" 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 : ....

DEVELOPMENT OF VISION BASED MEASUREMENT DEVICE FOR RAPID UPPER LIMB ASSESSMENT (RULA)

NURULFIZAH BINTI RAZIF

A report submitted in partial fulfillment of the requirements for the Degree of Bachelor of Mechatronic Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

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 : ....

Student's Name : Nurulfizah Binti Razif.

Date : ....

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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.

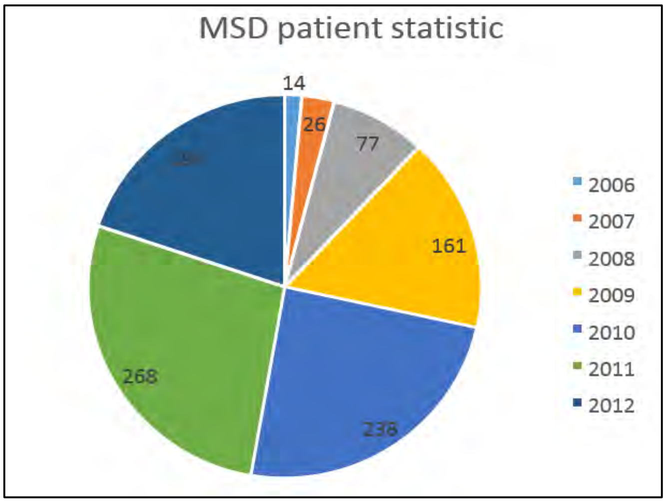


Figure 1.1: MSD static patient in Malaysia

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]

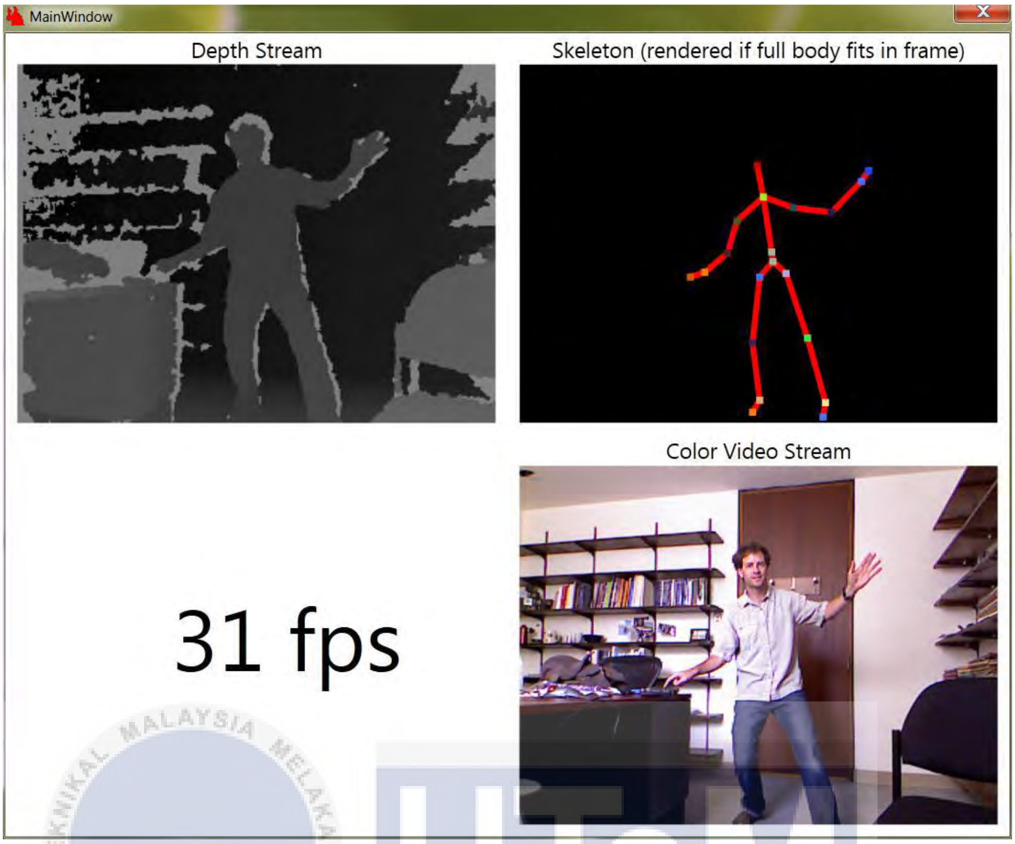


Figure 2.2: Result of the Kinect[15]

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.

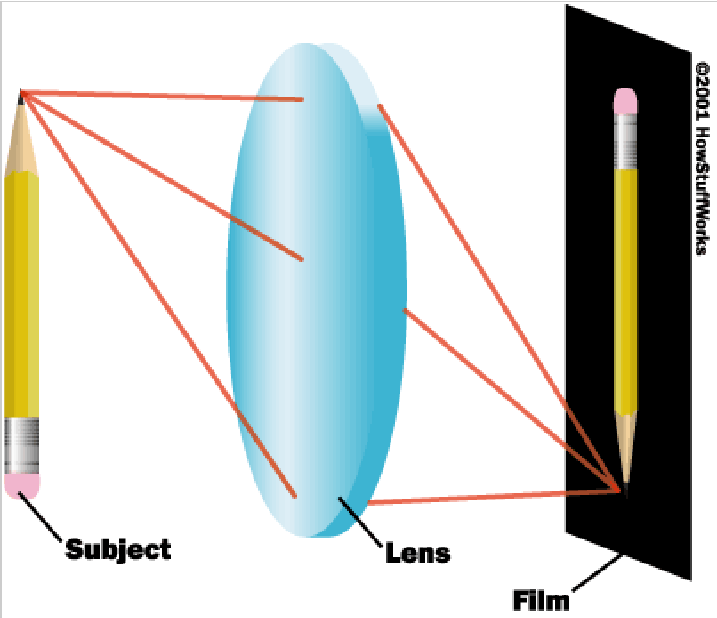


Figure 2.6: General process of real image[16]

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.

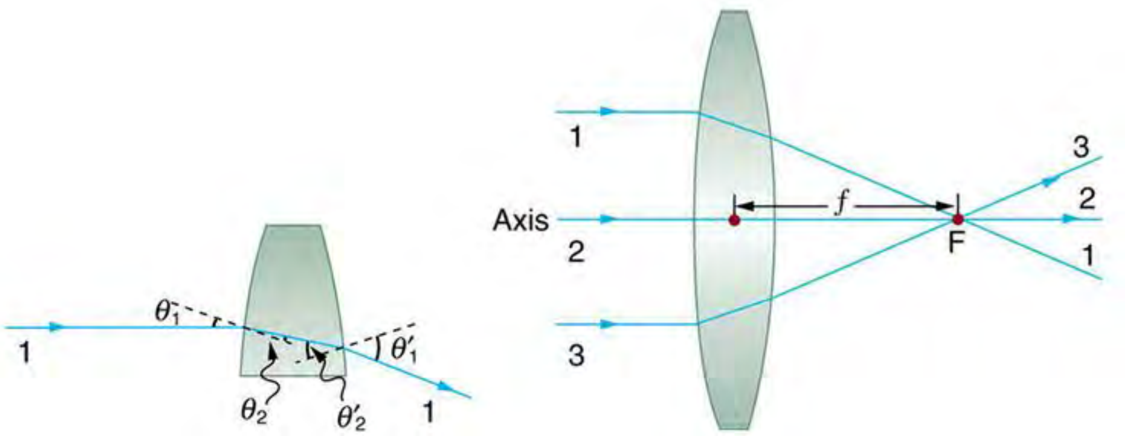


Figure 2.7: Converging process[17]

Two basic equation was involve:

Lens equation:

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i} \qquad 2.1$$

Where:

$d_0 = object\ distance$

$d_i = image\ distance$

$f = focal\ length$

Magnification equation:

$$M = \frac{h_i}{h_0} = -\frac{d_i}{d_0} \qquad 2.2$$

Where:

$h_o = object\ height$

$h_i = image\ height$

2.1.3.2: Sensor method.

2.1.3.2.1: Wiimote sensor

Wiimote sensor also known as Wii remote sensor. This sensor is one of the motion sensor. The Wiimote sensor capable to allow user to interact with manipulate item on screen via gesture recognition or pointing. This sensor are equipped with accelerometer and optical sensor technology. Main feature of the Wiimote motion sensor is the accelerometer and infrared camera. For the accelerometer build with 3-azis accelerator, x,y and z. These three axis help to measure the acceleration. The x-axis runs side-to-side, y-axis aligned with the longest dimension, z-axis runs up-and-down. Figure 2.7 show the position of the axis.

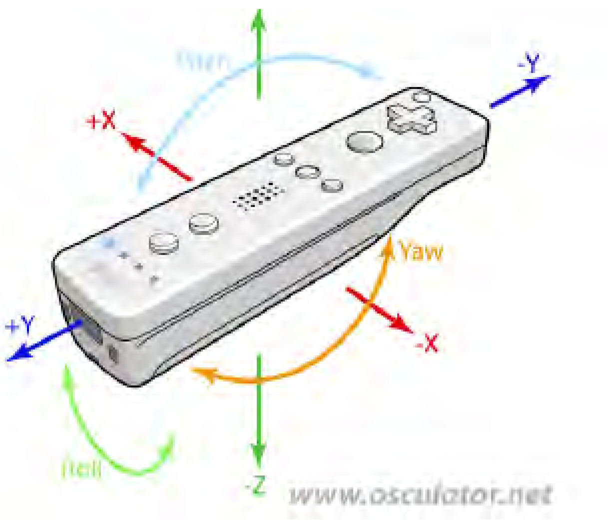


Figure 2.8: Axis of the accelerator[18]

For the infrared camera Wiimote motion sensor capable to support 128 × 96 pixel monochrome camera. This infrared camera have two infrared light source. This infrared light source was supply by the ‘sensor bar’. Wiimote camera will perform triangulation based on the images that being capture from the camera to determine where the Wiimote is point as shown in figure 2.8.

