Faculty of Electrical Engineering

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AUTOMATIC DISTANCE MEASUREMENT DEVICE USING STEREO VISION TECHNIQUE

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Bachelor of Mechatronics Engineering with Honours

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor Degree of Mechatronic Engineering.

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A report submitted in partial fulfilment of the requirements for the Bachelor of Mechatronics Engineering with Honours

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DECLARATION

I declare that this thesis entitle "AUTOMATIC DISTANCE MEASUREMENT DEVICE USING STEREO VISION TECHNIQUE" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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Date : ....

DEDICATION

This project is dedicated to my beloved family who always encourage me to always not give up in my study at Universiti Teknikal Malaysia. I would like to express my gratitude to all my beloved family members, lecturers, and to my friends whom have been supprting and inspiring me to complete this research project successfully.

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ABSTRACT

As a human, the distance estimation of an object is limited because human eye has a limitation and cannot determine the precise value of the object. Human can only roughly estimate the value of the distance of an object. The system use by the human to estimate the object is known as stereo vision of human's eye. In this project, a stereo vision system is proposed to measure the distance of object in view accurately. A stereo camera is used to develop the system for measuring the distance of an object from the device. Nowadays, multiple cameras system is very popular because it development is becoming more easy and cheap. This situation make an easy for everyone to purchase a camera and learn on how to used it. But what is interesting is how a user can develop a system to measure a distance of an object by using a multiple cameras system which is stereo vision camera. Stereo vision camera is a camera with multi image capture. This study introduced an automatic system measurement device using a stereo vision technique. The objective of the study is to design an experiment of stereo vision technique in order to investigate the effect of different type of camera resolution used on the data collection. In other to measure the distance of specific object, a distance measurement algorithm is develop and the validity of the equation is calculated. The measurement system consist of stereo image capture using stereo camera, image processing, and object distance measurement. In image processing, an algorithm is employs to make sure the distance measurement can be conducted in real time. Research found that an object distance measurement using stereo camera is greater than using a single camera system that was proposed in many previous research works.

ABSTRAK

Sebagai manusia, anggaran jarak objek adalah terhad kerana mata manusia mempunyai had dan tidak boleh menentukan nilai objek dengan tepat. Manusia hanya kira-kira boleh menganggarkan nilai jarak objek. Penggunaan sistem yang digunakan oleh manusia untuk menganggarkan objek dikenali sebagai penglihatan stereo mata manusia. Dalam projek ini, sistem penglihatan stereo adalah dicadangkan untuk mengukur jarak objek dengan tepat. Sebuah kamera stereo digunakan untuk membangunkan sistem untuk mengukur jarak objek dari peranti. Pada masa kini, pelbagai sistem kamera sangat popular kerana ia membangunan menjadi lebih mudah dan murah. Keadaan ini memudahkan semua orang untuk membeli kamera dan belajar bagaimana untuk menggunakannya. Tetapi apa yang menarik adalah bagaimana pengguna boleh membangunkan satu sistem untuk mengukur jarak objek dengan menggunakan kamera yang merupakan kamera penglihatan stereo. kamera penglihatan stereo adalah kamera dengan tangkapan imej pelbagai. Kertas kerja ini memperkenalkan peranti pengukuran sistem automatik menggunakan teknik penglihatan stereo. Objektif kajian ini adalah untuk mereka bentuk satu eksperimen teknik penglihatan stereo untuk mengkaji kesan yang berlainan jenis resolusi kamera digunakan pada pengumpulan data. Untuk mengukur jarak objek tertentu, algoritma pengukuran jarak dibentuk dan kesahihan persamaan dikira. Sistem pengukuran terdiri daripada tangkapan imej stereo menggunakan kamera stereo, pemprosesan imej, dan pengukuran jarak objek. Dalam pemprosesan imej, algoritma digunakan untuk memastikan ukuran jarak boleh dilakukan dalam masa nyata. Penyelidikan mendapati bahawa ukuran jarak objek menggunakan kamera stereo adalah lebih tepat daripada menggunakan sistem kamera tunggal yang telah dicadangkan dalam banyak kerja-kerja penyelidikan sebelumnya.

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LIST OF ABBREVIATIONS

SVS	Stereo Vision System
FKE	Fakulti Kejuruteraan Elektrik
PSM	Projek Sarjana Muda
OCVS	OpenCV Software
SW	SolidWorks

CHAPTER 1

INTRODUCTION

1.1 Introduction

Since most autonomous system these days are furnished by using vision sensors or cameras, it is exceptionally gainful that the vision data is used to got remove data that can be utilized to assist the framework. A lot of research have been done to get a distance of an object from an image[1]. At first a large portion of the proposed strategy uses just a single vision sensor. The variety in eye distance in pixels with the adjustments in camera to individual separation is figured to acquire the distance.The valuable approaches to measure the separation of an object with cubic impact utilizing image processing can be directed a human vision mimicking system. One of the strategy to measure object distance is Stereo Vision System (SVS) by utilizing a binocular disparity of a two cameras framework [2, 3, 4]. A distance of detected object is obtained by applying a distance measurement algorithm. Many research proposed a distance measurement system, but the system or device is not a portable system or device. This project is conducted to upgrade the distance measurement system by making the device portable and can automaticly measure a detected object.

In this project, a distance measurement of an object is proposed by using a stereo vision system camera. An object is placed at a certain distance from the stereo camera. A stereo camera will captured the image of an object from both side of lens. An implementation of a Raspberry Pi as the hardware of the system is applied by installing an OpenCV software in the Raspberry Pi board. A colour-based and shape-based detection algorithm is coded in the Open CV software to process the image. Then, a distance measurement algorithm is applied to measure the distance of a detected object.

This project consist of two phase which are Phase 1 and Phase 2. Phase 1 is a software development and Phase 2 is a hardware development. For Phase 1, the topic that will be covered is stereo vision implementation, colour and shape based detection, and distance measurement algorithm. In this phase, the development of stereo vision system is produced by conducting a different type of experiment in order to study the stereo vision system implementation. Phase 1 also covered colour and shape based detection in order to study the accuracy of the data collection. A distance measurement algorithm is also covered in Phase 1 in order to verify the mathematical equation for distance measurement system.

Phase 2 covered the development of hardware for portable measurement device. The fabrication body of the device will be covered in this phase. For this session, there is only Phase 1 that need to be done and Phase 2 is a future work for the next researcher.

1.2 Motivation

In the era of full technologies, all of industries have already to compete with each other to create a new technology for the future. In automotive industry, the development of the technology to create a powerful vehicle is already beyond human imagination. The customers only want a vehicle that is very unique and speedy. For example, a Ferrari's company already come out of their own design of car to achieve a powerful speed. But, the consequences of a powerful vehicle need to be considered especially in safety driving system developed for the car.

In order to overcome the problem, a distance measurement system using stereo vision is proposed. A distance measurement distance can be applied in the vehicle safety system to avoid the obstacle faced by the vehicle especially when the vehicle is drived in a top speed. A sport car especially exceed 300km/h when drived at a top speed. This situation can bring unexpected dangerous condition if the driver loss control of the vehicle. A distance measurement system is used to detect the obstacle came from front and behind the vehicle.

A distance measurement system is also used in measuring the distance of the object by applying a different method such as sensing the object using ultrasonic sensor, laser sensor and etc. All of the proposed system is already being marketing in the world nowadays. But, there is still no one develop a portable device that can automatically measure a distance of a detected object. From the overview of the previous proposed system, this project is an upgraded both from hardware and software of the device. A portable device that can measure the distance of an object using a stereo vision system is develop to overcome the unsolved problem.

1.3 Problem Statement

Nowadays, many people developed an object distance measuring system. By applying many concept into their system, there is still several problem that cannot be solved by using the previous proposed system. Some of the previous proposed system is not suitable to be used in certain places. The previous design is developed only for indoor experiment. In that case, there are still a several problem that cannot be solved.

The first problem is it is very difficult to automatically measure a distance from one place to another by using a simple portable measurement device. There is a system proposed before this, but the system can only conducted at indoor environment and the device is power up by a electric plug, which mean it is no portable device.

The second problem is a human can only estimate the distance but the estimation is not accurate and that inaccurate estimation could result in a dangerous way. A safe distance is very important to make sure a human is not hurt and far from any unwanted condition, which mean dangerous situation. A human can estimate the distance but the eye cannot tell the exact number of the distance.

The third problem is happen when a person is driving a heavy vehicle. A heavy or long vehicle is very dangerous especially when it want to turn at the road. The safe distance is very important to obtain when a heavy vehicle want to turn especially when there is another vehicle involved in the situation. A driver of heavy vehicle face a difficulty to determine a safe distance with the obstacle coming from front or behind the heavy vehicle.

1.4 Research Objective

The direction in the development and implementation of this research are based on several objective. A number of research objectives have been planned as the main goal to be realized. The main objectives of this study are listed as below:

1. To design an experiment based on distance measurement system that can measure the distance of the object using stereo vision technique.
2. To develop a distance measurement equation that detect the specific distance of the object within the range limit.
3. To analyze the distance accuracy from the device using distance measurement algorithm and error calculation.

A methodology for object distance measurement is proposed by relating all these three objectives. The methoology of this project will be discussed in Chapter 3.

1.5 Scope

To conduct the project, a several scope has been listed out below to achieve the objective stated.

1. Design an experiment based on stereo vision technique implementation.
2. Detect the red circle onject by using a colour-based method.
3. Detect the red circle object by using a shape-based method.
4. Stereo vision implementation for distance measurement system by using a specific mathematical equation.
5. Detect red circle object within the range 25cm until 50cm.
6. Measure the distance of the object only when the full body of the object is detected.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, it will devide into several part of topic to discuss about the general knowledge and overall view about the project. The parts that will be discuss in this topic are distance measurement system, stereo camera application, colour-based detection, and shape-based detection.

2.2 Distance Measurement System

From the research that have been done, a distance measurement can be used in various function. An automatic berthing of ships used image sensors to persistently measure a distance from the ship to a dock in a port. To continuously measure the relative distance, a sensor system for the programmed berthing system is accommodated the ship movement such as, pitching, rolling, and yawing. The range of the distance measurement is from 100m to 5 m and the accuracy near the dock is about 1m. The distance estimation system measures the relative distance from a ship to the dock by following a target on the dock with the versatile image sensors[5]. A distance measurement is also used in automatic measurement of flying distance of ski jumper's. A speeding up sensor and video recording for landing slant is utilized to distinguish landing stun. A distance between edge of jumping light and a point where ski jumper's leg at a minute when whole posterior of the both skis have addressed landing incline is characterized as flying distance. It is significance to acknowledge great feedback system for ski jumpers by taking an estimation of flying distance to ensure that a specific take-off movement in a specific jump is great or not have an immediate bearing on flying distance at the specific jump [6].

A distance estimation system is utilized as a part of a ratbot programmed navigation method in obscure situations with electrical reward simulation. When the ratbot walks leaving the problems such as how to avoid obstacles and how to choose a feasible route to ratbot themselves, a method is focused on giving the reward. Aforementioned distance information is evaluated to decide and sent the reward commands [7]. An automatic measurement method is utilized to calculate the distance from the skin to the posterior wall of the stomach aorta by applying a ultrasound picture. An ultrasound image is utilized to measure three sorts of distance, particularly the distance from the skin surface to the posterior wall of the stomach aorta [8]. In distance measurement system, a different sort of sensor is utilized, for example, 61 GHz radar sensor node that is utilized for modern situating and distance measurement [9]. Research found that a camera is widely used to capture three-dimensional image, the parameters of the image, and the distance to the individual elements. A technique in view of the physical impact of the reliance of the distance to an object on the image from the local length or focal point gap of camera is proposed to determine the distance to objects by analyzing a progression of images by utilizing the defocus depth estimation [10].

A distance measurement system from different device methods is assessed to design a preliminary experiment. For distance measurement, based on the well ordered length values decided from the gathered information is proposed. To allow the calculation of the distance, the progression to-step length depends on the client's height which is contribution to the settings[11]. Furthermore, distance measurement is also used in position estimation with application to multi-operator system control. The position of neighbor agents is estimated by developing control algorithms where only distance measurement are accessible to every operator [12]. In care environment monitoring system, such as office circumstance monitoring, taking care of old people, preventing crime and maintaining security is very important nowadays. A movement detection system is studied by using novel ultrasonic distance measurement and movement detection method which have been installed in ZigBee-based sensor network [13]. Besides environment monitoring, a distance measurement is also used for automatic ship control using stereo camera system. For this proposed method, the performance of the system for automatic ship control is controlled by using a stereo camera for a long distance measurement [14].

