles, nerves, tendons and structure that support limb, neck and back. An article from Bernama told that MSD statistics for seven years from year 2006 until 2012[1] the detail was shown in figure 1.

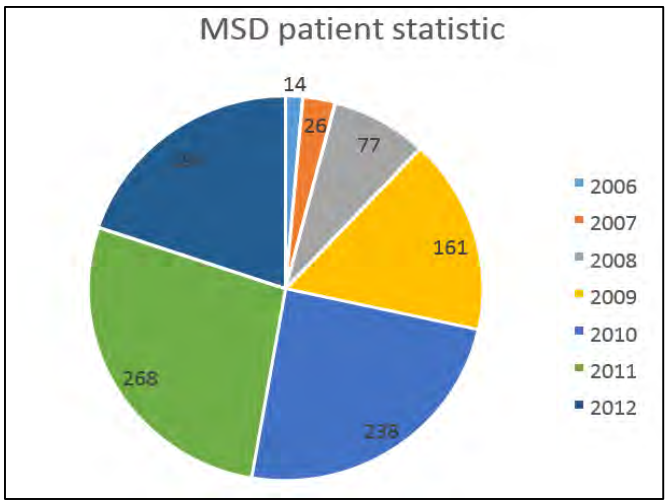

Figure 1.1: MSD static patient in Malaysia

In the chart above show that the number of the patient, increasing from 2006 until 2011. But the number decreasing for the last year. However the number of the patient still something needs to be worried. These MSD diseases not only happened in Malaysia but also occur in many country such a United State. More than 57.2 million suffered MSD injury in 2004. And the number keep on increasing.[2]

Therefore in order to decrease the number of patients most factories use this assessment to evaluate their worker posture to identify whether their worker practice the right position while doing their working process. A vision system that can measure the correct position of the human body was proposed in this project.

1.2 Problem statement

Rapid Upper Limb Assessment (RULA) process begins with the posture data collection. The worker is required to make their working process while the evaluator evaluate their posture. The data collection has been done manually. The evaluator will observe the movement of the worker and give marks for the position of worker posture. The marks or

data that's being collected by the evaluator are based on their opinion and thought. The data that they get are subjective. Hence different evaluator will collect different values of marks or data with the same worker. Therefore the first problem that being face is the data that's collected are not consistent. The accuracy of the angle that produced by the worker is not correctly valued.

The second problem is, when using the vision system to detect and reading the position of the posture. A multiple object detecting occurred. The only object that in this research want is detecting the local object to get the correct reading or data. Thus, it can be effected the collection of the data. Due to the interference from the other object the data obtain cannot be used in the RULA table.

Therefore in this project, I propose a vision system that able to measure the angle produced by the worker accurately using a software called opencv. This software track the colour sticker on the human body and calculate the angle each time movement was made. And the vision can locate the local object using colour tracking algorithm with moment algorithm to determine the center of the colour sticker.

1.3 Objective

The objective of this project is:

1. To develop a vision system detect the position, posture of the human body and produce wanted data such as the angle of the body posture.
2. To develop a vision system that can detect and tracking the local object.
3. To analysis the accuracy and latency of the vision system with the value of x and y axis obtain from the system and detect yellow color of the object with value x and y axis.

1.4 Scope

The vision system main scope is detecting the color object. Each color had its own scalar. In this project the yellow and blue sticker is used. Therefore, in the coding the range value of HSV for the yellow and blue color is written. If using black and white object the range value for HSV will also change according to the color. The vision system are also will detect the position of the sticker based on the yellow and blue color. These devices also need to calculate the angle of the object so that the RULA data can be calculated and the last scope of work in this project is detecting the color object. To achieve all the objective of this project three experiments were conducted. The second experiment is to locate and tracking the local object using the color algorithm.one accuracy and latency test using DC motor and line with fixed angle to conduct both experiments. The third experiment is different blue colour range was used to identify is the system can track colour palate effectively. The last experiment is two different colors of the sticker was place to human body and test that the system can implement to real life.