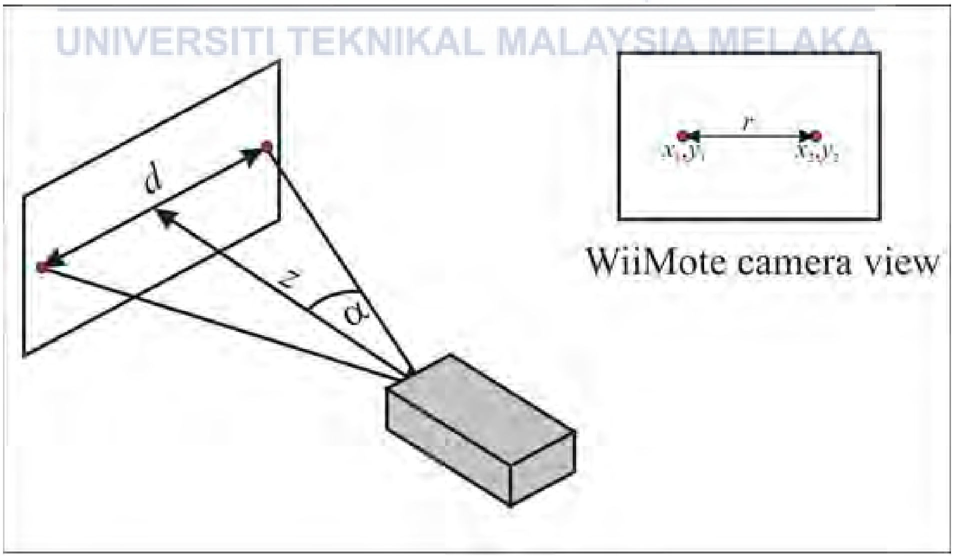


Figure 2.8: Wiimote camera view[19]

Value of z is very important to determine the distance between the Wiimote with the image. Several equation was involve to determine the value of z.

Angular field of view per pixel on the camera, Θ_{FOV}:

$$\theta_{FOV} = \frac{\left(\frac{HFOV}{1024} + \frac{VFOV}{768}\right)}{2} \quad 2.3$$

Where :

$HFOV = angular\ field\ horzontal$

$VFOV = angular\ field\ vertical$

The distance between the two dot

$$r = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad 2.4$$

Total angle between the two dot and the Wiimote sensor:

$$2 \propto = r\theta_{FOV} \quad 2.5$$

$$= \frac{\left(\frac{HFOV}{1024} + \frac{VFOV}{768}\right)\left(\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}\right)}{2}$$

Angle, α

$$\alpha = \frac{r\theta_{FOV}}{2} \quad 2.6$$

Distance between the Wiimote sensor and the sensor bar

$$z = \frac{d}{2\tan(\alpha)} \quad 2.7$$

2.1.3.2.2: Pressure sensor

Using the pressure sensor is one other option in sensor method[13]. Pressure is the sensor that able to measure the pressure. The operation of the pressure sensor contain three main functional block. Figure 2.9 show the pressure sensor functional block.

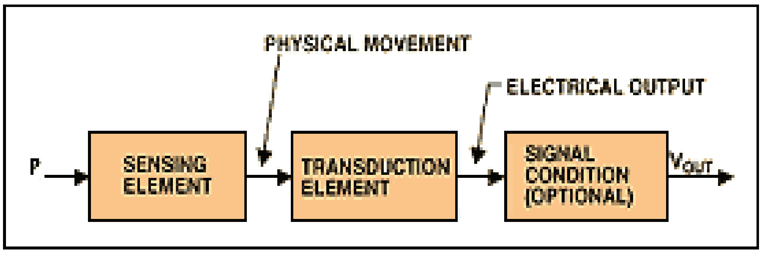


Figure 2.10: Functional block[20]

For the sensing element, there are many type of sensing element. For example Bourdon tube, diaphragms, capsules and many more. Refer figure 2.10 to look other type of sensing element.

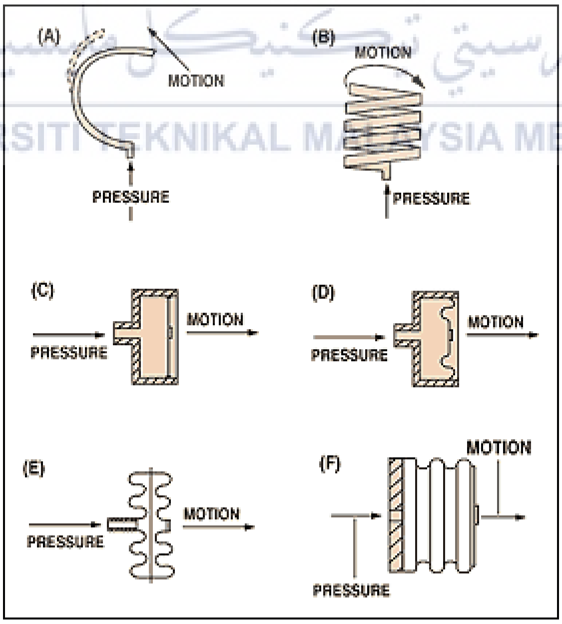


Figure 2.11: type of sensing element[20]

In ergonomic case the common pressure sensor used was the body pressure sensor. This body pressure sensor can be in the form mattress[21] or driver seat[13] and other form.

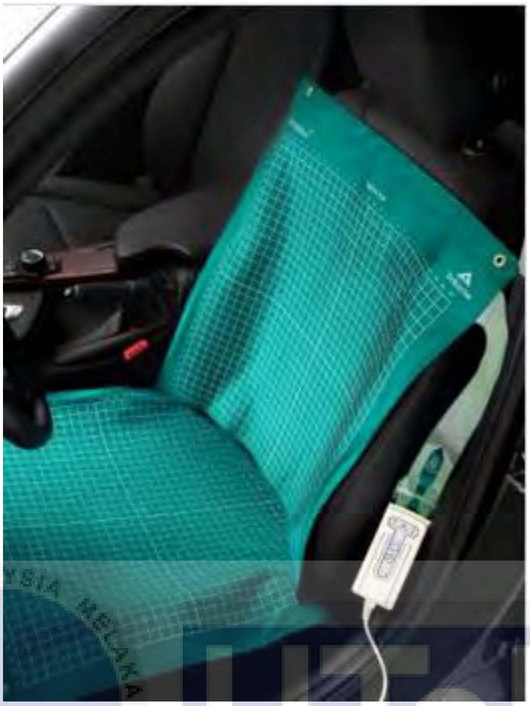
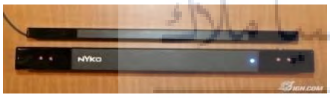


Figure 2.12: Body pressure sensor in car seat[22].

The main role of the body pressure is to map the pressure that apply by the user. Then raw data was obtain from the body pressure. An improving process was conducted to make the product more comfortable and less MSD injury to the user.

2.1.4: Analysis

Table 2.1: Comparison between methods.

Method	Accuracy	Latency
Camera with 3D depth sensor and RGB camera 	- System identify most lifting pattern successfully. - Provide valuable insight regarding accuracy	- NA
Monocular camera 	- Can capture all 100 sample position accurately.	- NA
Wiimote sensor 	- Less accurate due looseness of mounting system.	- NA
Body pressure sensor 	- Not accurate due to unbalance position.	- NA

2.1.5: Summary.

Based on table 2.1 accuracy for all the method was carry out but the result was not in value form. Among all the method monocular camera giving general value for the accuracy. It show that the monocular have high accuracy since this method can capture all the 100 sample position accurately. For the latency all the method do not conduct any latency test or experiment. Hence it is difficult to identify which method have high latency. The latency test for this project is very important.

In this project the accuracy test is important to determine the error produce by the system. Monocular camera is better option compare than other. For this project the result for the accuracy test are in value form different than other method. It is easy to determine the accuracy of the system. And the test of latency also are conducted in this project.

2.2: Image processing.

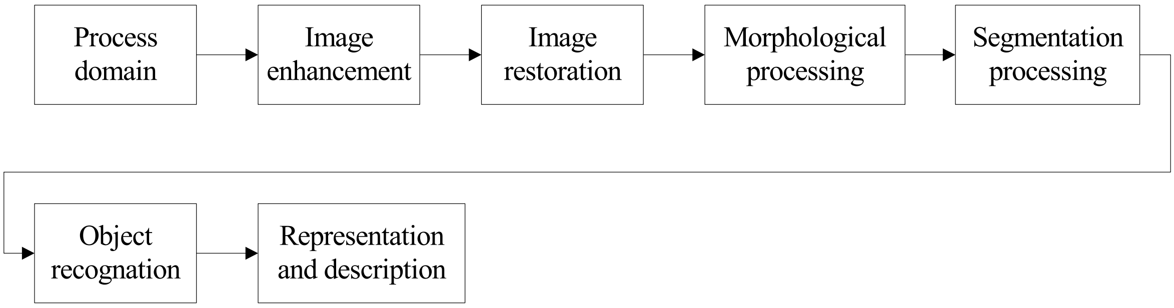


Figure 2.13: Digital image processing block diagram.

Image processing is any signal processing that the input of these processes is the image. Such as picture or any video. Image processing usually relates to digital image processing. Digital processing is the process where the computer algorithm is used to perform on the digital image. The block diagram of digital processing can be seen in figure 2.6 above. This section explain contain of each of the blocks in the block diagram above.

For the first block is the problem domain. Problem domain can be defined as the area of expertise or application that need to be investigated to solve the problem. In this project the problem domain is to detect the color of the object. Besides detecting the color object to track the position of the object also become of the problem domain in this project.

The second block contains image enhancement. Image enhancement is the process where the image of the output improves so that the output image seems subjectively. The output image will enhance when the additive noise and interface are removed. Besides those two things multiplicative, image contrast increase and blurring is decrease show that the image is already enhanced. There are several methods can be used to remove all the unwanted element that is being listed before. The methods are smoothing and low pass filter, sharpening or high pass filter, histogram manipulation and the last one is a generic blurring algorithm.