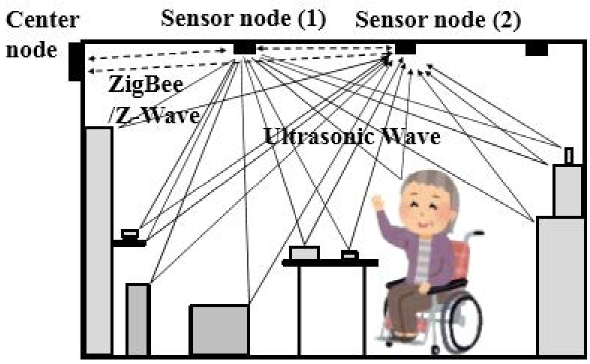


Figure 2.1: Room model with walking person [13]

A measurement of the distance to an object is also proposed by using an application of the MEMS(Micro Electro Mechanical System) scanner. A single laser spot is used to measure the distance and MEMS scanner is used to scan a laser beam [15]. There is also a research about a magnetic field analysis for distance measurement in 3D positioning applications. The analysis is based on the quasistationary magnetic field produced by coils and its pertinence to 3D positioning applications[16]. Distance measurement information is also used for iterative localization of network nodes. An information about the absence of distance measurements as well as all available distance measurements is utilized in order to localize a significantly larger number of nodes [17]. A system based on low coherence interferometry for long distance measurement is presented by using an optical tomography technique(OCT). In the proposed method, a high resolution but the sample size does not exceed 4 mm is used to extends the range of industrial applications [18]. In distance measurement, a linear frequency modulated signal is proposed to simplify a technique for distance measurement. In the method, the deliberate parameter values comparing to the moment in the time of the latest measurement is chosen in the meantime [19].

(a) (b)

Figure 2.2: (a) The FMCW tranceiver used for the experiments [19], and (b) Indoor experiments [19]

Distance measurement is very important and is widely used nowadays. The different of distance measurement is depends on the method used. There is a method to measure a distance by using ultrasonic transceiver with the possibilities of the data communication and the two point distance measurement [20]. A smart mobile device is also used to measure the distance of the single image. The accelerometer which is the standard configuration of smart mobile services is utilized to obtain the view direction of the device, andbuilds the geometric relationship between pixels in the image plane [21]. As we know, the safety of the Tunnel Boring Machine (TBM) is one of the major concerns in the development project. At that point, a tunnel deformation monitoring based on laser distance measuring and vision collaborator is proposed. A naturally measurement of relative distance varieties of the marked encompassing rock positions through vision helped laser distance measurements should be possible by applying a tunnel monitoring method [22]. An online distance measurement for three data event streams is proposed. In the project, the properties of the incremental distance measurement is analysed and compared to the well known tree edit distance [23]. The impact of object size on the scope of distance measurement in the new depth from defocus technique is one of the project that used a distance measurement system. The distance range measured between the camera and diaphragm used in the external pneumatic prosthetic heart is the factor that affect the object size [24].

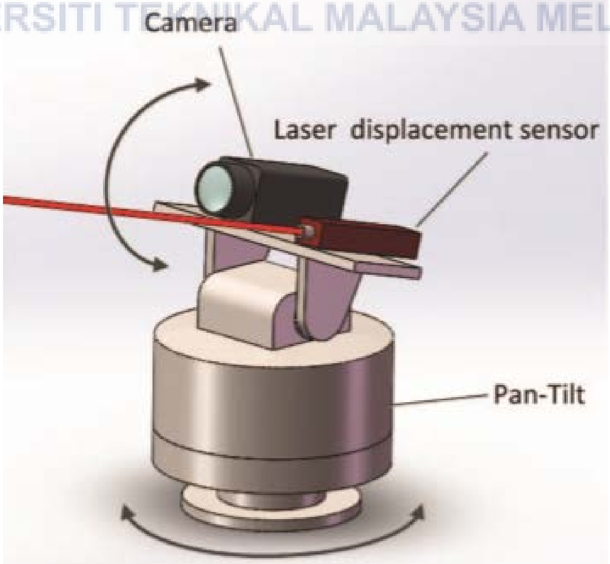


Figure 2.3: Basic structure of tunnel deformation monitoring hardware [22]

2.3 Stereo Camera Application

A stereo camera is know as a camera with a multi lens of image capture. Basically, a stereo camera performance is greater than a single camera. Stereo camera is widely used in many application nowaday. One of the application of stereo camera is depth estimation using an infrared dot projector and an infrared colour. Infrared cameras can capture the scene textured by the dots and the depth can be estimated even where the surface is not tectured by using an infrared dot on the scene. An infrared colour stereo camera consists of an infrared projector and two infrared colour cameras that can capture an infrared image and a colour image simultaneously [25]. A stereo camera is also used to propose a continuous self calibration based on particle filter system for endoscopic recordings. A stereo matching algorithm is performed to create a three dimensional point set by acquiring the picture match at every time step is redressed. The point arrangement process is performed to adjust a few point cloud caught from various viewing angles and the bigger field of view is shaped for better scene understanding after the three dimensional reproduced information focuses are done [26]. An entire 3D navigation correction utilizing low frequency visual following is proposed by utilizing a stereo camera system. A stereo camera is utilized to rectify a conventional route arrangement with camera tracking feedback from a stereo camera with little computational overhead [27].

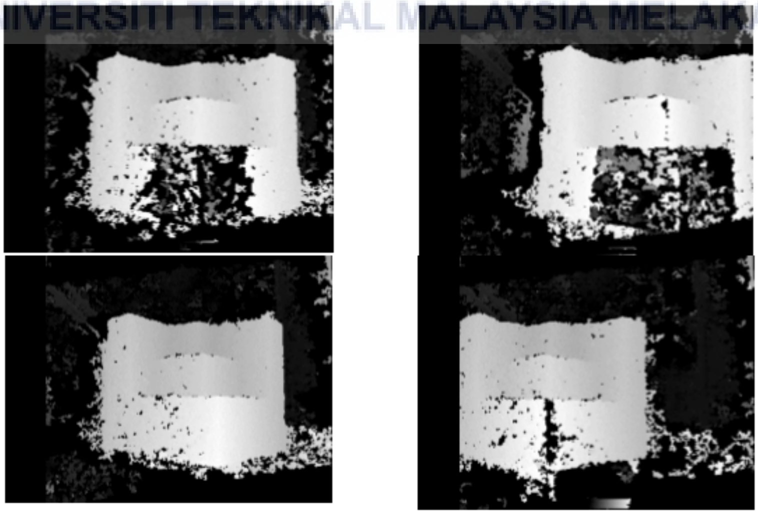


Figure 2.4: The disparity generated with the camera parameters calibrated by OpenCV stereo calibration toolbox [26]

Furthermore, a stereo camera is used for palm vein biometrics. To increase the performance of the current palm vein identification systems, a mirror is used to scan vein depths as well as the vein patterns using the visibility of venous blood under the near infrared (NIR) light. This method is used as the input of the system to improve the performance using stereo depth information [28]. A faster feedback for remote scene review is likewise proposed by utilizing skillet tilt stereo camera. A live stereo video is being prepared and showed in a Head Mounted Display. The fitting subset of the image is chosen and showed by utilizing a more extensive field of view, and a higher resolution of camera [29]. Nowadays, a pedestrian tracking posed a bigger challenges in indoor environments rather than outdoor environments. This condition makes pedestrian tracking with only a camera or radar become difficult. In case of that situation, a fusion of stereo camera and radar targets is also implemented to improve in tracking of pedestrians indoors especially suited for surveillance and security applications [30].

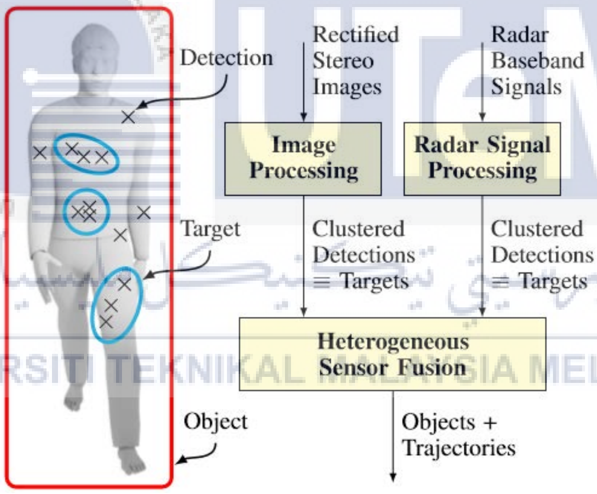


Figure 2.5: Overview of the fusion system for indoor detection and tracking of pedestrians [30]

Besides, a stereo camera is also used in vehicle self localization using 3D building map to reduce the lateral error of result result. To gives lateral position, the technique for the GNSS lateral position is moved in urban gully, side perspective of the stereo camera and 3D building guide is proposed. The precision of the stereo camera building distance detection is led in downtown area in Tokyo [31]. In distance measurement, a fisheye stereo camera is used by implementing an equirectangular images. The measurement range of stereo camera can be increase by using a fisheye camera. This is because of a fisheye camera can improve the stereo correspondence seek in the pictures by utilizing an equirectangular projection.

The element purposes of far objects correspond in the images of the two cameras in order to remove mismatches due to the errors of intrinsic and extrinsic parameters can be done by applying point of view change. The distance measured from the disparity and stereo coordinating in the distorted image is connected to calculate the comparing focuses [32].

Figure 2.6: The appearance of the ïňĄsheye stereo camera [32]

Indoor service robot research using an intelligent stereo camera mobile platform is proposed by connecting the stereo camera with an open source electronic prototyping platforms, for example, Arduino and Raspberri Pi. A depth image and 3D recreation research is obtained by installing a stereo camera with locally available PC and wireless communication system to control wheel speed system [33]. A stereo camera is also used inideal following a moving focus for incorporated mobile robot. In the system, a pair of cameras is placed on the mobile robot and the rotation of the camera, pan and tilt directions is controlled by using a platform camera in two degree of freedom robot. The target's image is holded on the origin of the camera coordinate to control the pan tilt robot, and two wheels is used to move the robot by applying the suitable torque to reach to the target [34].

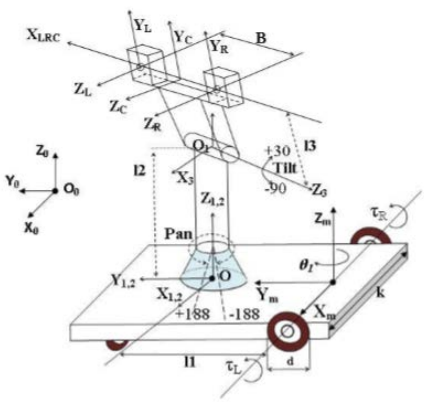


Figure 2.7: Structure of mobile robot- pan/tilt-stereo camera [34]

In addition, a stereo camera is used to meager 3D reconstruction on a mobile phone for short proximity optical tracking. Image acquired from an aligned camera system is presented to determine 3D coordinates of a specific object in a worldwide coordinate frame. The reconstruction geometry of the scene is constructed by using the disparity between a couple of images, taken at various vantage focuses. In camera calibration by comparing the 3D point sets obtained from the system with a reference geometry, an unmodified HTC Evo 3D mobile phone with stereo camera is used in the project [35]. In vehicle stereo camera, a lasers is used to propose a method of rut detection. The inspection and repair of the roads is necessary to carry out regularly. It is because the traffic volume, weather and temperature may caused the road to damage such as ruts, cracks, and potholes. This situation increase the traffic accidents. Thus, a method of rut detection using lasers and in-vehicle stereo camera is used to reduce the processing time and cost [36]. A mobile robot with a stereo camera is also used to track a specific person in dynamic environment. A target tracking using a stereo camera based on colour and location information is used to distinguish a target from the other people [37].