1.5 Chapter arrangement

In the first chapter, the motivation, problem statement, objective and scope will be mention and explain in this part.

Chapter two is the literature review. Here the problem statement in this project will be explained more detail. In this part method used to solve each of the problem statement will be explain.

Methodology is the third chapter in this report. In this part the objective of the project are being mention back. In this part the material and the experimental setup are being explained. And the last two parts is the methodology and the method analysis.

Chapter 4 include the result of the experiment. This chapter accuracy, latency, color detection and field test result are state. The discussion are also state in this chapter

CHAPTER 2

LITERATURE REVIEW

The ergonomics assessment also refers to workstation assessment. Make sure that the workplace or workstation is ergonomic design to reduce the risk of injury. Common ergonomic assessment tools include NIOSH, Metabolic Energy Expenditure, OWAS and RULA. The first tools are NOISH the lifting tool. This method can help evaluate the symmetrical and asymmetrical lifting task and give appropriate and scientific suggestion. It gives a relative estimate of the level of physical stress and damage associated with manual lifting task. The other method is a metabolic energy expenditure tool. It helps predict metabolic energy required of a specific task. Third method is OWAS. OWAS is a practical method for identifying and evaluating poor working posture. And the method that used in this project is RULA tool. A useful tool to evaluate the exposure of workers to the risk upper limb disorder.

2.1 RULA

2.1.1 Background

RULA is stand for Rapid Upper Limb Assessment. This RULA is a survey method used to investigate the ergonomic condition at the workplace. RULA table is widely used at the workplaces where the MSD occur are highly rated. MSD or musculoskeletal disorder. It is a type of disease face of the worker because of improper posture while doing their work. RULA scores indicate the level of intervention required to reduce MSD risk. This assessment purpose is to make an assessment on neck and upper-limb loading mainly fixed task at the workplace. RULA table is divided into two parts. Part a, the score focus for upper arm, lower arms and wrist. Part b, covers the trunk and neck. The grand score is thes part where all the score for both parts are combined together. This table data are collected manually by the observer. Refer the RULA table in the Appendix.

2.1.2 Problem in collecting the RULA data

Most of Rapid Upper Limb Assessment (RULA) data are taken manually. The data that being collected by the observer are not quantitative. RULA manual data are recorded subjectively. Data are obtained depend on the observer, hence the data are not consistent.

2.1.3 Solution to collecting the ergonomic data

There are two method can be consider to gather the data for ergonomic posture. The first method is using vision to gather the data for ergonomic posture. Under vision method there is two type of method, the first one is using camera with combination of two 3D depth

sensor and RGB camera such as Kinect [3][4][5][6][7][[8] and the second method is using monocular camera[9][10]. The second method is using sensor to gather the data. The sensor use are Wiimote sensor[11][12], pressure sensor[13][14]

2.1.3.1: Vision method

2.1.3.1.1: Kinect

Kinect is a motion sensing input device by Microsoft for xbox 360 and xbox one. This Kinect camera combination of two 3D depth sensor with one RGB camera Figure 2.1 shows the real pic of the Kinect.

Figure 2.1: Kinect features[15]