Image restoration is in the third block. These block explain about improvement of an image using objective criteria and prior knowledge as to what the image should look like. But in other source the image restoration means remove distortion from the image in order to get back the original image. The factor that make why the image need for restoration is because an image may be degraded or may be distorted. Method to perform the image restoration are divided into four categories the first one is homogenous linear image restoration. Under these categories, there are about 3 types of process that is inverse filtering, Wiener filtering and constrained matrix inversion. The second categories are inhomogeneous. Compare than homogenous, inhomogeneous categories contain only one process that is the whirl transforming. Nonlinear is the third categories. MAP estimation is under nonlinear. The last categories is geometric image restoration.

Morphological processing is the next block after the image restoration. According to the open source it says that morphology is a collection of non-linear operation related to the shape or morphology of features in an image. To solve morphology of features in an image two basic operation are introduced. The first one is erosion, shrink the image and dilation grow the image. The combination of these basic operations will remove structures and fill the hole of the image without affecting remain parts of the image.

The second last of the block is object recognition. Object recognition is related with determining the identity of an object being observe in the image from a set of known labels. Three method which was introduced, the first one is geometry-based approaches, appearance based algorithm, and the last is features-based algorithm.

The last block is representation and description. Representation means the object may be represent by its boundary. Description means the object may be describe by its length, orientation or number of concavities.

By referring the block diagram above an image can be processed easily without having any trouble. And help people to get better image flawless. Digital image processing bring lots of advantages to people who work with image or vision system.

2.2.1: Tracking local object.

2.2.1.1: Background.

In vision system, there will be two parts of object tracking. For the first part is a global object, this part is where the area is referring to the whole area of the video. And for the second part is local object. This part is where the desired object that want to be detected. In this project only local object needs to be detected, so that the position posture of the user is easily detected and calculated. The process where the local object will be track and recognize is in the sixth block of the digital image processing block diagram.

2.2.1.2: Problem to tracking local object.

Even the image undergoes all the process listed in the figure above, but still there is one or more image problem. In this research the image that the produce of the vision system undergoes multiple object detection. In the video the vision system detects unwanted object. This problem is located under object recognition block.

2.2.1.3: Solution to tracking local object.

In order to solve this problem. A research was being made on the method on how to track the local object. After several of journal reading it show that about three method can be done in tracking the object. The most reliable method in tracking local object is by using color object algorithm coding.

2.2.1.3.1: Lucas-Kanade.

For Lucas-Kanade[23] using this method to tracking the object. Base on the Lucas-Kanade optical flow method the purpose a dynamically selecting model has been made. The Lucas-Kanade optical flow was applied to these study is to calculate the tracked features point. A consistence constrain strategy is design to constrain the features point by removing some unfit features point. A random sample model is used to resample the tracked objet to get some new proper features. This method can deal with features point disappearance problem. The optical flow are working base on these three assumption.

a. Brightness constancy. It is means that the brightness of a pixels does not change as it is tracked from frame to frame.

b. Temporal persistence or known as small movements. The motion range of the object being small from one image frame to other frame.

c. Keeping the image space consistence.

Based on the assumption 1 and 2 the constraint equation was generate as below:

$$I(x, y, t) = I(x + dx, y + dy, t + dt) \tag{2.1}$$

Then the first order Tylor series was expand as equation below:

$$-I_t = [I_x I_y] \binom{u}{v} \tag{2.2}$$

Where the (u,v) is the optical vector$\left(\frac{d_x}{d_t}, \frac{d_y}{d_t}\right)$ and for the (I_x, I_y, I_t) is the gradient of the image coordinate (x, y, z). By assuming that (u, v) has same value in small local range then easily solve for the motion of the central pixel by using the surrounding pixels to set up a system of equation. The equation are shown are required in the Lucas-kanade Optical flow below:

$$\begin{bmatrix} I_{x_1} & I_{y_1} \\ I_{x_2} & I_{y_2} \end{bmatrix} \binom{u}{v} = \binom{I_{t_1}}{I_{t_2}} \tag{2.3}$$

Adaboost algorithm also used in the experiment[24]. With these algorithm the system manage to detect the face of the user. The first part of the research is detection of the user face.. The next step of the process is recognition of the location of the eyes in the first frame using template matching was conducted. After the process are finish the process was proceed tracking the eyes using combination of two type of algorithm, Lucas-Kanade optical flow algorithm and pyramid algorithm. The main focus here is the combination of these algorithm. Figure 2.9 below show combination of both algorithm.

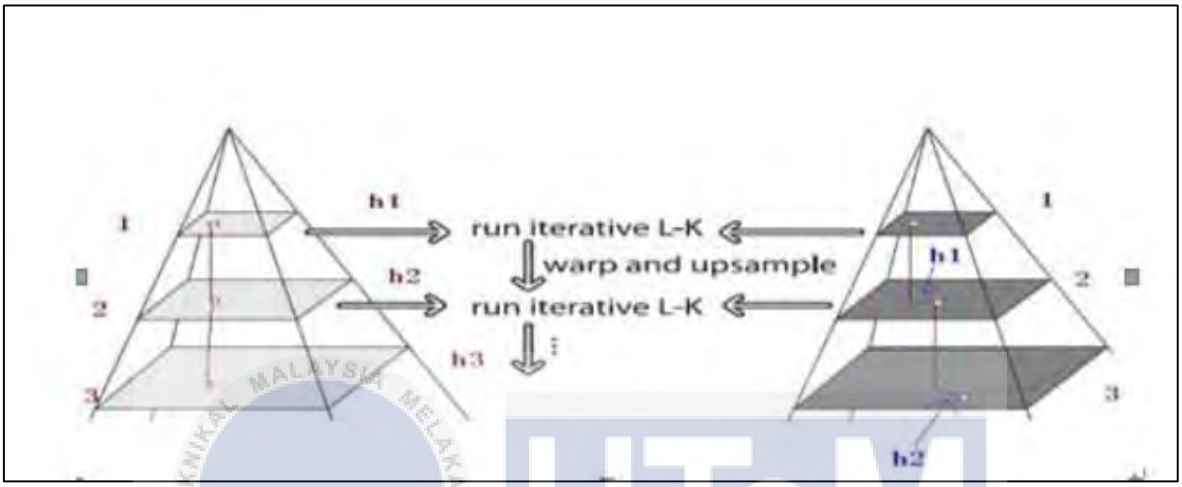


Figure 2.14: Pyramidal Lucas-Kanade algorithm.

Step involve in these algorithm is:

a. Initialize the point need to be track. That point are two pupils of the eyes hat being track by the template matching.
b. Calculate the optical flow of two frames to compute the initialized target point.
c. Exchange the input and output points.

2.2.1.3.2: Kalman filter

The second method is using the Kalman filter[25][26][27][28]. All these experiments having problem with tracking the object. Therefore Kalman filter was choose to solve the problem face in each of the research. The general equation for the system state and the measurement model of the Kalman filter are state in the equation 2.4 and 2.5:

$$x_k = Fx_{k-1} + Bu_k + w_k \tag{2.4}$$

$$z_k = H_k x_k + v_k \tag{2.5}$$

F is stand for the transfer matrix, while for the H is the measurement matrix. Both matrix is to connect between the state and the measurement. The function of u_k is to allow the external control on the system. The measurement error is represent by value of v_k. Above equation only state the general equation of two important element. The first step in filter is prediction step. In this early step the predict state, $x_{\bar{k}}$ and error covariance, to be find. The equation as follows:

(2.6)

(2.7)

$$x_{\bar{k}} = Fx_{k-1} + Bu_{k-1} + w_k$$

$$P_{\bar{k}} = FP_{k-1}F^T + Q_{k-1} \tag{2.7}$$

And the next step is the correction step. The kalman filter will calculate the kalman gain using equation in 2.7 and then calculate the measurement value using equation 2.5. And finally the corrected gain and error covariance for prediction step are calculated using equation that state below.

$$K_k = P_{\bar{k}} H_k^T (H_k P_{\bar{k}} H_k^T + R_k) \tag{2.8}$$

$$x_x = x_{\bar{k}} + K_k (z_{\bar{k}} - H_k x_{\bar{k}}) \tag{2.9}$$

$$P_k = (I - K_k H_k) P_{\bar{k}} \tag{2.10}$$

With this algorithm calculation all the research using the Kalman filter the researcher manage to track the object. Even each of the research paper are using the different type of Kalman filter but the basic function of the kalman filter are still same for all four journal.

2.2.1.3.3: Color tracking algorithm.

The color algorithm usually used for color object. This method is the easiest way of tracking the local object since in this system the main idea is to locate the color object to the human body in order to calculate the position of the body. In this case the color space changing from blue, red and green (BGR) will convert to hue, sat and value (HSV). Using

HSV for tracking the object is easy. HSV is easy to calculate. The researcher [29][30][31] using color tracking algorithm to track their local object either using BGR or HSV colour. HSV color was used to locate the local object[32][33][34][35][36][37][10]. The main idea about the color tracking algorithm is using the color function in C++ code in order for the system to tracking the color. Example of the color tracking algorithm function is cv2.cvtcolor ( ) and cv.InRange ( ). Changing the color basic blue, red and green to HSV color is easy for the system to tracking the object. This is because HSV color have its own specific color. HSV color has its own formula use to converting the RGB color to HSV color. Most all the journal mention before used these formula as their guide line in their research.