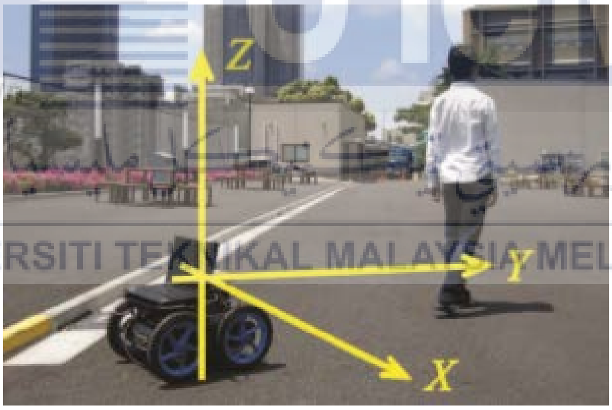


Figure 2.8: Robot coordinate system [37]

In stereo camera system, there is also a system detecting fingertip robust scale invariant and rotation invariant. A method to detect the fingertip using stereo camera robust scale and rotation invariant is proposed in order to solve the problem of the false detection in order to wrist and classification wrist [38]. A 3D quality assessment model to modify stereo camera pattern is implemented to determine the visual comfort zones. The estimation of depth planes, for each video frame, in order to associate their locations with different visual comfort zones is being determined by employing a method of stereo vision geometry and stereo matching algotihms [39]. Cross based dynamic programming with cost volume channel is utilized to assess the depth based on an infrared projector and an infrared colour stereo camera. The time varying 3D models of dynamic scenes for 2D and 3D video production is integrated and constructed to estimate the depth maps using an infrared colour stereo camera [40]. A stereo camera is also used to perform a high accuracy road segmentation for cover level of forward view estimation.A segmentation of the road region can be done by using a stereo cameras system [41].

Figure 2.9: Illustrates on how to determine high cover level of forward view and low cover level of forward view [41]

In other case, a stereo camera is used to calibrate the hand eye through pure rotations-fitting round curve in 3D space with joint edge limitation. Hand eye calibration is a camera mounted on a Pan-Tilt unit and the function is to adjust its gathering position and orientation. The limitation of the circular arc that can be measured by the camera can be solved by including an extra joint edge imperative that specifically fits the round circular segment in 3D space [42]. A real-time FPGA amendment algorithm implementation combine with stereo camera is proposed by coordinating the stereo arrangement left and right images, including adjustment of radial distortion. The combination of the implementation of rectification module in the FPGA with a stereo camera should be possible to check in video circumstance [43]. A road boundary detection method also used a stereo camera in order to detect low height curbs, curved curbs, slopes, vegetation and ditches. In the method, the height detection changes against street surface on a few multi-directional filtering lines on a dense disparity map [44].

2.4 Colour Based Detection

A colour based is one of the method used in the image processing process. Localization of human faces intertwining colour segmentation and depth is one of the implementation of colour based detection. A depth map of the scene is produced and a head model is fit into record the state of the model and skin colour data. The extraction of skin colour areas assumed control over a similar information images while the depth map of the scene is registered. The calculation of colour histograms is the fundamental area order by utilizing a calculation for skin-like that have been produced [45]. The conception of a vision system committed to vehicle location in decreased visibility conditions is been proposed. A monocular colour based identification of vehicle lights and a stereo vision extractor of 3D edges of obstruction is the principle thought of recognition of vehicle lights to perceive vehicles and give a preemptive guidance of potential danger. The vehicle lights, raise lights, raise break lights, blazing lights, cautioning lights, invert lights, and headlights is identified using vision system. The review on the colour is vital to give robust and reliable result in reducing the perceivability conditions [46].

A stereo vision system is used for extraction of 3D edges of obstacle detection. A computer vision has a problem which is matching of features between two colour images. In that case, a vertical edges focuses utilizing dynamic programming based on geometric, non-inversion, uniqueness and colour photometric contrains is approached in colour matching process [47]. Besides, there is a research on the colour recognition of LCD instrument board in light of machine vision. An experiment of a relative colours which are shown in a projector screen system and self-iridescent colours are shown on a PC-LCD screen to locate their characteristic contrasts in machine vision system is being conducted in order to identify the colour of demonstrating symbol and LCD screen at the same time [48].

Recently, a colour based detection is also used in a detection of objects by using a fuzzy classifier. The detection method is conducted in a real-time object detection system and a colour histogram from distributions of the appearance of an object on a non-uniformly partitioned hue and saturation (HS) colour space as a feature vector is obtained [49]. Moreover, a colour based detection is also used in the implementation of multimedia touch system based on computer vision algorithm. The technique is approached via video processing alongside an adjusted colour detection based on computer vision algorithm. Colour intensity, brightness, and size is defined in particular red mark to move mouse pointer and execute mouse clicks. The image is being processed from RGB to grayscale conversion, image subtraction, noise filtering, grayscale to binary image conversion, and lastly coloured background subtraction [50].

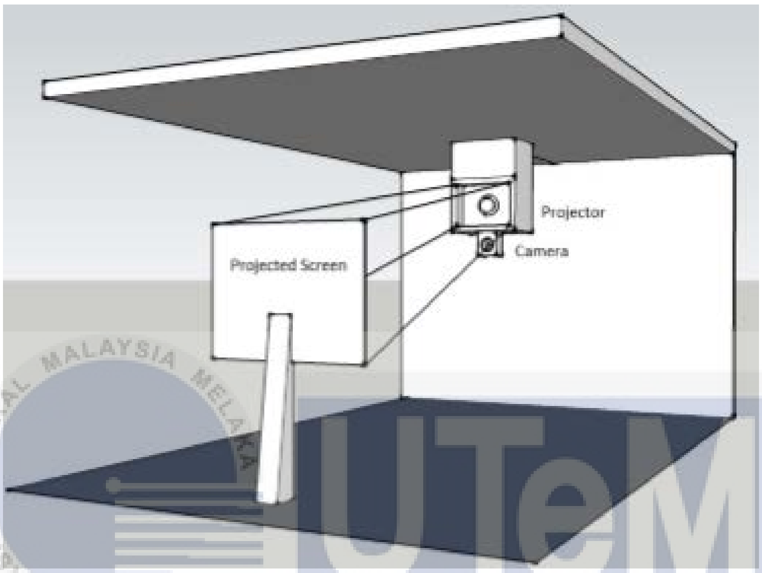


Figure 2.10: Multimedia touch system with colour detection experimental setup [50]

Besides, a colour detection technique is used for computer vision based human-computer interaction. The calculation of the changing in pixels values of RGB colours from video to get exact sequence of motion of hands and fingers is done to control a real time motion of mouse in windows [51]. An object tracking and colour detection is used in order to propose computer vision based analysis for cursor control. There are a few parameters that are utilized to lock the target will track in the tracking system. A colour contrast based on the selected colour and overlooking other objects that have the different colour segmentation is one of the parameter that need to be considered [52]. There is also a research of determination of ripeness and grading of tomato using image analysis on Raspberry Pi hardware. In the project, a colour detecting algorithm is used for the ripeness determination of the selected tomato [53]. A vision tracking system via colour detection is exhibited by utilizing a monocular camera as a sensor to track and measure the relative stance of the target based on specified colour detection with the assistance of four LED markers [54].

2.5 Shape Based Detection

A shape based detection is one of the image processing method that cen be used in various system application. The investigation of the shadow evidence to focus on building regions is conducted to propose an automatic identification of buildings from single high resolution optical images with only visible red, green, and blue bands of data. The recursive minimum bounding rectangle is used to determine the final building. The vegetation and shadow of the buildings is detected and a collection of rectangles is characterized by focusing on buildings with right-angle corners [55]. Circular Hough transform and Contour detection is used in automatic detection and counting of circular shaped overlapped object. The Circular Hough Transform (CHT) is utilized to locate the circular patterns inside an image scene. The object is detected, segmented, counted and sorted efficiently to count a circular shaped image objects that are overlapping or very close to each other, including some random shaped overlapping objects [56].

An accidenal deaths among the elderly is caused by the falls that effect vision, hearing, bone degeneration, and other external factors such as furnishings and environments. A mixture of Gaussians to segment background and foreground, and applies MHI to analyze fall behaviours is used to detect vision based fall detection thorugh shape features. In the method, a human shape body is detected to conduct the experiment [57]. An automatic detection of a large number of anthropometric landmarks on 3D faces is proposed by using an automatic shape based detection. An algorithm for face detection is used by minimizing the bending energy between patches around seed purposes of offered countenances to those of a reference confront extricated by versatile level set curves to establish a corresponding 3D face dences [58].

Figure 2.11: Preprocessing shown on four identities of FRGCv2 database. The upper row corresponds to the raw 3D image with texture while the lower one is the output of our preprocessing step [58]

Besides, a manual microaneurysm to detect visible microsneurysm in retina detection is proposed by using size and shape based detection. An algorithm is used to filter the skeleton of possible microaneurysms to increase the line segment until the object borders. The circular shape of the examined object is ensured to check whether the length at the individual objects to be approximately equal [59]. An implementation of HOG and AMDF based shape detection algortihm is used for computer vision and robotics education using LEGO mindstorms NXT. HOG algorthm is used in utilizing the shape detection modules to exhibit superior performance in numerous applications under diverse conditions. The geometri properties is used to extract HOG features and a histogram is constructed based on the angle of gradients in order to find a shape ob the object such as triangle [60].

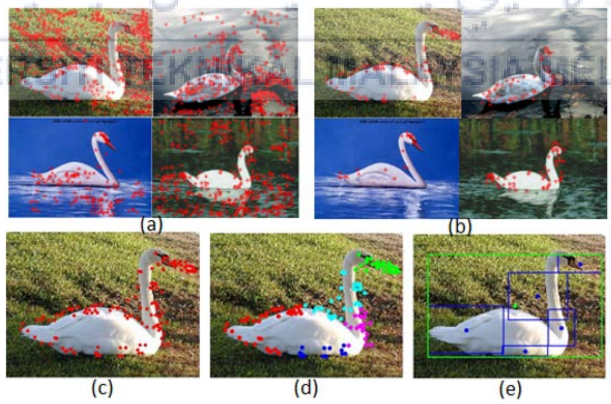


Figure 2.12: Illustrationof theproposedpartbased shape model. (a)The original training images. (b)Foreground features selected via weight update. (c)The category center image. (d)Foreground features after clustering. (e)part-based shape model for object detection [61]

In addition, a section based shape model and foreground contour feature selection is utilized for object recognition in order to take in a shape demonstrate from cluttered training images without need to certainly given bounding box on object. An Earth Movers Distances based matching is utilized to lead a section based shaped model that can be utilized for object recognition [61]. In other proposed project, colour and shape feature based detection is used to detect speed sign in real time under real life environment. The consideration of the gradient orientation can be done by regarding every pixel of the red edge as a component of the circle, and every pixel of the red edge assesses the focal point of the circle [62]. A shape matching method for human detection and tracking is one of the imperative and challenging research territory in visual surveilliance. Detecting humans can be done by using shape detection due to large appearance variability. The codebook passages which comprise of shape setting and highlight parameters of the training images is extricated from the input images of various scapes and are coordinated with the layouts [63]. A bicyclist detection by means of locally available stereo vision using shape based pedestrian is know as a challenging topic nowadays. A location of potential rigions is determined by using a productive stereo stereo and an obstacle detection algorithm based on shaped based detection [64].

2.6 Summary

In overal view from the discussion of this topic, a summary can be done by concluding this project consist of important element of machine vision system. A distance measurement system is widely used in this world. It can be conducted in various way of method. For example, the method that is widely used to measure a distance is vision, ultrasonic, laser and etc. The important thing in this project is the implementation of stereo vision system. Based on the previous study from jurnal and conference, there is still no one develop an automatic distance measurement using stereo vision system using Raspberry Pi. By using a colour and shape detection, a specific object is detected to measure the distance of the object from the device. In Chapter 4, the methodology of the measurement system will be discussed.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

From the previous chapter, the literature review about this project is already briefly explained to conduct an object distance measurement. In this chapter, the implementation of colour detection and shape detection will be discussed to develop a distance measurement method using a stereo vision technique. The harware and software components will be discussed in this chapter to design the experiment on how to measure a distance of an object using all of the component and technique that being chose.

3.2 Control Method

In this section, the development of the object distance measurement system will included by discussion of several important topic that already covered in the literature review section. The topic that will be discussed are stereo vision system using Raspberry Pi 2 Model B board, image processing method using colour based detection and shape based detection using OpenCV. In order to calculate the error of distance measurement, a formula is used to calculate the percentage error of the distance measurement. Figure 3.1 shows the flowchart of distance measurement of a detected object.