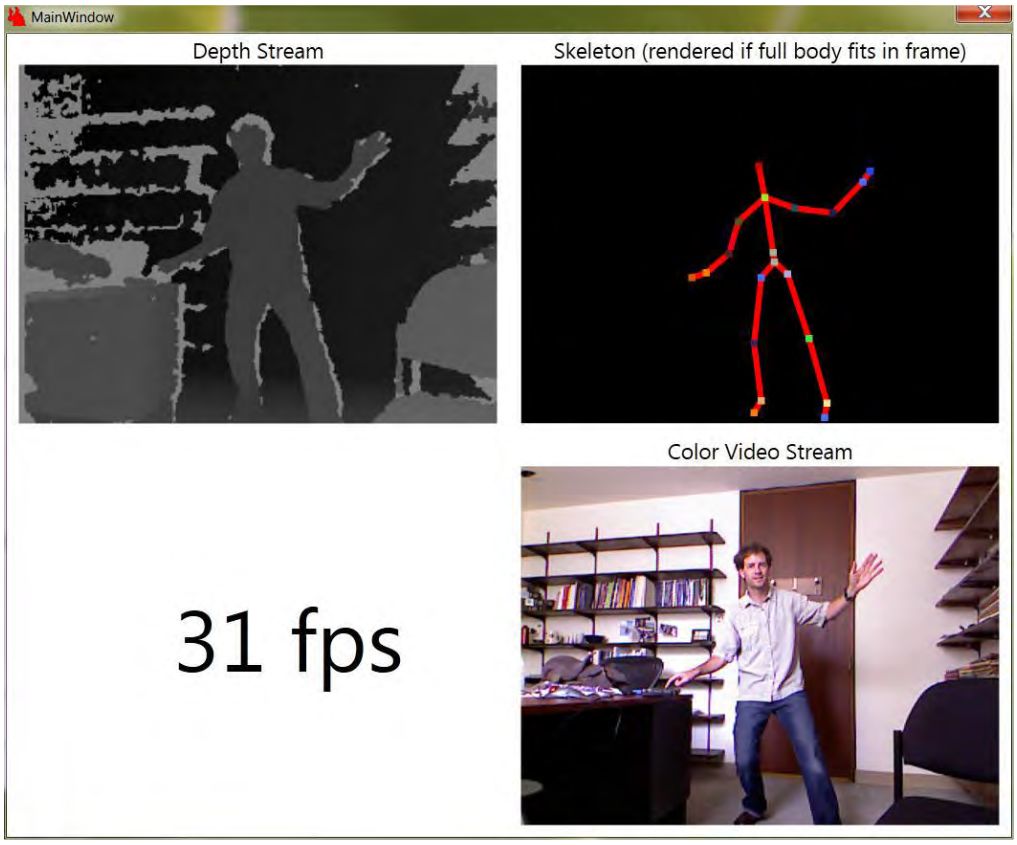

Figure 2.2: Result of the Kinect[15]

Kinect use two stages process in order to get result in figure 2.2. The first stage is compute a depth map using an analyzing technique. This technique is call as structure light. After the depth map was compute the process will proceed to next stages, infer body position using machine learning. For the stage one compute depth map, Kinect xbox was the main element in order to compute the depth map. The construction of the depth map involving the analyzing a speckle pattern of infrared laser light. This analyzing is known as the structure light as mention before. The general principle of these analyzing technique is project a known pattern onto the scene and infer depth from the deformation of that pattern. Figure 2.2 illustrate the principle structure of light

Figure 2.3: Principle structure of light.[15]

Then the Kinect combine structure of light with depth from focus and depth from stereo known as old school computer vision technique. After the depth map was finish compute the process will move to the next stage infer body position. In this stage the process are divided into two part. The first sub stage is 100,000 depth of known skeleton are obtain form the motion system.

Figure 2.4: 100, 000 depth of known skeletal[15].

When the 100,000 depth image is done a technique for mapping images to body part was used. This techniques known as random decision forest. Then second sub stage is where the body part was transform to the skeletal. In this stage the mean shift algorithm was used to robustly compute mode of probability distribution.

2.1.3.1.2: Monocular camera

Meaning of monocular camera can be divided into two. The first is monocular, it is a modified refracting telescope used to magnify the image of a distant object. And the second is the camera. The Camera is a device can that have the ability to record the visual image either in a form of picture, film or video. Nowadays, in market many types of camera can be found. Usual monocular camera used most in the experiment is camera that digital and able to record video well.

Figure 2.5: Mono- camera used on a mobile robot[10].