The RGB color value are divided by 255 in order to change the range from 0 to 255 to 0 to 1:

$$R' = \frac{R}{255} \tag{2.11}$$

$$G' = \frac{G}{255} \tag{2.12}$$

$$B' = \frac{B}{255} \tag{2.13}$$

$$C_{max} = \max(R', G', B') \tag{2.14}$$

$$C_{min} = \min(R', G', B') \tag{2.15}$$

$$\Delta = C_{max} - C_{min} \tag{2.16}$$

Hue calculation:

$$H = \begin{cases} 60^\circ \times \left(\frac{G' - B'}{\Delta} mod6\right), C_{max} = R' \\ 60^\circ \times \left(\frac{B' - R'}{\Delta} + 2\right), C_{max} = G' \\ 60^\circ \times \left(\frac{R' - G'}{\Delta}\right), C_{max} = B' \end{cases} \tag{2.17}$$

Saturation calculation:

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \dfrac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases} \tag{2.18}$$

Value calculation:

$$V = C_{max} \tag{2.19}$$

RGB to HSV color conversion table:

Table 2.2: color conversion

Color	Color name	Hex	(R,G,B)	(H,S,V)
	Black	#000000	(0,0,0)	(0°,0%,0%)
	White	#FFFFFF	(255,255,255)	(0°,0%,100%)
	Red	#FF0000	(255,0,0)	(0°,100%,100%)
	Lime	#00FF00	(0,255,0)	(120°,100%,100%)
	Blue	#0000FF	(0,0,255)	(240°,100%,100%)
	Yellow	#FFFF00	(255,255,0)	(60°,100%,100%)
	Cyan	#00FFFF	(0,255,255)	(180°,100%,100%)
	Magenta	#FF00FF	(255,0,255)	(300°,100%,100%)
	Silver	#C0C0C0	(192,192,192)	(0°,0%,75%)
	Gray	#808080	(128,128,128)	(0°,0%,50%)
	Maroon	#800000	(128,0,0)	(0°,100%,50%)
	Olive	#808000	(128,128,0)	(60°,100%,50%)
	Green	#008000	(0,128,0)	(120°,100%,50%)
	Purple	#800080	(128,0,128)	(300°,100%,50%)
	Teal	#008080	(0,128,128)	(180°,100%,50%)
	Navy	#000080	(0,0,128)	(240°,100%,50%)

2.2.2: Analysis.

Table 2.2 show that the different between two method that is Lucas-Kanade and Kalman filter. All the advantage and the disadvantage between these two methods have being taken from the journal that used these two method to locate the local obeject.

Table 2.3: Comparison between the three methods tracking local object.

Method	Advantages	Disadvantage
Lucas-kanade	- Can assess motion between two frames. - Deal with the features disappearance.	- N/A
Kalman filter	- Predict the object motion direction. - Define searching window. - Has wider application.	- Possibility to miss the target or the object. - Accuracy decrease when the size of object change a lot. - Leads to divergence of expected value from actual value if not tuned properly.
Color tracking algorithm	- Easy to calculate. - Used for adaptive background modelling.	- Does not recognize same color a different lighting. -

2.2.3: Summary.

As can see in the table above that being investigated in order to solve problem in locating the local object in this project is Lucas-Kanade, Kalman filter. From the two journals that used as a reference for this method, states that Lucas-Kanade method have advantages in dealing motion in two frames and can solve problems with disappearance objects. However, the disadvantages of this method are not mentioned in the journals. For the second method is Kalman filter, researchers from the journal that used this method state the advantages and the disadvantages of the Kalman filter method in locating the local object. Kalman filter well in predicting the object motion direction and has wider application, but this method has disadvantages in detecting the object. One of the journals that use this method to locate their object state that Kalman filter has the possibility of losing the target or object which is tracking and locate the object all the time is one of the important part in this project. For these project the main idea is to detecting the color sticker that stick to the body of the user. After the system manage to detect the color the system begin to calculate the position and the angle produce. Therefore color tracking algorithm are choose in this project. Even these method have the weakness difficult to detect the same color under different lighting but it's easy to calculate and by adding color space changing from BGR to HSV color the system can track object with specific color.

CHAPTER 3

METHODOLOGY

In this chapter there were three experiment are conduct to prove that method vision using camera and colour algorithm can detect the position of human body, calculate the angle accurately and can locate the local object. The objective of each experiment are state in this chapter three. All the experimental set up and material are conducted and explain in the part in these chapter. In experiment 2 the experiment was conduct base on the position state in the RULA sheet [refer appendix A]. For experiment 3 the methodology on how detecting and tracking object was taken in journal [38] as a reference on how to conduct the experiment. . Below is the flowchart of the experiment:

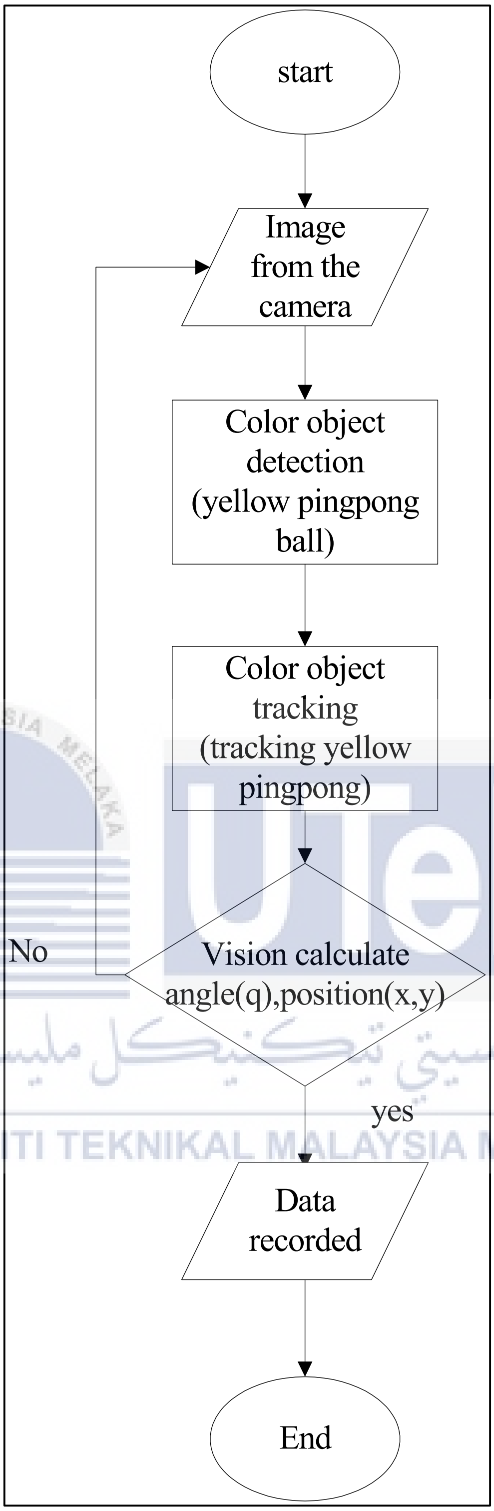


Figure 3.1: Flowchart experiment.

3.1: Objective.

For the experiment one the main objective of these experiment is to produce the graph of the accuracy in order to analysis the accuracy of the system and analysis the latency happen in the system. In the second experiment the objective is calculating the angle of the worker posture and collecting the data is the main objective. And for the third experiment, the objective is to tracking the local object.

3.2: Material/equipment

The equipment that is involved in these experiments is the code block for the software. The code block is a free and open-source, cross-platform IDE which support for many compilers. The example of the compiler are GCC, clang and visual C++. This software develops in C++ using the wxWidget as the GUI toolkit. Cross-platform IDE is operating system or programming environment.

In this software there will be two types of library used. The first one is OpenCV library. OpenCV or Open Source Computer Vision is the library of programming function for real-time computer vision. It means that the image will obtain live from the real life. OpenCV is written in C++ language and its primary interface is in C++. This library was used for many real-time applications such as mobile robotics, human-computer interaction and much more. In this project this library is used to detect the object in the real-time. The OpenCV library plays the main role in this project to get the real-time object tracking. Without these libraries it is impossible to track the object in the real-time.

The second library applies in code block software is CVblob. This library is for computer vision to detect connected regions in binary digital images. Cvblob perform connected component analysis or known as labelling and feature extraction. This libraries important in detecting the colour of the object. The combination of these two libraries in one software produces a vision system that can manage to detect the colored object in real time.

3.3: Experimental set up

This experimental set up are made base on the manual RULA table sheet to collect data. The step of the process are same with the manual RULA table sheet. This set up are set to collect the RULA reading.

3.3.1: Experiment 1

In this experiment the accuracy and the latency. The yellow ball are move slowly in straight line.

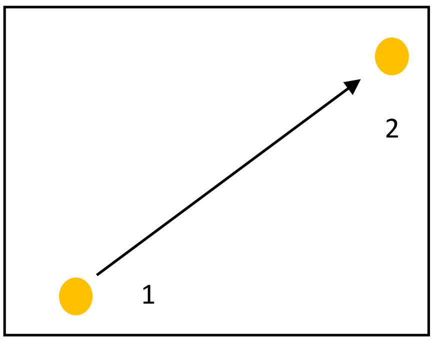
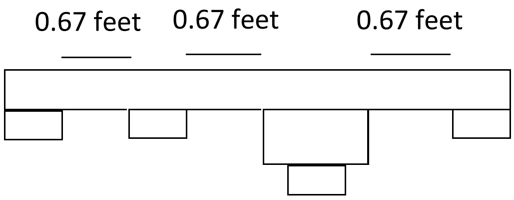


Figure 3.2: position of yellow sticker in straight line

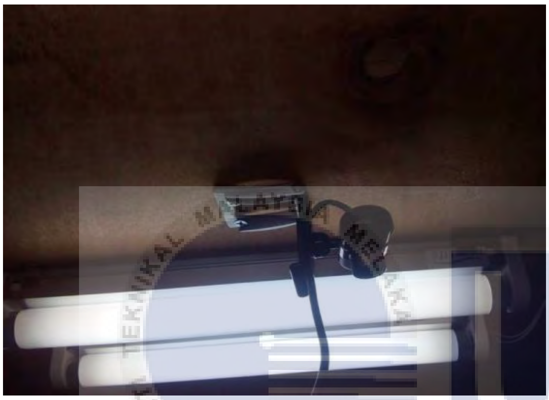
In this experiment, the analysis of the accuracy and latency of the system is conducted. In these project there will be two data obtain from the experiment. The first data is the value of the x and y. the ball will be place on the part of the workers body based on the experimental set up. The worker will do the same movement for five time. Each of the movement the reading for the axis will recorded. A graph will be construct base on the five data that being recorded. The accuracy will be evaluate base on the graph. The reading will give early assumption about the consistency of the data collected. Second data is the latency of the system. The real position of the ping Pong in real life will be recorded using the ruler, then the reading are compare with the reading produced by the vision system. If there is different between the real reading with the reading produce from the vision system, it show that the system experience latency. In figure 3.2 it show the illustration of the experiment. Firstly the ball is placed at position 1 and slowly the ball was move toward position 2 in straight line. A hardware was constructed in order to conduct the accuracy and latency of the experiment.