The distance measurement system is begin with object detection by using a colour and shape based method to detect the red colour and circle shape. Then, a stereo camera will run the video recording the image of detected object. For example, in this project the scope is already mentioned that the targeted object is red circle shape. The next step is

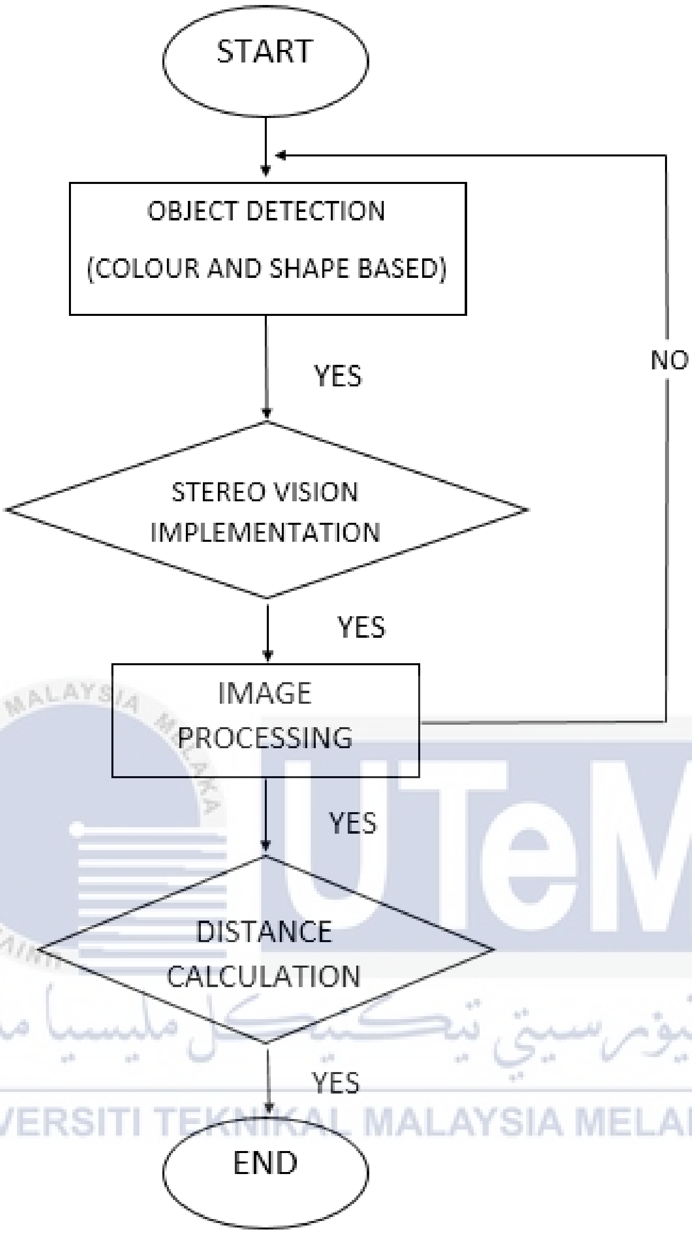
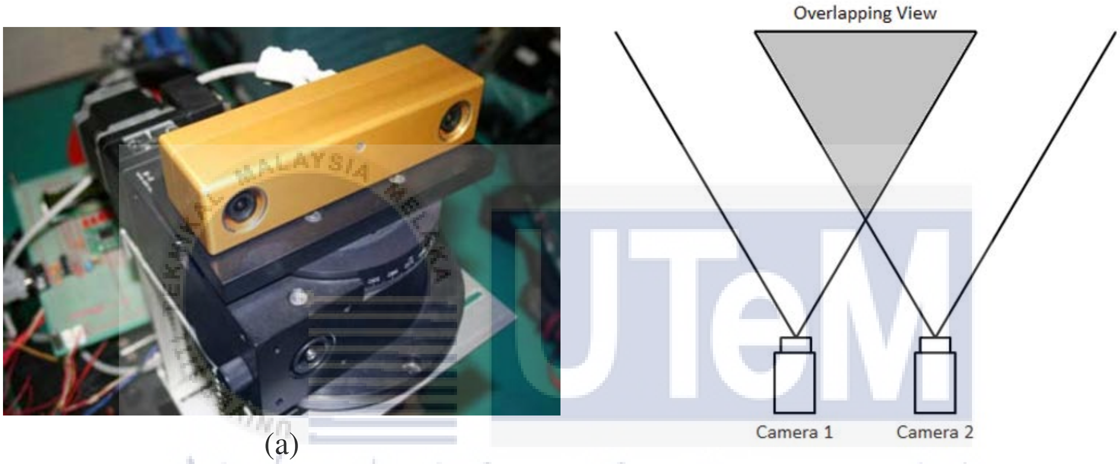


Figure 3.1: The distance measurement system

image processing through the data gain from the two camera with different orientation. In order to calculate the distance of the red object, the distance measurement mathematical formula is develop by using the data from the two camera. After the data is collected, the data is tabulated in orderly manner according to specific experiment that already conducted to calculate the distance of an object by using the specific mathematical formula.

3.3 Stereo Vision System

A three dimensional image from the two images taken from different points is define as stereo vision. An eye structure of the human being is one of the model of stereo vision process. The information taken from the real world with human two eyes is known as the human sense. In the project, a stereo camera is introduced to produced a stereo image system which included right side image capture and left side video recording. The video of the object is compared after being captured at the same time from two cameras within an unknown distance [65]. Figure 3.2 (a) and (b) shows the stereo camera system and stereo image capture.



(a) (b)

Figure 3.2: (a)Stereo camera system [66], and (b)Stereo image capture [67]

In the project, a two cameras is connected with a Raspberry Pi board and an image of the object is captured by using a stereo vision video recording system. In order to catch an image of the object using stereo vision technique, a stereoscopic mode is enabled before enabling the camera component or setting the camera number. Stereoscopic mode needs to take control of both cameras and allocate memory differently. When conducting a stereo image using two camera connected at the same time on the Raspberry Pi board, only one camera is allowed to go online with a stereo image capture. Firstly, two cameras is aligned at the same point within 8cm from each other. The angle for both camera is point straight forward for about 90 degree.

The Raspberry Pi board only can connect with one camera only at one time. In that case, the data is collect separately between the right and left camera, but the distance and angle orientation is fixed for both of the camera. Then, a right side camera is on to collect the data from the object detected. After that, the experiment is switch to the left side camera to collect the data from the object detected. Both data from the right and left cameras is collected and tabulated in the table to compare the value. For stereo vision technique, there will be four different experiment. The Experiment 1 is a stereo vision technique with two same quality of camera by placing the object in front of each side of the camera, and the Experiment 2 is conducted by using two same quality of camera by placing the object in between the two camera. The Experiment 3 is a stereo vision technique with two different quality of camera by placing the object in between the two camera, and the Experiment 4 is conducted by using two different quality of camera by placing the object randomly in between the two camera by still in the range of limit that already being set. Experiment 5 is conducted by using two same quality of camera by placing the object randomly in between the two camera

3.3.1 Experimental Setup for Stereo Vision Implementation

3.3.1(a) Experiment 1: Stereo Vision Technique Using Two Identical Camera Placed In Front Of The Object

(a) (b)

Figure 3.3: Experiment setup by using two identical camera within (a)Object in front of left camera, and (b)Object in front of right camera

The first experiment is about the data collected by using the same quality of cameras for both side. Figure 3.3 shows the experimental setup for Experiment 1. The procedure for the first experiment is listed as below:

1. Two identical quality camera is placed at the same starting point at right straight angle in front of the object.
2. A piece of paper is used as a medium for object calculation by marking the specific distance that going to be measured. The lowest and highest limit of distance is marked by using the marker in order to make sure that each side of the camera can detect full body of the object that being detected, which is from 25cm until 50cm.
3. The object is placed in front of the right side camera.

4. The data is collected by turning on the right side of camera for distance 25cm from the object.
5. The object is now placed within increment 2.5cm from the first distance until it reached 50cm.
6. The data is tabulated and right side of camera is turn off.
7. The object is now removed and being placed in front of the left side of camera.
8. The data is collected by turning on the left side of camera for distance 25cm from the object.
9. The object is now placed within increment 2.5cm from the first distance until it reached 50cm.
10. The data is tabulated and left side of camera is turn off.
11. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

The first experiment is about using the same quality of the two identical camera which locate separately but at the same angle orientatation. The distance between the two camera is fixed by 8cm. This is the limit of the distance between the cameras so that both of the camera can record the full size of the object from both right and left side. The object is placed in front of each side of the camera in order to take the experimental data to calculate the distance of the object detected. The aim for this experiment is to study the stereo vision concept when the object is placed in front of both side of the camera.

3.3.1(b) Experiment 2: Stereo Vision Technique Using Two Identical Camera By Placing The Object In Between The Two Camera

The second experiment is about the data collected by using two identical quality of cameras for both side as shown in Figure 3.4. The procedure for the second experiment is listed as below:

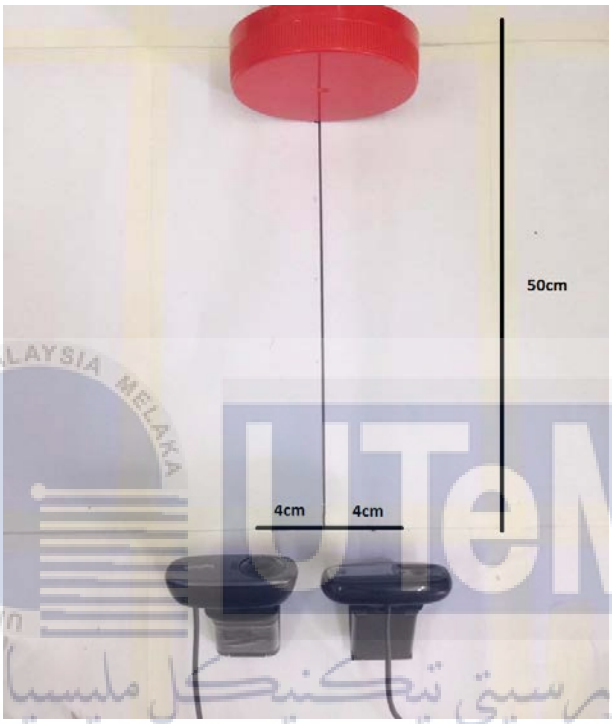


Figure 3.4: Experiment setup by using two identical camera within the object in between both of the camera

1. Two identical quality camera is placed at the same starting point at right straight angle in between of the object.
2. A piece of paper is used as a medium for object calculation by marking the specific distance that going to be measured. The lowest and highest limit of distance is marked by using the marker in order to make sure that each side of the camera can detect full body of the object that being detected, which is from 25cm until 50cm.
3. The object is placed in between of the two side of camera.
4. The data is collected by turning on the right side of camera for distance 25cm from the object.

5. The data is tabulated and right side of camera is turn off.

6. The data is collected by turning on the left side of camera for distance 25cm from the object.

7. The data is tabulated and left side of camera is turn off.

8. Step 3 until Step 7 is repeated by placing the object in between the two camera within increment 2.5cm from the first distance until it reached 50cm.

9. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

The second experiment is about using the same quality of the two identical camera which locate separately but at the same angle orientatation. The distance between the two camera is fixed by 8cm. This is the limit of the distance between the cameras so that both of the camera can record the full size of the object from both right and left side. The object is placed in between the two camera instead placed it in front of the camera as in the Experiment 1. The aim for this experiment is to study the stereo camera concept when the object is placed in between both of the camera. This experiment is the main objective in order to study the stereo vision system implementation.

When the object is placed at center in between both side of the camera, both side of the camera is recording the full body of the object. Since both side of the camera collecting data, the average data is calculated in order to produce a single data for average area of object detected, which is known as the data collected from the third camera, the imaginary camera located in between both side of the camera. This is the concept of stereo vision system that being implemented in this project.