In figure 2.4 is one of the example mono-camera that is being used in an experiment. The camera was attached to the mobile robot. The mono-camera was made of two important basic elements. The first element is the optical element which is the lens. The Second element is the mechanical element which is the camera itself.

However, optical element play important role. Here where the image start to form. The lens used converging to form the real image. The general operation of the converging process is start from the beams of light. The beams of light bouncing off from an object and that beams will redirect so that can form real image.

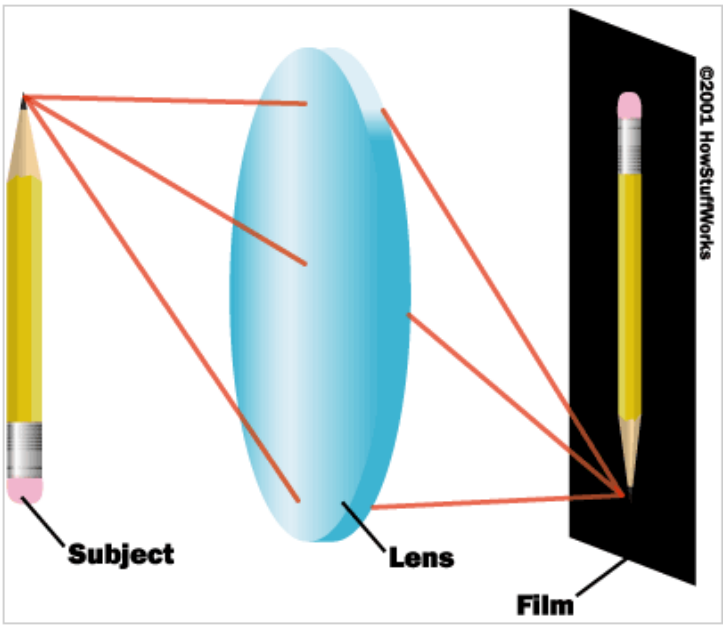

Figure 2.6: General process of real image[16]

The first step in the real image formation is it start when the light wave enters the glass at the certain angle. When the light wave enters the glass one part of the wave will reach the glass. At the moment that part enter the glass the wave will start slowing down first. Then the light that enters the glass will bend in one direction. The beams light will constantly diverge. The converging lens then redirects all the rays at one point. This is how the real image is formed. The figure shows the illustration how the converging process happened.

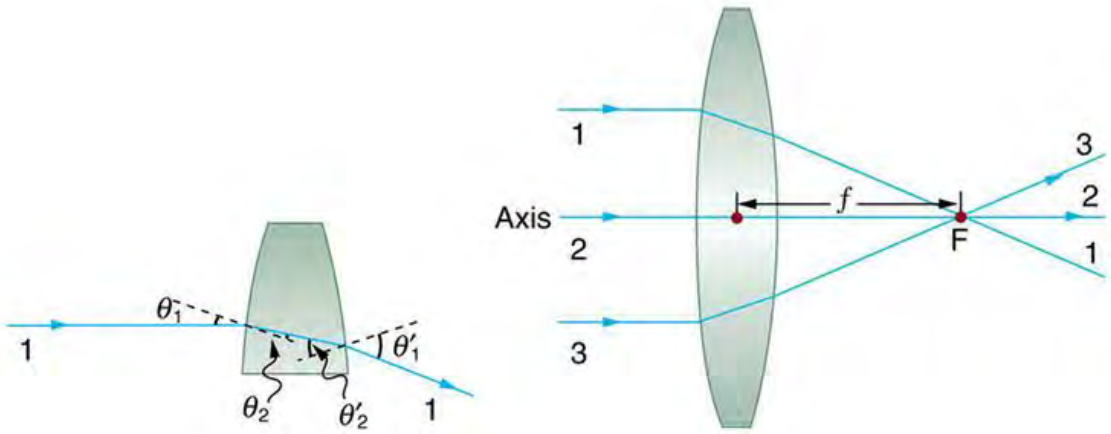

Figure 2.7: Converging process[17]