(a) (b)



(c)

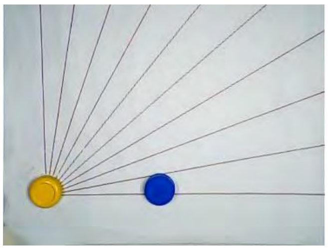
(d)



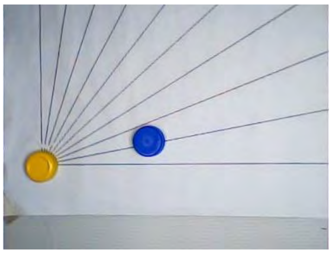
(e)

Figure 3.3: (a) First stage of the construction of the hardware, (b) Complete construction (c) Lamp done installing, (d) camera done installing.

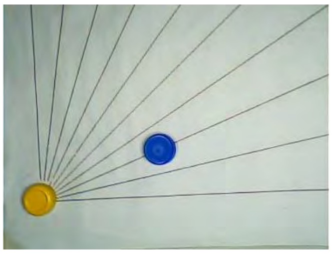
In figure 3.3 show the stages involve in the construction of the hardware. In figures 3.3.a show that the early stage of the construction. With using 6 millimeter of wood as the top and the base and aluminum stick was used as the leg of the hardware to support the 6 millimeter wood. After the skeleton of the hardware finish as shown in figure 3.3.b three T6 fluorescent bulb was placed on the top of the hardware skeleton. After the installation of the bulb done regular webcam with 5 megapixel was installed in the middle between the fluorescent bulbs.



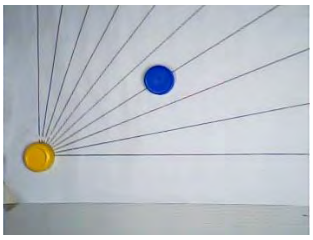
(a) 0˚



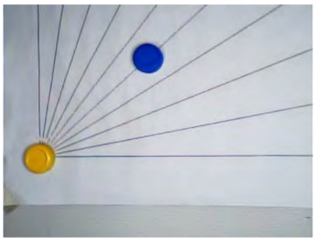
(b) 10˚



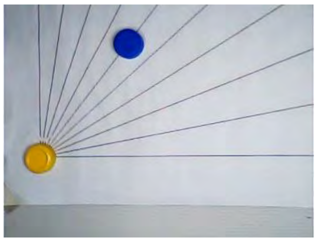
(c) 20˚



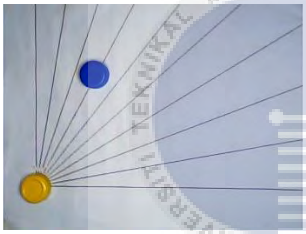
(d) 30˚



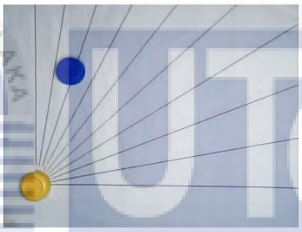
(e) 40˚



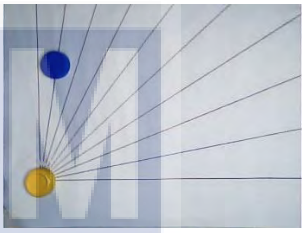
(f) 50˚



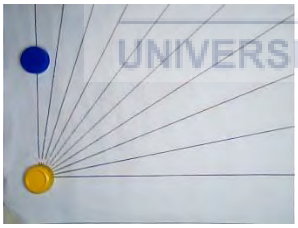
(g) 60˚



(h) 70˚



(i) 80˚



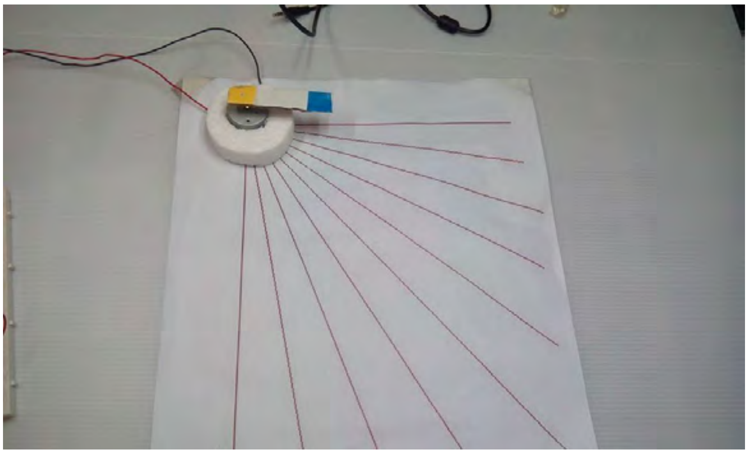
(j) 90˚

Figure 3.4: Color object movement for each 10˚

Figure 3.4 is the experimental set up to test either the system measure the angle accurate as the angle measure by the protector. An A3 paper with angle 0˚ until 90˚ was drawn using the brisCAD software to get the accurate angle. Degree between each line is 10˚. After that a protractor was used to measure the angle on the A3 paper. Then the drawing was placed under the hardware. The fluorescent lamp was on in order to make sure that the system have enough light so that it can tracking the color sticker smoothly. The web cam connected to the laptop, build in web cam was disable in order to use the external camera. The blue color sticker, then was moved each 10˚ follow the line during the system recording the reading. The reading was recorded and insert into excel to get the graph of the accuracy.

(a)

(b)



(c)

Figure 3.5:accuaracy test

Figure 3.5: (a) voltage divider circuit, (b) dc motor with polystyrene, (c) fully set up Figure 3.5 is set up an experiment to test the latency of the system. A voltage divider circuit was constructed using two 10K potentiometer, 7.4 volt battery and 3-12 volt dc motor. The function of the potentiometer is to control the speed of the motor. By using a polystyrene to hold the dc motor in position. A stick was used to stick the color sticker with the motor. Then four different speed were set and the reading of the angle record by the system was taken.

3.3.2: Experiment 2

Step 1: Locate right upper arm

(a)

(b)

(c)

(d)

Figure 3. 6: (a) hand in normal positon, (b) hand backward, (c) hand forward, (d) hand staright

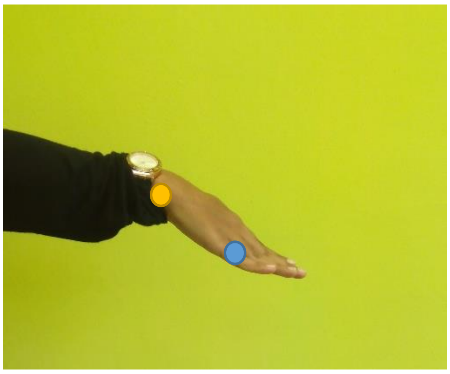
Step 2: Locate right lower arm

(a) (b)

Figure 3.7: (a) arm low position, (b) arm upper position.

Step 3: Locate right wrist

(a) (b)



(c)

Figure 3.8 (a) wrist in normal position, (b) wrist upward, (c) wrist downward

The positions in these experiments were set up according to the RULA sheet. Each of the movements will produce angle. The yellow and blue colour sticker was place on certain body part. The first one until third step was set up for the right arm. Step one until three is repeated for the left hand. The angle that produce then will be recorded. After that the RULA score will be given base on the angle obtain then the score evaluate either the worker doing the working process in correct posture. Posture in normal line will be set as 0°. Each of the movement make the angle will be calculate from the original positions.

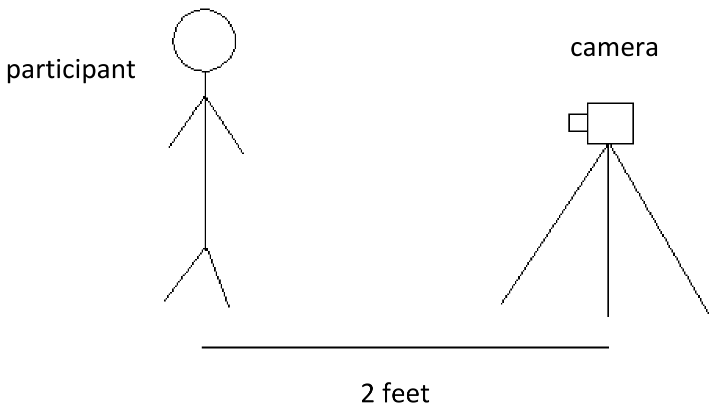


Figure 3.9: Full set up for the system

In figure 3.9 show that the whole set up for the system. Participants or user will stand about 2 feet from the camera. The participants must maintain the distance. The distance can be change at any distance. So the participant will do movement based on RULA sheet as shown in the figure 3.8.

3.3.3: Experiment 3

The local tracking object the setup of the system will be illustrate as shown in figure 2. The frame will be illustrate as the video frame.

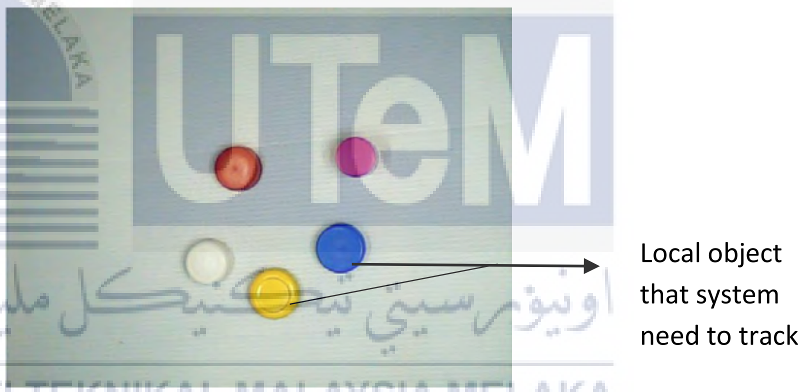


Figure 3.10: set up to locate local object

The colour algorithm were applied to the coding of the vision system. After the colour algorithm was applied to the system, then the system was test to tracking and locate the local colour object. In this experiment the testing will be starting from many different color object. The vision system then will be observed and decide either the system manages to track and locate the local object that being placed. And the color of the object will be constant from experiment one to experiment three.