3.3.1(c) Experiment 3: Stereo Vision Technique Using Two Different Camera By Placing The Object In Between The Two Camera

The third experiment is about the data collected by using the different quality of cameras for both side as shown in Figure 3.5. The procedure for the third experiment is listed as below:

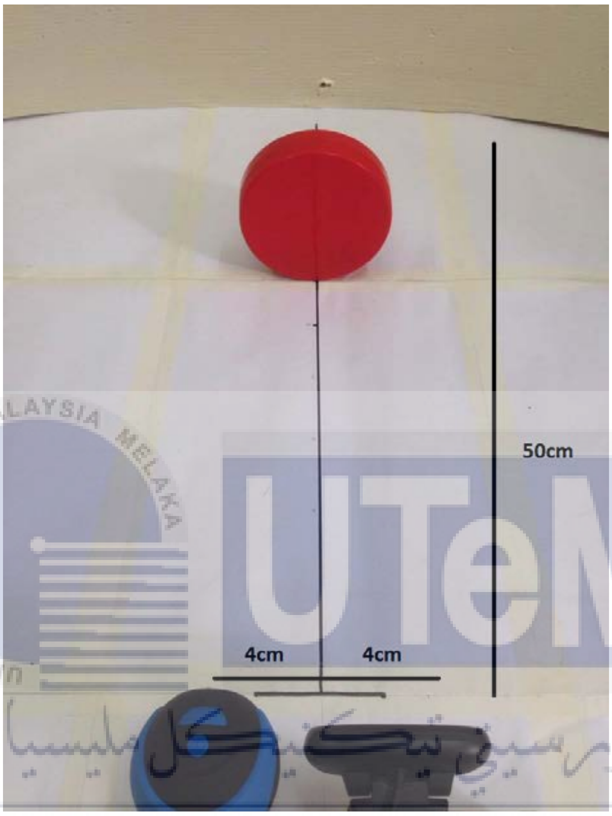


Figure 3.5: Experiment setup by using two different camera within the object in between both of the camera

1. Two different quality camera is placed at the same starting point at right straight angle in between of the object.

2. A piece of paper is used as a medium for object calculation by marking the specific distance that going to be measured. The lowest and highest limit of distance is marked by using the marker in order to make sure that each side of the camera can detect full body of the object that being detected, which is from 25cm until 50cm.

3. The object is placed in between of the two side of camera.

4. The data is collected by turning on the right side of camera for distance 25cm from the object.

5. The data is tabulated and right side of camera is turn off.

6. The data is collected by turning on the left side of camera for distance 25cm from the object.

7. The data is tabulated and left side of camera is turn off.

8. Step 3 until Step 7 is repeated by placing the object in between the two camera within increment 2.5cm from the first distance until it reached 50cm.

9. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

10. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

The third experiment is about using two different type of camera which has different quality of video recording. The type of camera used in this experiment is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam, and Standard USB Camera 5MP. The experiment is conducted to investigate the data and result collected is affected by different quality of the cameras. The different type of camera resolution used may give the different result for the average area of object detected. This is because different type of camera resolution captured different number of pixel per frame. From this experiment, the conclusion can be made after the data is collected and the result calculation of the distance is analysed.

3.3.1(d) Experiment 4: Stereo Vision Technique Using Two Identical Camera By Placing The Object Randomly In Between The Two Camera

The fourth experiment is about the data collected by using the identical quality of cameras for both side as shown in Figure 3.6. The procedure for the fourth experiment is listed as below:

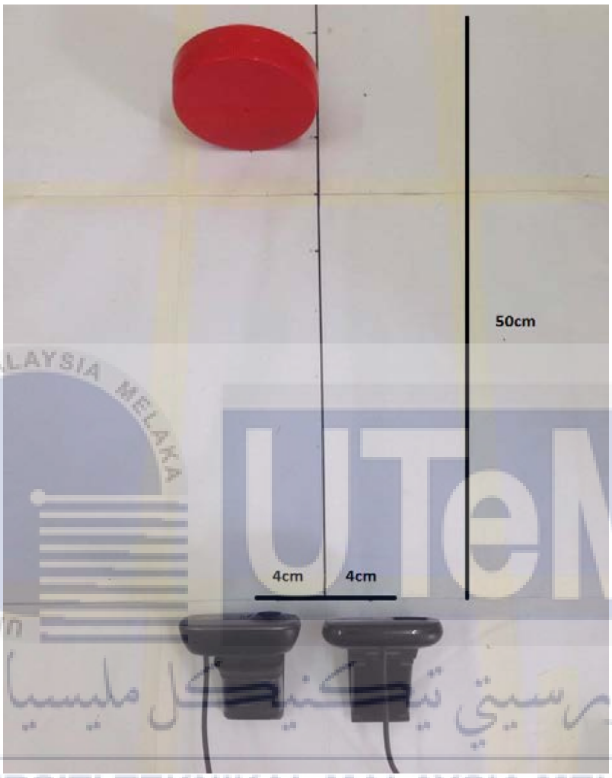


Figure 3.6: Experiment setup by using two identical camera within the object in between both of the camera in random distance

1. Two identical quality camera is placed at the same starting point at right straight angle in front of the object.

2. A piece of paper is used as a medium for object calculation by marking the specific distance that going to be measured. The lowest and highest limit of distance is marked by using the marker in order to make sure that each side of the camera can detect full body of the object that being detected, which is from 25cm until 50cm.

3. The data is collected by turn on the right side of camera and the object is placed randomly in distance but still in the range that already being marked.

4. The data is tabulated and right side of camera is turn off.

5. The left side of camera is turn on to collect the data from the detected object, same with the randomly distance of object as Step 3.

6. The data is tabulated and left side of camera is turn off.

7. The experiment is continue by repeating Step 3 until Step 7 for three different value of random distance of the object.

8. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

The fourth experiment is conducted in order to analyse the data from same type of quality of two different camera in which effect the data gathered. The object is placed randomly in distance within the range marked and the data from this experiment is compared with the Experiment 1, Experiment 2, and Experiment 3 to analyse the different type of data that being collected. The randomly distance in this experiment is known as Random1, Random2, and Random3. Acutal distance for Random1 is 34cm, Random2 is 39cm, and Random3 is 37cm.

3.3.1(e) Experiment 5: Stereo Vision Technique Using Two Different Camera By Placing The Object Randomly In Between The Two Camera

The fifth experiment is about the data collected by using the different quality of cameras for both side as shown in Figure 3.7. The procedure for the fifth experiment is listed as below:

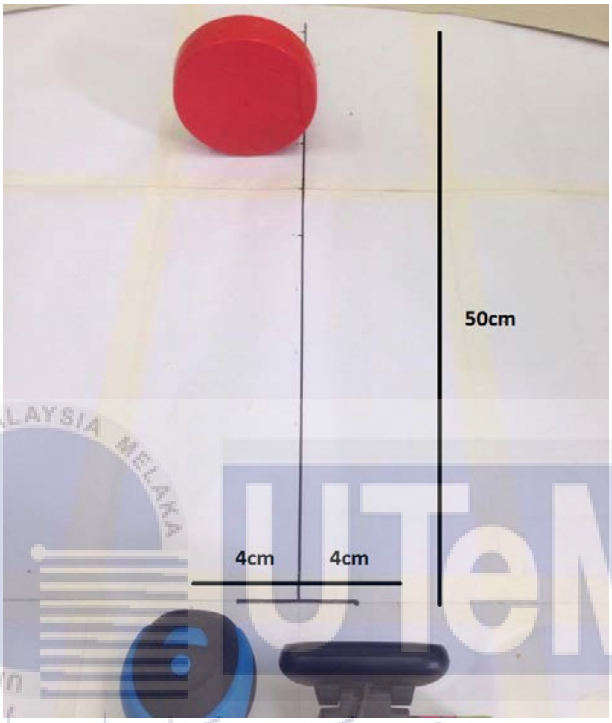


Figure 3.7: Experiment setup by using two different camera within the object in between both of the camera in random distance

1. Two different quality camera is placed at the same starting point at right straight angle in front of the object.
2. A piece of paper is used as a medium for object calculation by marking the specific distance that going to be measured. The lowest and highest limit of distance is marked by using the marker in order to make sure that each side of the camera can detect full body of the object that being detected, which is from 25cm until 50cm.
3. The data is collected by turn on the right side of camera and the object is placed randomly in distance but still in the range that already being marked.
4. The data is tabulated and right side of camera is turn off.
5. The left side of camera is turn on to collect the data from the detected object, same with the randomly distance of object as Step 3.

6. The data is tabulated and left side of camera is turn off.

7. The experiment is continue by repeating Step 3 until Step 7 for three different value of random distance of the object.

8. Both of the data from right and left side of the camera is compared to analyse the different value from both of the camera.

The fifth experiment is conducted in order to analyse the data from different type of quality of two different camera in which effect the data gathered. The object is placed randomly in distance within the range marked and the data from this experiment is compared with the Experiment 1, Experiment 2, Experiment 3, and Experiment 4 to analyse the different type of data that being collected. Acutal distance for Random1 is 34cm, Random2 is 39cm, and Random3 is 37cm.

From all experiment conducted, the data is calculated and analysed in order to find the exact value of distance by using a specific mathematical expression. Then, the distance calculated is compared with the actual distance of the object in order to find the percentage error of the result. The mathematical equation is develop in order to minimize the percentage error of the value of the distance of the object detected. The randomly distance in this experiment is known as Random1, Random2, and Random3.

3.3.2 Stereo Vision Hardware Development

In developing the hardware of the system, a specific components have been choosen in order to provide an object distance measurement system. The list of the hardware components is listed in below :

1.Raspberry Pi 2 Model B

2.Logitech C270 3 Mega Pixel USB 2.0 HD Webcam

3.Standard USB Camera 5MP

3.3.2(a) Raspberry Pi 2 Model B

Based on the discussion in Chapter 2, there is many type of microcontroller that have been used to conduct the distance measurement. From the previous study, one of the example of the microprocessor used to measure a distance of the object is Arduino Kit. The application and the processor of the Raspberry Pi is better than the other microprocessor because of it provided many function same as a computer. The Raspberry Pi 2 Model B is on a totally new level to its ancestors by being an amazing 6X speedier than the Raspberry Pi Model B+. The ultra-minimal effort, deck-of-cards estimated Linux PC has had yet another makeover and this time the Raspberry Pi Foundation have gone hard and fast. It has an indistinguishable impression and format from the past Model B+ variant, so will fit all Model B+ things [67]. Figure 3.8 shows the Raspberry Pi 2 Model B board.

Figure 3.8: Raspberry Pi 2 Model B [67]

3.3.2(b) Logitech C270 3 Mega Pixel USB 2.0 HD Webcam

The Logitech C270 3 Mega Pixel USB 2.0 HD Webcam is a widescreen HD 720P video calls with pan, tilt, and zoom controls. [68].

For this project, two camera is needed to product a stereo camera system by applying a binocular concept. This two cameras will be connected with a multi camera adapter module because a Raspberry Pi board can only connected with one camera only. So an adapter is needed to produce a stereo vision camera system. Both camera will produced a right and left side of the image. This condition can be known as a stereo image capture. A stereo image is captured in both side of cameras after detecting a specific object after the object detection is done. Figure 3.9 shows the Logitech C270 3 Mega Pixel USB 2.0 HD Webcam and its specification.

Technical Specifications
HD video calling (1280 x 720 pixels) with recommended system
Video capture: Up to 1280 x 720 pixels
Logitech Fluid Crystal™ Technology
Photos: Up to 3.0 megapixels (software enhanced)
Built-in mic with noise reduction
Hi-Speed USB 2.0 certified (recommended)
Universal clip fits laptops, LCD or CRT monitors
Logitech webcam software:
Pan, tilt, and zoom controls
Video and photo capture
Face tracking
Motion detection

Figure 3.9: Logitech C270 3 Mega Pixel USB 2.0 HD Webcam and its Specification [68]

3.3.2(c) Standard USB Camera 5MP

The standard USB camera is used in order to investigate the different type of camera would effect the result collected. The quality from the USB camera maybe not as good as Logitech C270 3 Mega Pixel USB 2.0 HD Webcam, but the main purpose using two camera is to create a stereo vision technique. This camera come with 640x480 Video mode with 24 bits true colour Interfaced. Although both of the camera has the same exact resolution, but the result from the both camera will be discuss in order to analyse on how the resolutioon and quality of the camera can effect the data and result that will be collected[69].Figure 3.10 shows the Standard USB Camera 5MP.

Figure 3.10: Standard USB Camera 5MP [69]

3.4 OpenCV-Python Connection

In OpenCV, all algorithms are executed in C++, an alternate languages like Python or Java can be utilized as a algorithm. The generators is binded to make this association. An extension between C++ and Python can be made by utilizing these generators which empowers users to call C++ functions from Python. A good knowledge of Python is required so as to get an entire picture of what is going on in background. Extending all functions in OpenCV to Python by writting their wrapper function manually is a tedious assignment. All things considered, OpenCV creates these wrapper functions naturally from the C++ headers utilizing some Python scripts which are situated in ‘$modules/python/src2$’.

Firstly, ‘$modules/python/CMakeFiles.txt$’ is a CMake script which checks the modules to be reached out to Python. A header files is grabbed and every one of the modules that should be amplified is checked automatically. A list of all classes, functions, contants for that specific modules is given in these header files.Secondly, these header files are passed to a Python script, ‘$modules/python/src2/gen2.py$’. This is known as Python bindings generator script.

It calls another Python script ‘$modules/python/src2/hdr_parser.py$’. This is the header parser script. By utilizing this header parser, the entire header file is splitted into little Python lists. These list contain all details about a specific functions, class and so etc. Final list contains details of all functions, structs, classes in that header document.

At the point when a capacity is called, ‘$res = equalizeHist(img1, img2)$’ is said in Python, a two numpy arrays is passed and anotheroutput of numpy array is normal. These arrays are changed over to ‘$cv :: Mat$’ and after that calls the ‘$equalizeHist$’ work in C++. As a last outcome, ‘res’ will be changed over again into a Numpy array. In conclusion, all operations are done in C++ which give nearly an indistinguishable speed from that of C++ [71].

3.4.1 Image Processing

In image processing method, a specific object is selected to test the proposed algorithm that is used to measure a distance of an object detected. So, a specific information of the detected object is decided to make sure the system is only detect the specific object. The information of the detected object is the object is in circle shape and has a red colour. In that case, a suitable method is developed to detect the object according to it specific information. Figure 3.11 shows the flowchart to detect a specific object from input image.

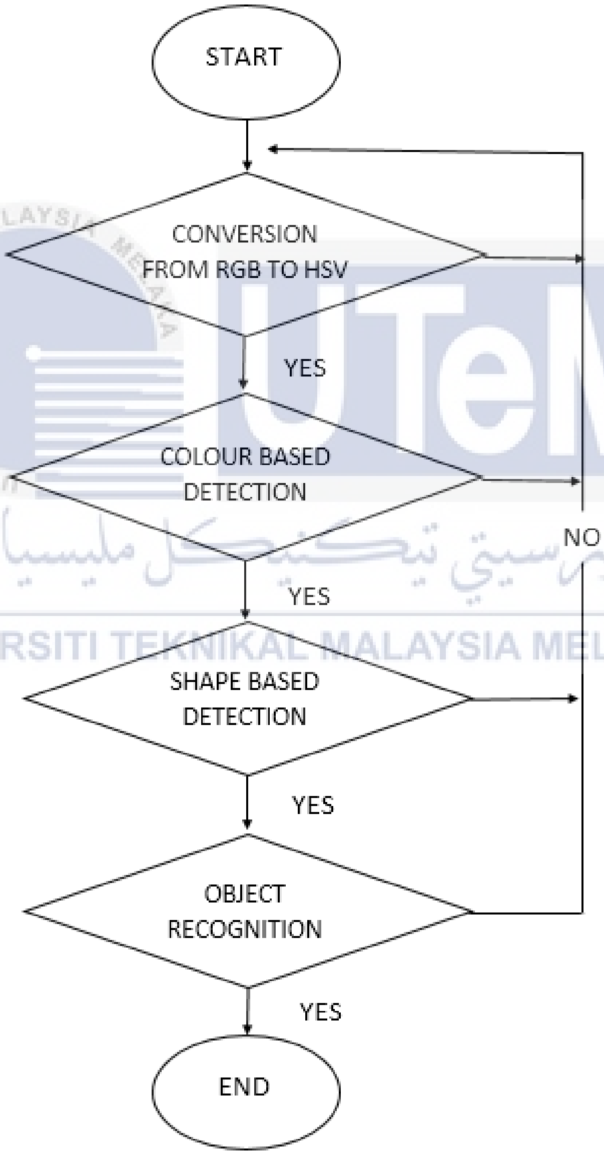
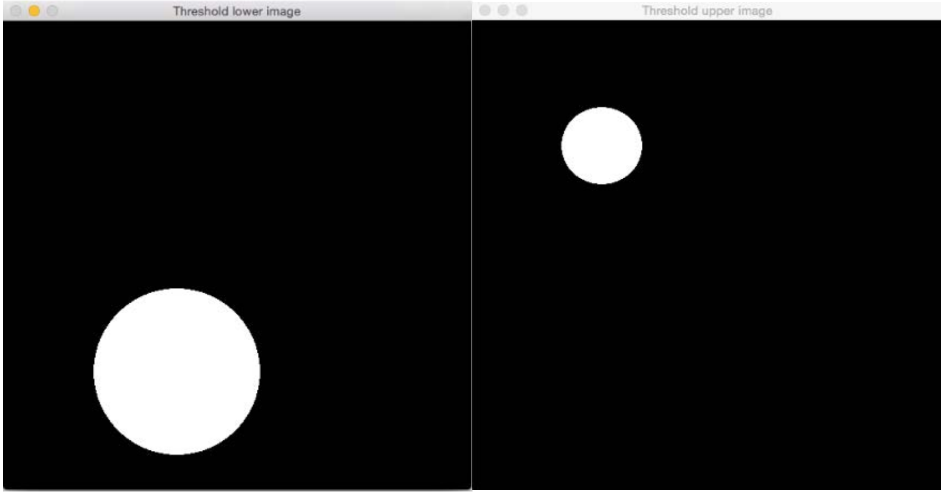


Figure 3.11: The process of object detection from input image

3.4.1(a) Colour-Based detection using Image Thresholding

Image thersholding is a simple method of image segmentation that is used to create binary images. If the pixel value is lower than a threshold value, it is assigned another value (may be black), else it is assigned one value (may be white). The '*cv*2.*threshold*' is used as a function. The first step is taken by thresholding the input image for anything that is not red. The standard RGB colour space is changed over into HSV space, which has the alluring property that permits to distinguish a specific colour utilizing a single value, the Hue, rather than three qualities. In OpenCV, H has values from 0 to 180, S and V from 0 to 255. For the red colour in OpenCV, it has the tone values around in the scope of 0 to 10 and 160 to 180. A BGR format is used rather than RGB to convert the image into HSV and the HSV image is thresholded for anything that is not red. Figure 3.12 shows the example of an input image [72].

Figure 3.12: An example of input image[72]



(a) (b)

Figure 3.13: Lower red image (a), and (b)Upper red Image [72]

In Figure 3.13,the primary threshold image captured the huge red circle from the input image, while the second threshold image captured the littler red circle. After obtained the red colour from colour detection using a threshold image processing, both upper and lower detected colour is combined and the result is slightly being blur in order to avoid false positives. Figure 3.14 shows the combined threshold images.

Figure 3.14: Combined threshold images [72]

3.4.1(b) Shape-based Detection

After a sample image is processed through a colour-based detection by using a threshold method, a detected object is then being proceed to the next step. In the next step, a Hough Transform is used to detect a circle shape. In a two dimensional space, a circle can be described by :

$$r^2 = (\mathrm{x}-\mathrm{a})^2 + (\mathrm{y}-\mathrm{b})^2. \tag{3.1}$$

Equation 3.1 shows a general equation of a circle. (a,b) is the center of the circle, and r is the radius. The parameters can be found according to equation (1) by fixing a 2D point (x,y). The parameter space would be three dimensional, (a,b,r) and every one of the parameters that fulfill (x,y) would lie on the surface of a modified right-calculated cone whose peak is at $(x,y,0)$. In the 3D space, the circle parameters can be distinguished by the crossing point of numerous conic surfaces that are characterized by focuses on the 2D circle. This procedure can be separated into two phases. The main stage is settling range then locate the ideal focus of circles in a 2D parameter space. The second stage is to locate the ideal radius in a one dimensional parameter space. Figure 3.15 demonstrates a recognized red circles on the info picture [73].

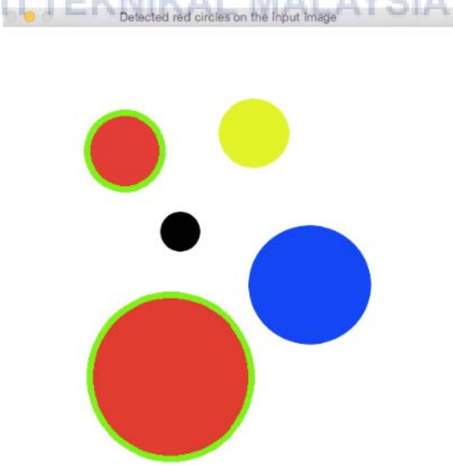


Figure 3.15: Detected red circles on the input image [72]

3.5 Distance Measurement Using Mathematical Equation

The mathematical equation for distance calculation is developed in order to calculate the distance of the object by using the data collected from all part of the stereo vision implementation experiment. The data from the experiment is about the detection of image processing through colour and shape based detection. The colour of the object is red colour and the shape of the object is circle. From the code that already being run in the Raspberry Pi board, the data collected is the area of the object detected. Based on this situation, it is very important to make sure that both side of the camera detect full body of the object from all experiments. The data is an area of the detected red circle and being tabulated in the table.

From the data that already tabulated, the equation for object distance from both of the camera is developed. It is very important to gather all the data from different kind of experiment in order to make sure the mathematical equation that already being developed is valid for all the data from all the experiment conducted. Figure 3.16 shows the graph generated to develop the distance measurement equation known as Equation 3.2.

$$y = -0.94447x^3 + 134.5x^2 - 6670.88x + 120700. \tag{3.2}$$

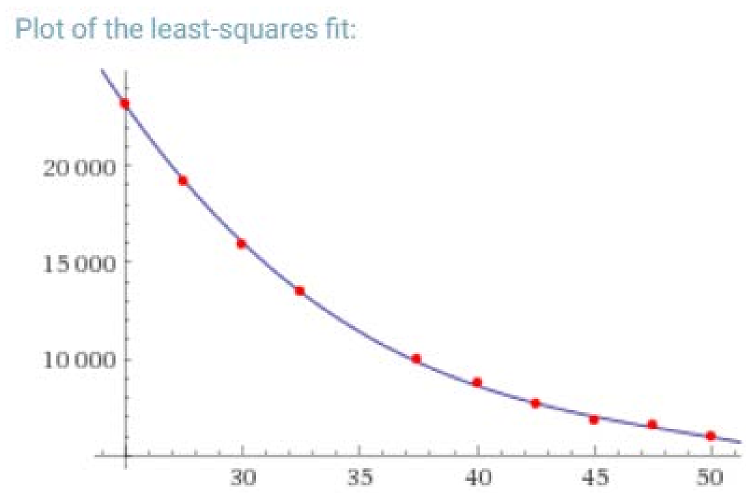


Figure 3.16: The graph for Equation 3.2

Equation 3.2 is a mathematical equation for distance measurement by using the area of the detected red circle object. From the equation 3.2, the variables 'y' and 'x' is the only data that need to be analysed. Variable 'y' stand for the area of the object detected came from the data that already being collected from all stereo vision implementation experiment. From value of variable 'y' that gained from the experiment, the distance of the detected object can be calculated. The variable 'x' is the value that need to be found from the calculation which mean the variable 'x' stand for the distance of the detected object. Although the equation is in cubic root, there will be three answer of the variable 'x'. From the calculation of cubic root equation, the value of variable 'x' will be two imaginary value and one absolute value. The answer of imaginary values can be ignored since the distance of the detected object is an absolute value. The absolute value of variable 'x' is tabulated in the table accordingly to each experiment that already being conducted. The final step is to calculate the error of distance of the detected object by using the distance measurement error equation.

3.5.1 Procedure Of Distance Measurement Calculation

From the following procedure below, the value of theoritical distance of the object can be calculated and the distance measurement error can be analysed by using Equation 3.2.

1. Setup the experiment within the value of the fixed distance of the object that already being marked on a white plane paper.
2. Run the code from the Raspberry Pi board by using stereo vision implementation.
3. Repeat each of the experiment ten times for each value fixed distance.
4. Collect the value of variable 'y' which is the area of the object detected.
5. Tabulate the data gained from the experiment.
6. Calculate the average value of variable 'y' for each set value of the actual distance.
7. Compare the value of variable 'y' from both side of cameras and calculate the average value.
8. Insert the value of variable 'y' in Equation 3.2 to calculate the value of variable 'x' which is the new distance of the detected object.

3.6 Distance Measurement Error Calculation

An experiment is conducted in order to calculate the error in distance measurement system. First, the distance between the device and the red circle object is set as a actual value by using a ruler. The actual value is set for 25cm, 27.5cm, 30cm, 32.5cm, 35cm, 37.5cm, 40cm, 42.5cm, 45cm, 47.5cm, and 50cm. Each of the set given, the experiment is conducted ten times by capturing the image of the red circle object in order to obtain the theoretical value of distance measure by using two cameras.