CHAPTER 4

RESULT

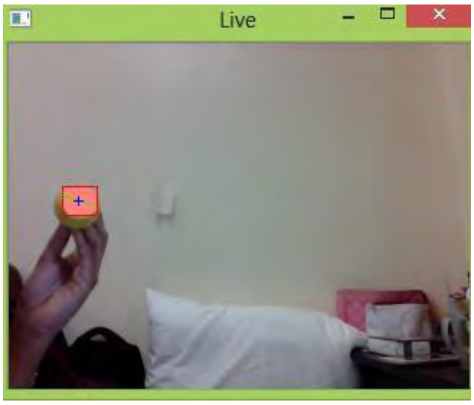
In these chapter early result of the project is shown and explain in this chapter. Discussion of these project also include in this chapter.

4.1: Result

4.1.1: Early result experiment

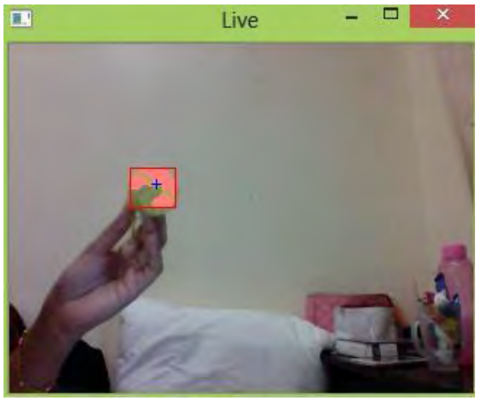
Figure 4.1: locate the local object

These result show that the system are tracking the local object. The system tracking the yellow and blue object. As can see from figure 4.1, line was draw around the yellow object and blue object. The system will only tracking and detect the area that only covered by the yellow colour and blue colour.



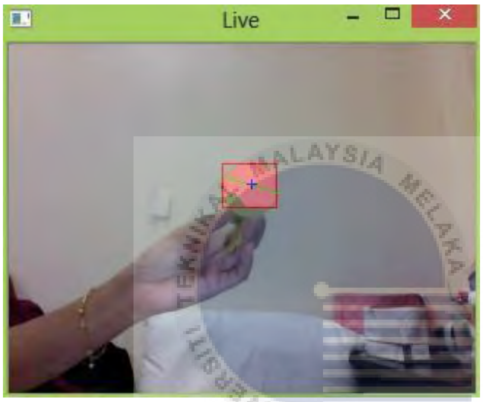
(a) Position 1

X= 170, Y= 336



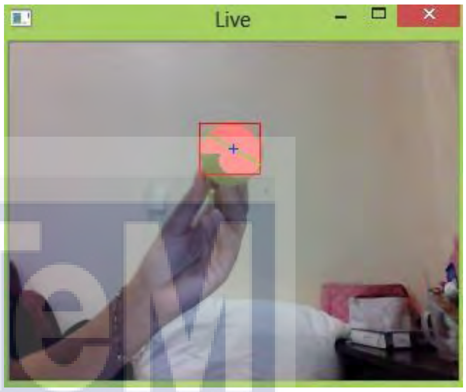
(b) Position 2

X= 183. Y=540



(c) Position 3

X= 576, Y= 352



(d) Position 4

X= 350, Y=601

Figure 4.2: position of the ping pong ball

Figure 4.2 show that the system detecting the yellow colour object and at the same time the system tracking the position of the yellow color object. Same like in figure 4.1 the system tracking the local object.

4.1.2: Result Accuracy

Table 4.1: Accuracy between protector and system

READING	DEGREE	PROTECTOR(°)	SYSTEM(°)
1	0	0	0
2	10	10	10.15
3	20	20	20.04
4	30	30	30.07
5	40	40	40.61
6	50	50	51
7	60	60	59.56
8	70	70	69.15
9	80	80	80
10	90	90	89

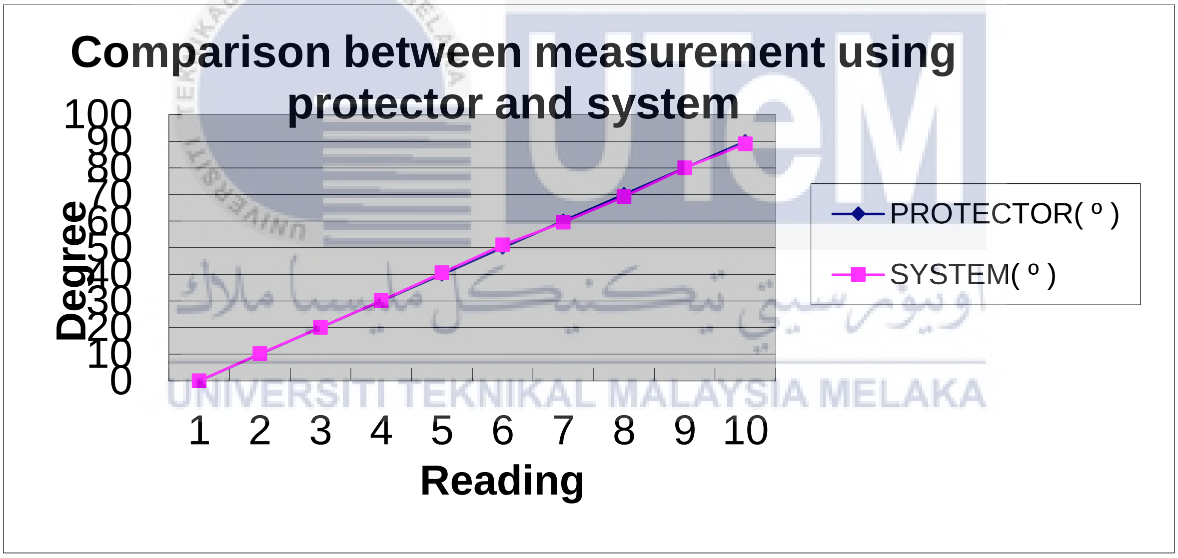


Figure 4.3

Based on the graph above it show that reading taken by the protector and the reading taken by the system almost have the same value. For reading 1 and 8 for both protector and system take the exact value of degree value. For reading 6 and 10 the reading is ± 1. Most of the system reading gives the value to four significant figures. The min and max value the system can measure is 0 and 90.

Error system and the protector are calculate based on the error formula below:

$$error = \left|\frac{\theta experimental - \theta theoritical}{\theta theoritical}\right| \quad (4.0)$$

In order to calculate the error between the systems and the protector mean of each degree was calculated. The formula is shown below:

$$mean = \frac{\sum \theta}{n} \quad (4.1)$$

Therefore, forr the mean of the system and the protector is:

$$mean(system) = \frac{\theta(system)}{n}$$

$$mean(system) = \frac{449.58}{10} = 44.958$$

And for the mean of the protector is:

$$mean(protector) = \frac{\theta(protector)}{n} \quad (4.3)$$

$$mean(protector) = \frac{450}{10} = 45$$

From the value mean from both, hence the error of the system is:

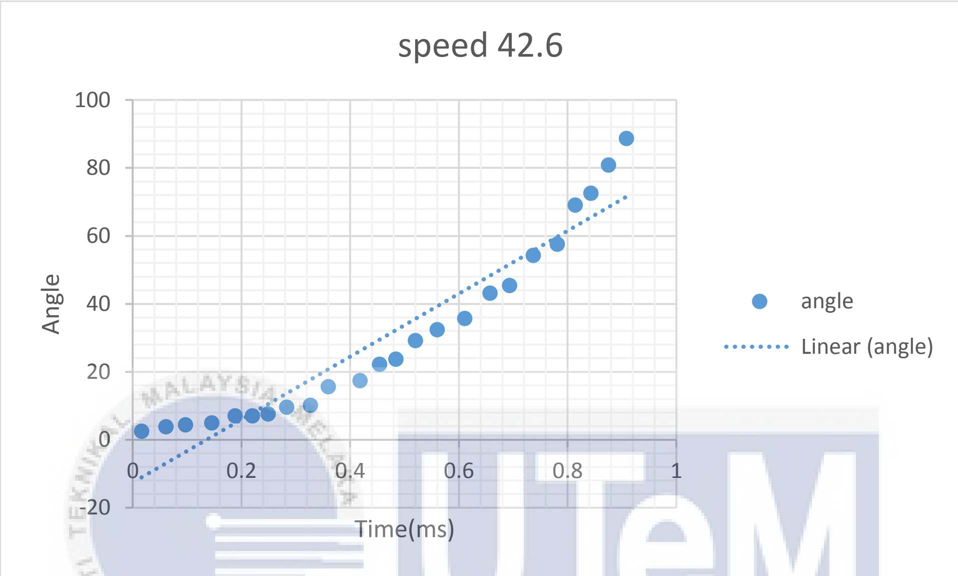
$$error = \left|\frac{44.958 - 45}{45}\right| = 0.000933$$

From the mean that obtain from the system and the protector it show that mean error of the system is less and not more than ± 1 than the mean for the protector.