The purpose of repeating the experiment ten times for each set is to obtain the average value of the theoretical distance for each set of theoritical set. Then, the average data from both camera is plus together and divide by two in order to produce a single data of distance measurement system. This single data is known as the data from third imaginary camera located in between both side of the camera. Figure 3.17 shows the experiment setup to calculate the distance measurement error. After all the actual value is obtain for each set, the error of distance measurement is calculate by using the Equation 3.3 :

$$Distance \quad Error = \left(\frac{Theoritical - Actual}{Actual}\right) \tag{3.3}$$

Figure 3.17: Experiment setup for distance measurement error

3.7 Summary

Based on the proposed methodology, a distance measurement system is finally proposed. An object is detected using a colour and shape based detection to detect a specific colour and shape. The colour choose to conduct the experiment is red and the shape choose is circle. The object detection can be done after the cameras detect the specific object. After the object is detected by using colour and shape detection, the camera will automatically identify the object based on the algorithm of object detection. Then, the data from the detected object is gathered and tabulated in the table. The data collected is being compared between right and left side of the camera. The data then is used to calculate the distance of the object by using specific mathematical equation. In the next chapter, a results from all stereo vision implementation experiment will be discussed in order to verify whether the equation of distance mesurement is valid for all kind of data from different experiments. Besides, a discussion about a different quality of camera used will also be analysed.

CHAPTER 4

RESULT AND ANALYSIS DISCUSSION

4.1 Result for Stereo Vision Implementation Experiments

From all the expriments that being conducted, the data is tabulated in order to calculate the theoritical distance for the object detected. Each of the data is tabulated accordingly into the specific table. The data that being collected is the area of the detected object that being measured accordingly to the specific actual distance. The data from the right and left side of camera is collected and the average from both data is calculated. The average area of detected object is used to find the theoritical distance by inserting the data into the specific mathematical equation.

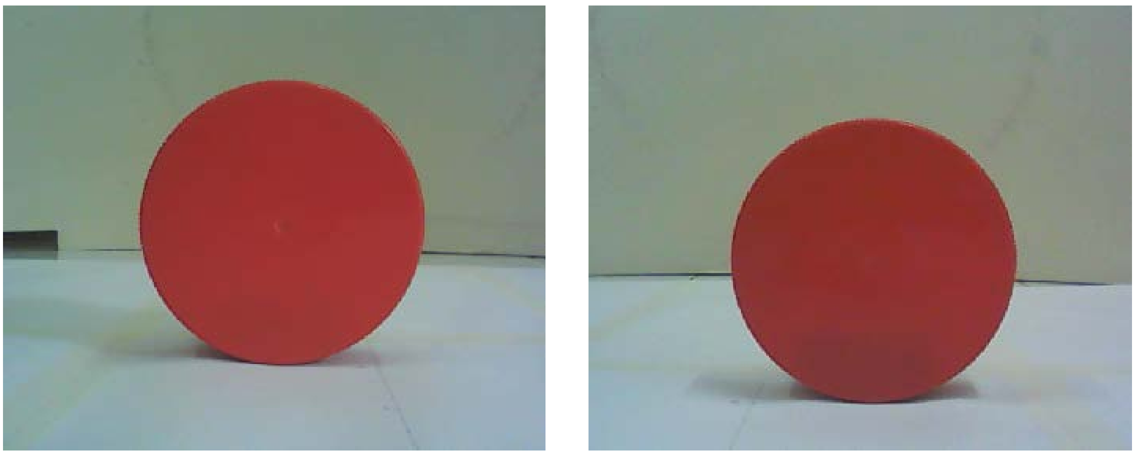
4.1.1 Experiment 1: Stereo Vision Technique Using Two Identical Camera Placed In Front Of The Object

Experiment 1 is about placing the object in front of the same type of camera which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam. Both of the camera is placed side by side at a distance 8cm from each other. Then, the object is placed in front of the right side camera first, and the data is collected. After that, the object is placed in front of the left side camera, and the data is collected. The actual distance to place the object is already being marked for each side of the camera. The result of Experiment 1 is collected and being tabulated accordingly to the specific distance marked. Figure 4.1 until Figure 4.11 are the picture show the object from both side of the camera which is presented side by side accordingly to the specific distance to compare the image presentation.

All of the information gained from the experiment is tabulated in the table to specify the function of each table. Every data from each side of the camera is tabulated separately to compare the differences of each data. Then, a new table is created in order to insert the average value from both side of the camera. This is done to find the value if imaginary camera in between the right and left side of the camera. Although the data only became one set of value, but all the experiment conducted is still used the stereo vision concept.

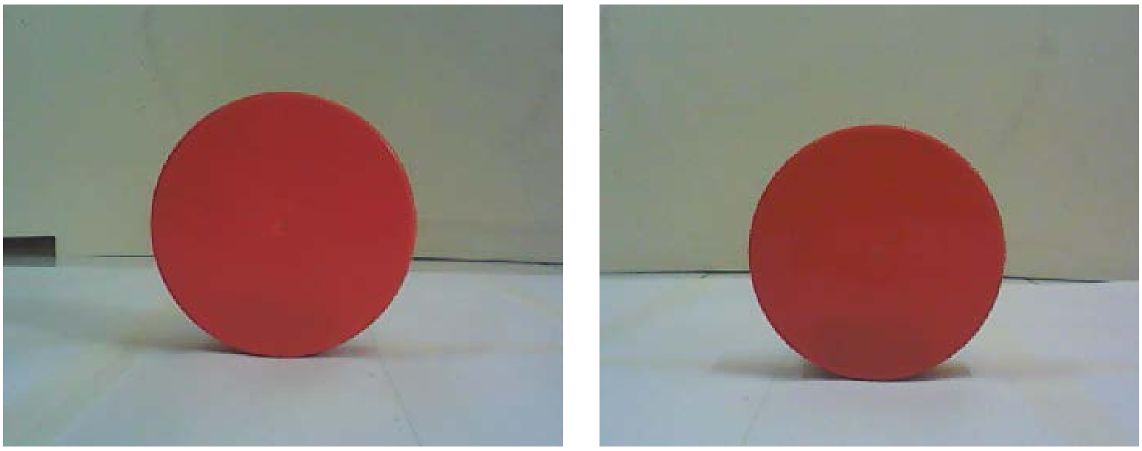
Table 4.1 shows the area of detected object from right side of the camera. Table 4.2 shows the area of the detected object from left side of the camera. Table 4.3 shows the average area of the detected object from both side of the cameras. Each of the area detected is tabulated accordingly to the specific distance that already being marked. Table 4.4 shows the comparison between the actual distance and theoretical distance. The theoritical distance is calculated by using the formula from Equation 3.2. Table 4.5 shows the error distance calculation by using Equation 3.3.

This experiment is conducted in order to investigate the data collection when the object is placed in front of both camera. In other word, it is similar when a human close one eye and target the object by using a single vision. This could result a parallax error when a human only seen the object with one eye. Both of the eyes have a minor and major focus in order to locate the exact location of the object. This could be explained as a disadvantage of single camera system.



(a) (b)

Figure 4.1: Object detected at a 25cm from camera(a)Left side camera, and (b)Right side camera

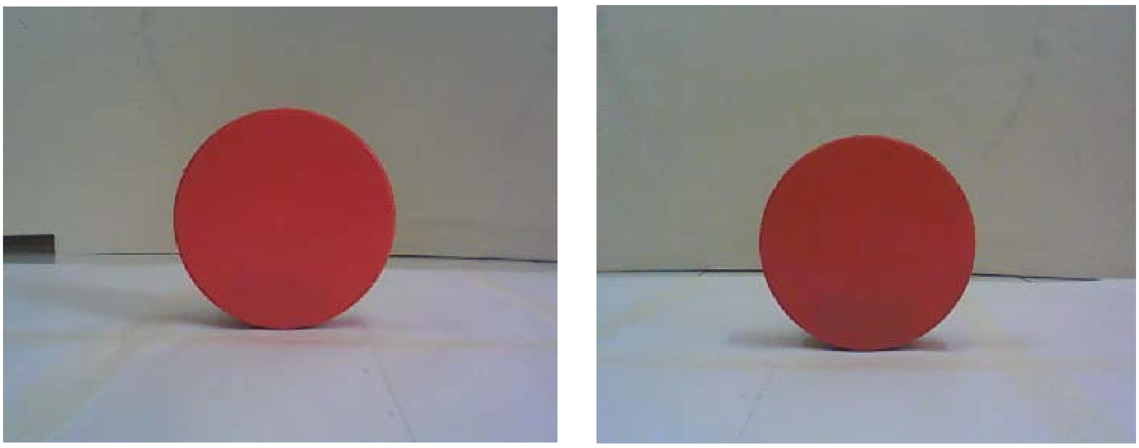


(a) (b)

Figure 4.2: Object detected at a 27.5cm from camera(a)Left side camera, and (b)Right side camera

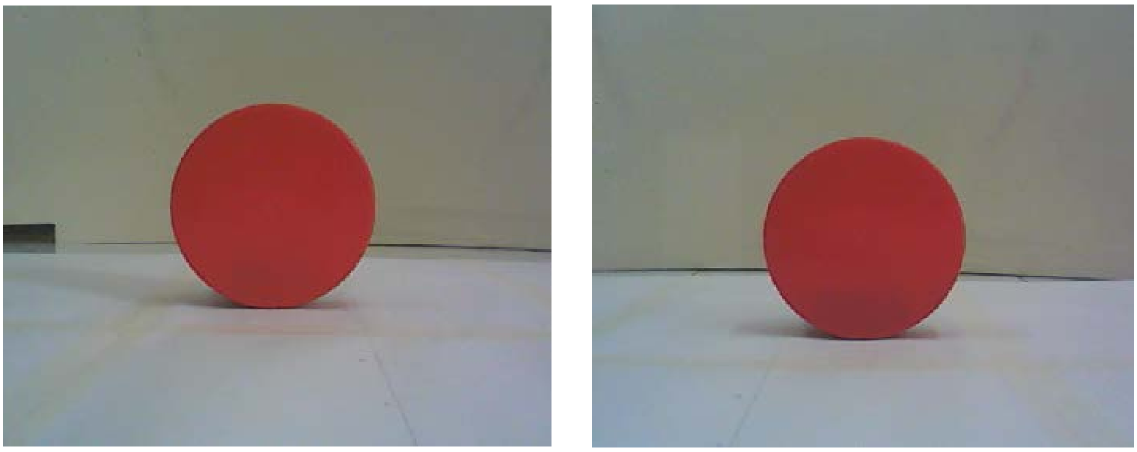
(a) (b)

Figure 4.3: Object detected at a 30cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.4: Object detected at a 32.5cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

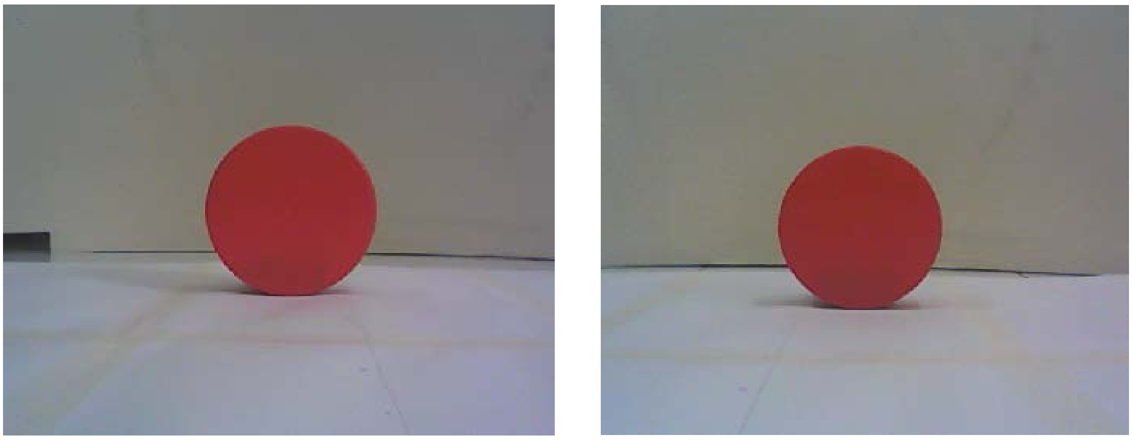
Figure 4.5: Object detected at a 35cm from camera(a)Left side camera, and (b)Right side camera

(a) (b)

Figure 4.6: Object detected at a 37.5cm from camera(a)Left side camera, and (b)Right side camera

(a) (b)

Figure 4.7: Object detected at a 40cm from camera(a)Left side camera, and (b)Right side camera