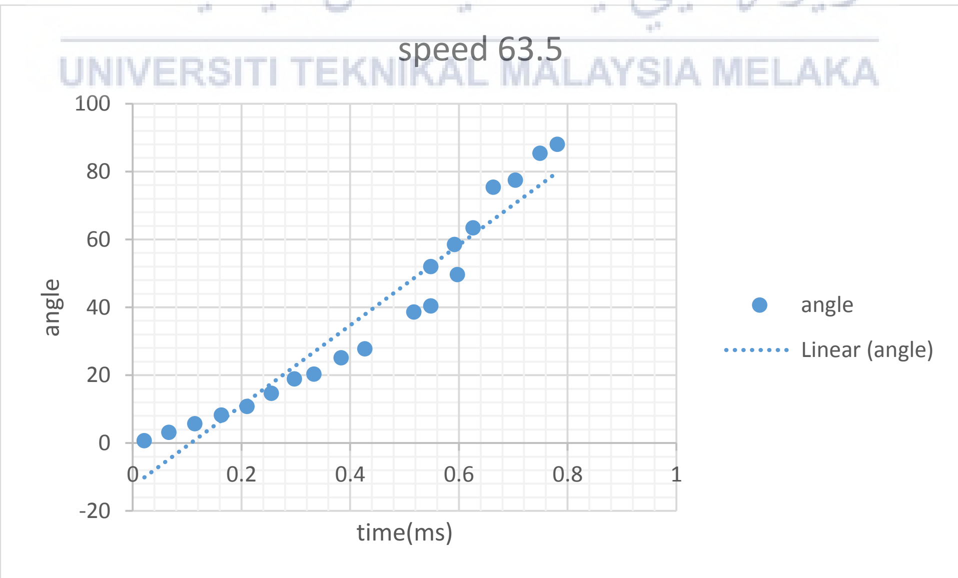
Why the system reading is slightly different from the protector reading. It's because of the angle that produce by the system are more sensitive. The degree reading produce by the system are more than 3 significant figures. The protector only can measure the angle with three significant figures. This is why the system reading is slightly different.

4.1.3: Latency experiment

In this experiment four different speeds was involved in order to test the latency of the system. Below is the graph for two different speed:



Graph 4.4: Speed 42.6



Graph 4.5: Speed 63.5

Time taken for the experiment is in millisecond. The reading of the angle was taken for 1 second. Form both graph 4.2 and 4.3 show that speed with 42.5 rpm take more time from 0˚ to reach 90˚ compare than 63.6 rpm that take within 0.8 millisecond. Angle that being recorded by the system for speed 42.5 rpm are many compare than angle. The line that produce in both graph is the linear line.

From the graph obtain standard deviation and mean was calculate. The calculation are shown below.

General equation

$$mean = \frac{\sum_{i=0}^{n} x_i}{n}$$

Mean for speed 42.5 rpm

$$mean = \frac{745.281}{24} = 31.053$$

Means for sped 63.6 rpm

$$mean = \frac{763.199}{20} = 38.159$$

General equation:

$$s_x = \sqrt{\frac{\sum_{i=0}^{n}(x_i - x)^2}{n-1}}$$

Standard deviation for sped 42.5 rpm

$$s_x = \sqrt{\frac{16692.276}{24-1}} = 26.939$$

Standard deviation for 63.6 rpm

$$s_x = \sqrt{\frac{15876.747}{20-1}} = 28.907$$

The value of angle keep on increasing as the time are increasing. Form calculation mean and the standard deviation show that both do not have number of reading.

Speed 42.5 have many reading because of when the speed is slower the value f the angle recorded. When the speed increase it will take only short time to reach 90 degree position.

4.1.4: Detect different color

Figure below show the ability of the system detecting various color sticker.

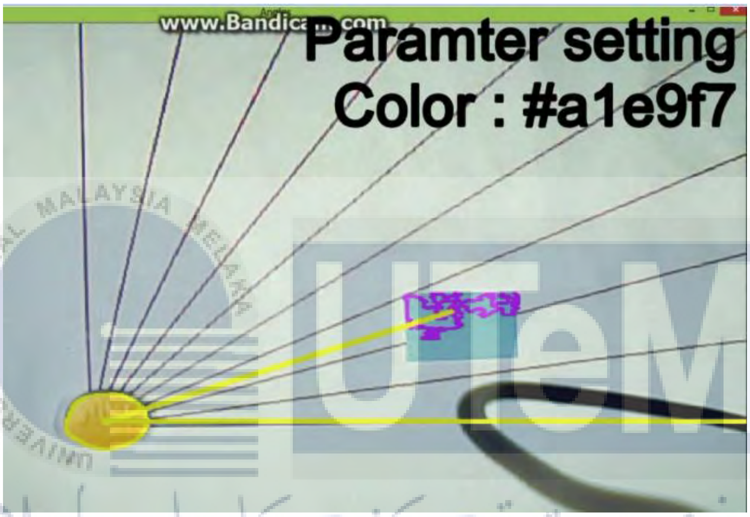


Figure 4.6: Color 1

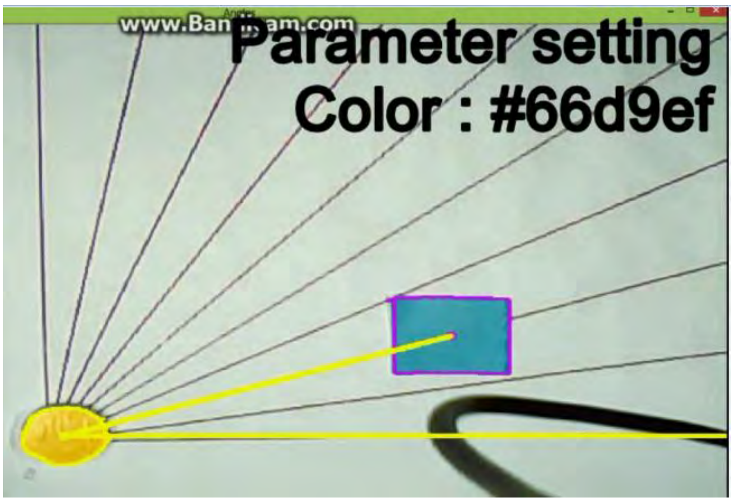


Figure 4.7: Color 2

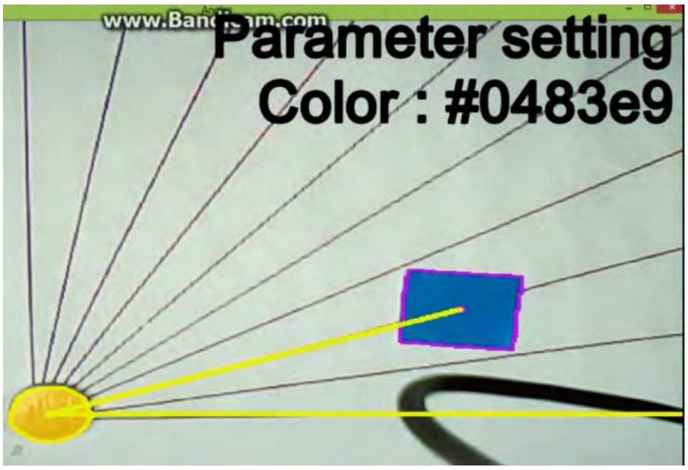


Figure 4.8: Color 3

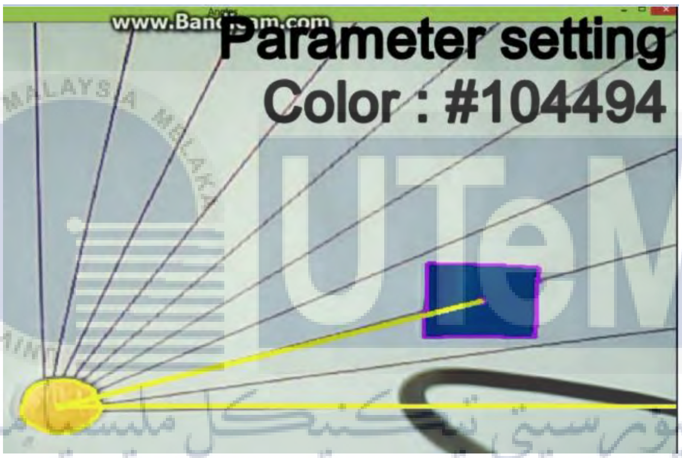


Figure 4.9: Color 4

Figure 4.10: Color 5

The system has the ability to detect the light blue color until dark blue color. The color use in this experiment is the blue color palate each of the color have their own color series. Figure 4.3 and figure 4.7 show that the sticker region detect by the system smaller compare than figure 4.4, 4.5 and 4.6.

These color able to detect by the system is because the range of the color has been set in the c++ coding. These color has been change from BGR and HSV and the value the minimum and maximum range has been set according to the fixed color range. Table 4.1.7 show the range for each color.

Table 4.2: Color range

Descriptor	Hue start	Hue end
Red	0 (ff0000)	19 (ff5100)
Orange	20 (ff5500)	49 (ffd000)
Yellow	50 (ffd500)	69 (d9ff00)
Lime	70 (d5ff00)	84 (99ff00)
Green	85 (95ff00)	170 (00ffd5)

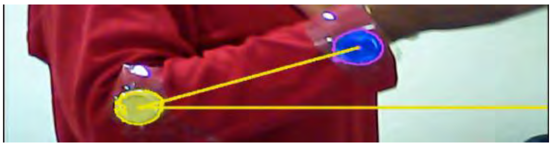
Aqua	171 (00ffd9)	191 (00d0ff)
Blue	192 (00ccff)	264 (6600ff)
Violet	265 (6aooff)	264 (d000ff)
Purple	290 (d500ff)	329 (ff0084)
Red	330 (ff0080)	360 (ff0000)

4.1.5: Field result

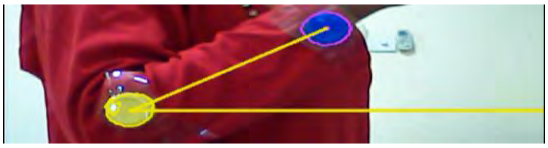
Field test was conduct is to test whether the system manage to work smoothly when the color sticker was stick to human body. The result of the field test was illustrate in the figure 4.7

(a)

(b)



(c)



(d)

In these experiment the system manage to detect the color sticker that stick on human hand. As the system keep on tracking the color sticker the system also keep on calculating the angle produce by those two colors. In figure 4.7.b the region color sticker was not fully detect by the system. This is because of some part of the color sticker was in position that the system unable to tracking the color. The region of the sticker was determine by the position of the user.

4.2: Discussion

Above diagram show that the position of different place of the yellow ball. It show that different distance the object with the camera giving different reading value of x and y axis. This problem will affect the reading that will be taken for analysis the accuracy of the system. When the first reading was taken and then the second reading was taken but with different distance from the camera will give error in collecting the data. Hence the accuracy of the system fail to analyze. Closer the object to the camera the bigger the different position of the x and y compare than the on which far from the camera. Base on the early result that being obtain the vision system manage to detect the color of the yellow ping pong. However the system still not tested with other different color object. In the result, big object was tested in this experiment, the system manage to detect the object but when the object used are smaller the system unable to detect the object smoothly. When the smaller object was used the tendency of the system to lose tracking the color is high.

For the experiment test the accuracy of the system. The mean error that was obtain was less and not more than ± 1. These error can be ignored because of the error was too small to consider.

To solve problem with the distance. A fix distance was set in order to get constant reading of value x and y. The vision system then will be tested with other color of object to make sure that the system only can detect the yellow color object only. To prevent the system from unable to detect the yellow object the size of the object used remain constant.

CHAPTER 5

CONCLUSION

In this simulation result only the axis for x and y are manage to generate. From the early result it show that the system manage to detecting yellow color and position of the yellow object, therefore the objective 1 is partially achieve . The yellow object not only used for detecting and tracking the color object but the yellow color will continue used for the rest of the experiment. However the other color will be used in this project

The yellow object was changed to yellow sticker because of it is easy stick them to human body. All the objective that have been listed in chapter 1 was fully achieved. A vision system was successfully develop with the ability to detect the position of the human body and to produce the angle and full fill the objective number 1. The second objective is to develop a vision system that can detect and tracking the local object was also achieved. This system can track and detect the local object by using the color tracking method. In this project two color was used to test the ability of the system to tracking the local object. And the last objective is to analyze the accuracy and latency of the system.

Here two experiment for accuracy and latency was conducted. It shows that the error between experimental and theoretical value that obtain in accuracy analyses is 0.000933 it is less than 1. This value too small to be considered so the value was decided to be ignored. And the latency experiment was also conducted. The system manage to track the color without delay but the angle recorded by the system only record at certain place when the system manage to track both color clearer.in slow motion and medium motion the system don not have any delay in tracking the sticker and manage to recorded the angle all the time.

For the future recommendation these system can also be modified for other ergonomic assessment.

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APPENDIX

CODING OF TRACKING YELLOW AND BLUE COLOR STICKER

```
#include <opencv2/core/core.hpp>
#include <opencv2/highgui/highgui.hpp>
#include <opencv2/imgproc/imgproc.hpp>
#include <iostream>
#include <math.h>
#define pi 3.14159265

int main(int, char**)
{
cv::VideoCapture cap(0);
if (!cap.isOpened())
return -1;

cv::Mat image_HSV;
cv::Mat image_Color1;
cv::Mat image_Color2;
cv::Moments moments_color1;
cv::Moments moments_color2;

cv::vector<cv::vector<cv::Point> >contours_1;
cv::vector<cv::vector<cv::Point> >contours_2;
cv::vector<cv::Vec4i>hierarchy_1;
cv::vector<cv::Vec4i>hierarchy_2;

cv::Scalar color_1 = cv::Scalar(255,51,204);
cv::Scalar color_2 = cv::Scalar(3,249,241);
cv::Mat image_frame;
cv::namedWindow("Angles",0);

std::string point1;
std::string point2;

cv::Point center_1;
cv::Point center_2;

for(;;)
{
cap>>image_frame;
if (image_frame.empty()) break;

cv::cvtColor(image_frame,image_HSV,CV_BGR2HSV);

cv::inRange(image_HSV,cv::Scalar(90,50,50),cv::Scalar(130,255,255),image_Color1);

cv::inRange(image_HSV,cv::Scalar(26,80,133),cv::Scalar(52,187,255),image_Color2);


findContours(image_Color1,contours_1,hierarchy_1,CV_RETR_TREE,CV_CHAIN_APPROX_SIMPLE,cv::Point(0,0));
```

```
findContours(image_Color2,contours_2,hierarchy_2,CV_RETR_TREE,CV_CHAIN_APPROX_SIMPLE,cv::Point(0,0));

cv::vector<cv::Moments>mu_1(contours_1.size());

for (int i=0;i<contours_1.size();i++)
{
mu_1[i] = moments(contours_1[i],false);
}

cv::vector<cv::Moments>mu_2(contours_2.size());

for (int i=0;i<contours_2.size();i++)
{
mu_2[i]= moments(contours_2[i],false);
}

cv::vector<cv::Point2f>mc_1(contours_1.size());
for(int i=0;i<contours_1.size();i++)
{
mc_1[i] = cv::Point2f(mu_1[i].m10/mu_1[i].m00, mu_1[i].m01/mu_1[i].m00);
}

cv::vector<cv::Point2f>mc_2(contours_2.size());
for (int i= 0; i<contours_2.size(); i++)
{
mc_2[i] = cv::Point2f(mu_2[i].m10/mu_2[i].m00, mu_2[i].m01/mu_2[i].m00);
}

for(int i=0; i<contours_1.size();i++)
{
if(mu_1[i].m00>1000)
{
center_1= mc_1[i];
drawContours(image_frame,contours_1,i,color_1,2,8,hierarchy_1,0,cv::Point());
circle(image_frame,mc_1[i],4,color_1,-1,8,0);


}
}

for (int i=0; i<contours_2.size();i++)
{
if(mu_2[i].m00>1000)
{
center_2=mc_2[i];
drawContours(image_frame,contours_2,i,color_2,2,8,hierarchy_2,0,cv::Point());
circle(image_frame,center_2,4,color_2,-1,8,0);
line(image_frame,center_2,center_1,color_2,4,8,0);
line(image_frame,center_2,cv::Point(image_frame.cols,center_2.y),color_2,4,8,0);

}
}

std::cout<<"Point 1:"<<center_1<<",Point 2:"<<center_2<<'\n';

cv::imshow("Angles",image_frame);
if(cv::waitKey(30)>=0)
break;

}

return 0;
}
```

CODING FOR CALCULATE THE ANGLE OF BOTH OBJECT

```
#include <opencv2/core/core.hpp>
#include <opencv2/highgui/highgui.hpp>
#include <opencv2/imgproc/imgproc.hpp>
#include <iostream>
#include <math.h>
#include <ctime>
#include<stdio.h>
#include <windows.h>
#define pi 3.14159265
using namespace std;
int timestamp()
{
SYSTEMTIME t;
GetSystemTime(&t);
printf("time:%02d:%02d:%02d.%03d\n",t.wHour,t.wMinute,t.wSecond,t.wMilliseconds);
}
int main(int, char**)
{
cv::VideoCapture cap(0);
if (!cap.isOpened())
return -1;
cv::Mat image_HSV;
cv::Mat image_Color1;
cv::Mat image_Color2;
cv::Moments moments_color1;
cv::Moments moments_color2;
cv::vector<cv::vector<cv::Point> >contours_1;
cv::vector<cv::vector<cv::Point> >contours_2;
cv::vector<cv::Vec4i>hierarchy_1;
cv::vector<cv::Vec4i>hierarchy_2;
cv::Scalar color_1 = cv::Scalar(255,51,204);
cv::Scalar color_2 = cv::Scalar(3,249,241);
cv::Mat image_frame;
cv::namedWindow("Angles",0);
std::string point1;
std::string point2;
cv::Point center_1;
cv::Point center_2;
for(;;)
{
cap>>image_frame;
if (image_frame.empty()) break;
cv::cvtColor(image_frame,image_HSV,CV_BGR2HSV);
cv::inRange(image_HSV,cv::Scalar(90,50,50),cv::Scalar(130,255,255),image_Color1);
cv::inRange(image_HSV,cv::Scalar(20,100,100),cv::Scalar(30,255,255),image_Color2);
findContours(image_Color1,contours_1,hierarchy_1,CV_RETR_TREE,CV_CHAIN_APPROX_SIMPLE,cv::Po
int(0,0
));
findContours(image_Color2,contours_2,hierarchy_2,CV_RETR_TREE,CV_CHAIN_APPROX_SIMPLE,cv::Po
int(0,0
));
cv::vector<cv::Moments>mu_1(contours_1.size());
```

```
for (int i=0;i<contours_1.size();i++)
{
mu_1[i] = moments(contours_1[i],false);
}

cv::vector<cv::Moments>mu_2(contours_2.size());

for (int i=0;i<contours_2.size();i++)
{
mu_2[i]= moments(contours_2[i],false);
}

cv::vector<cv::Point2f>mc_1(contours_1.size());
for(int i=0;i<contours_1.size();i++)
{
mc_1[i] = cv::Point2f(mu_1[i].m10/mu_1[i].m00, mu_1[i].m01/mu_1[i].m00);
}

cv::vector<cv::Point2f>mc_2(contours_2.size());
for (int i= 0; i<contours_2.size(); i++)
{
mc_2[i] = cv::Point2f(mu_2[i].m10/mu_2[i].m00, mu_2[i].m01/mu_2[i].m00);
}

for(int i=0; i<contours_1.size();i++)
{
if(mu_1[i].m00>1000)
{
center_1= mc_1[i];
drawContours(image_frame,contours_1,i,color_1,2,8,hierarchy_1,0,cv::Point());
circle(image_frame,mc_1[i],4,color_1,-1,8,0);


}
}

for (int i=0; i<contours_2.size();i++)
{
if(mu_2[i].m00>1000)
{
center_2=mc_2[i];
drawContours(image_frame,contours_2,i,color_2,2,8,hierarchy_2,0,cv::Point());
circle(image_frame,center_2,4,color_2,-1,8,0);
line(image_frame,center_2,center_1,color_2,4,8,0);
line(image_frame,center_2,cv::Point(image_frame.cols,center_2.y),color_2,4,8,0);

}
}

std::cout<<"Point 1:"<<center_1<<",Point 2:"<<center_2<<"
angle:"<<atan((abs(center_1.y-center_2.y
)*1.0/(center_1.x-center_2.x)*1.0))*(180.0/pi)<<timestamp();
cv::imshow("Angles",image_frame);
if(cv::waitKey(30)>=0)
break;

}

return 0;
}
```

RULA WORK SHEET