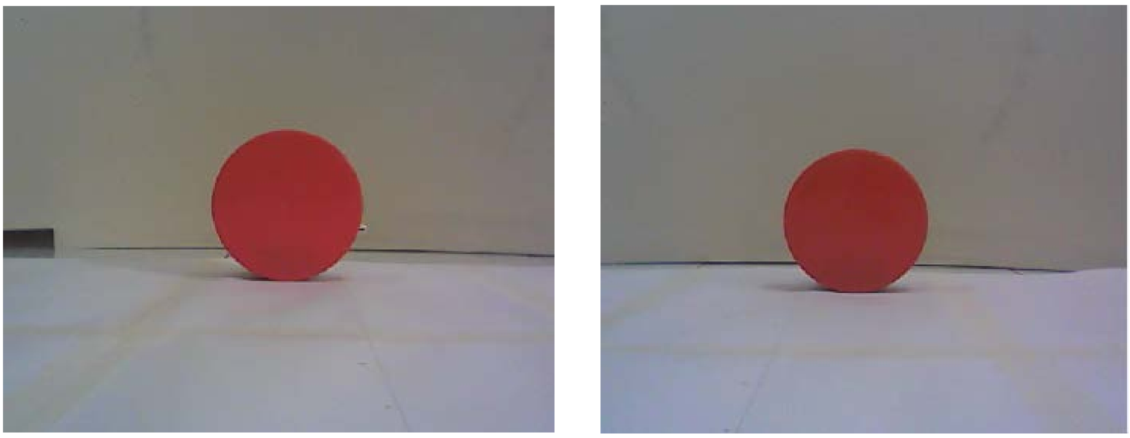


(a) (b)

Figure 4.8: Object detected at a 42.5cm from camera(a)Left side camera, and (b)Right side camera

(a) (b)

Figure 4.9: Object detected at a 45cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.10: Object detected at a 47.5cm from camera(a)Left side camera, and (b)Right side camera


(a)

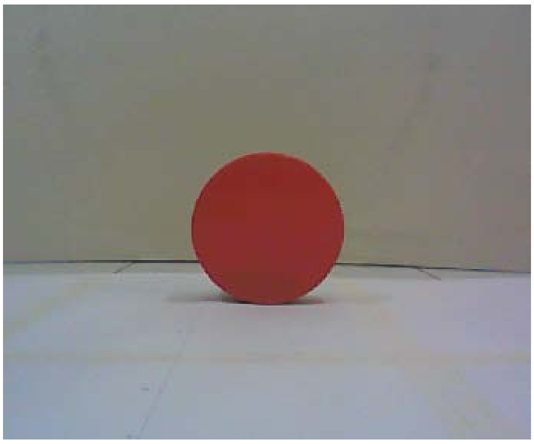

(b)

Figure 4.11: Object detected at a 50cm from camera(a)Left side camera, and (b)Right side camera

Table 4.1: Area of detected object from right side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	23222.6
27.5	19160.9
30.0	15873.8
32.5	13485.3
35.0	11532.3
37.5	9955.5
40.0	8706.5
42.5	7634.8
45.0	6775.1
47.5	6584.2
50.0	5955.3

Table 4.2: Area of detected object from left side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	23387.3
27.5	19008.9
30.0	15687.4
32.5	13423.6
35.0	11456.7
37.5	9913.0
40.0	8577.2
42.5	7601.9
45.0	6773.3
47.5	6440.0
50.0	5950.5

Table 4.3: Average area of detected object from both side of cameras

Actual Distance(cm)	Average Area of the Detected Object
25.0	23304.9
27.5	19048.9
30.0	15780.6
32.5	13454.5
35.0	11494.5
37.5	9934.3
40.0	8541.9
42.5	7618.4
45.0	6774.2
47.5	6512.4
50.0	5952.9

Table 4.4: Comparison between actual distance and theoretical distance

Actual Distance(cm)	Theoretical Distance(cm)
25.0	24.9
27.5	27.7
30.0	30.3
32.5	32.6
35.0	34.9
37.5	37.4
40.0	40.2
42.5	42.5
45.0	45.1
47.5	45.9
50.0	47.9

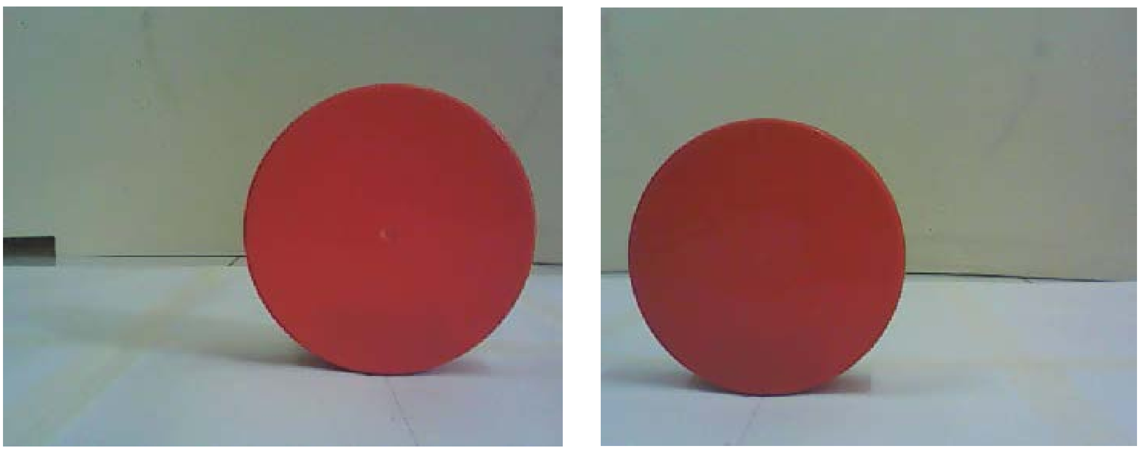
Table 4.5: Error distance calculation by using Equation 3.3

Actual Distance(cm)	Error Distance Calculation(%)
25.0	0.4
27.5	0.7
30.0	1.0
32.5	0.3
35.0	0.3
37.5	0.3
40.0	0.5
42.5	0.0
45.0	0.2
47.5	3.4
50.0	4.2

4.1.2 Experiment 2: Stereo Vision Technique Using Two Identical Camera By Placing The Object In Between The Two Camera

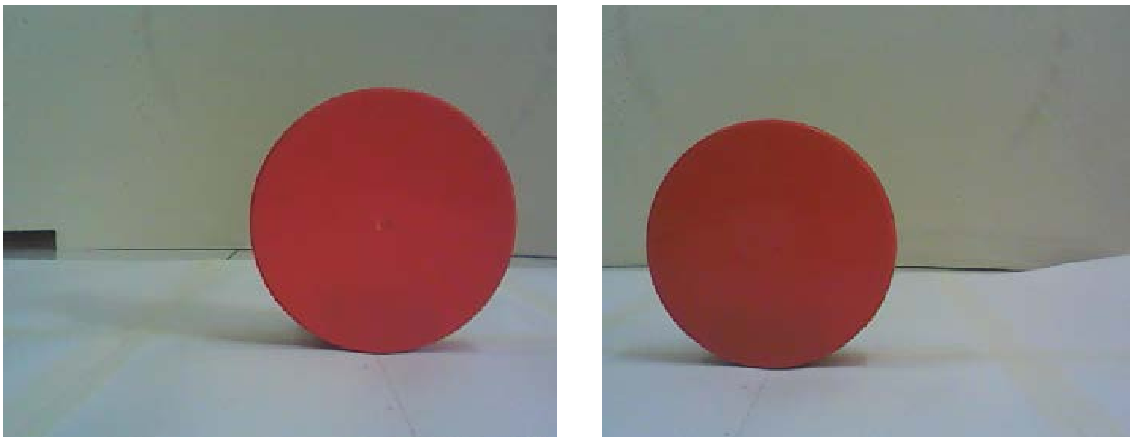
Experiment 2 is about placing the object at the center of the two same type of camera which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam. Both of the camera is placed side by side at a distance 8cm from each other. The object is now recorded by using both of the camera to collect the data which is the area of detected object same with Experiment 1. The result of the experiment is collected and being tabulated in the table accordingly to the specific distance. Figure 4.12 until Figure 4.22 are the picture of every specific distance from both side of the camera.

Table 4.6 shows the area of detected object from right side of the camera. Table 4.7 shows the area of the detected object from left side of the camera. Table 4.8 shows the average area of the detected object from both side of the cameras. Each of the area detected is tabulated accordingly to the specific distance that already being marked. Table 4.9 shows the comparison between the actual distance and theoretical distance. The theoritical distance is calculated by using the formula from Equation 3.2. Table 4.10 shows the error distance calculation by using Equation 3.3. This experiment is the main objective of the project because it applied exactly the stereo vision technique same with the human eyes. The object is bassically placed in between of the camera to overcome the parallax error when to locate the exact location and distance of the object.



(a) (b)

Figure 4.12: Object detected at a 25cm from camera(a)Left side camera, and (b)Right side camera

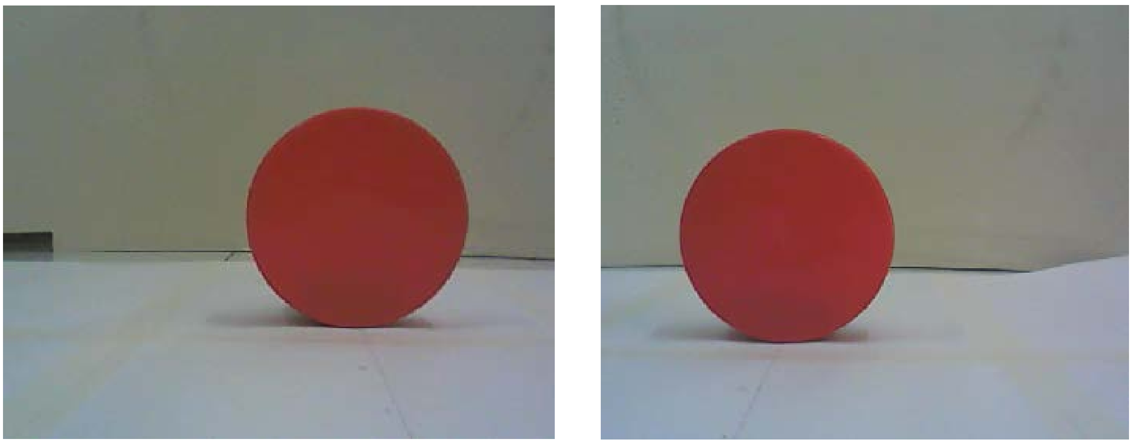


(a) (b)

Figure 4.13: Object detected at a 27.5cm from camera(a)Left side camera, and (b)Right side camera

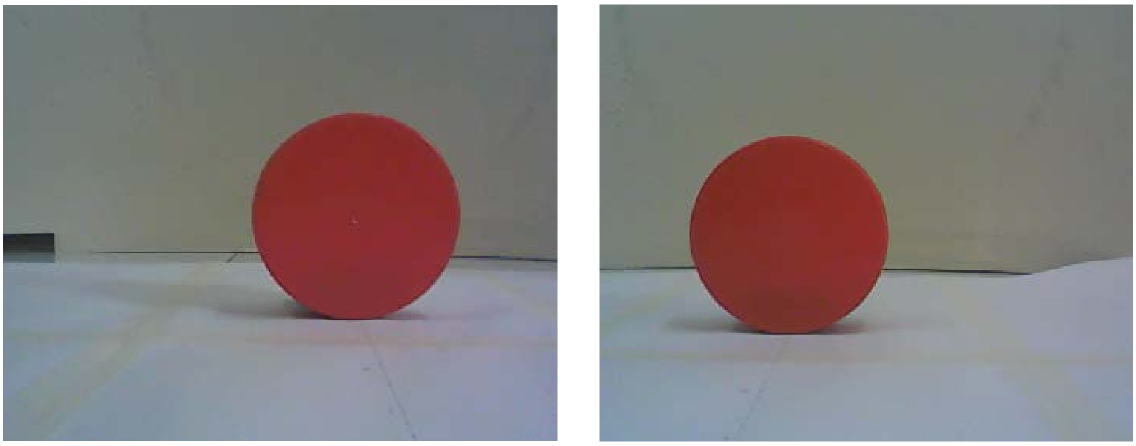
(a) (b)

Figure 4.14: Object detected at a 30cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.15: Object detected at a 32.5cm from camera(a)Left side camera, and (b)Right side camera

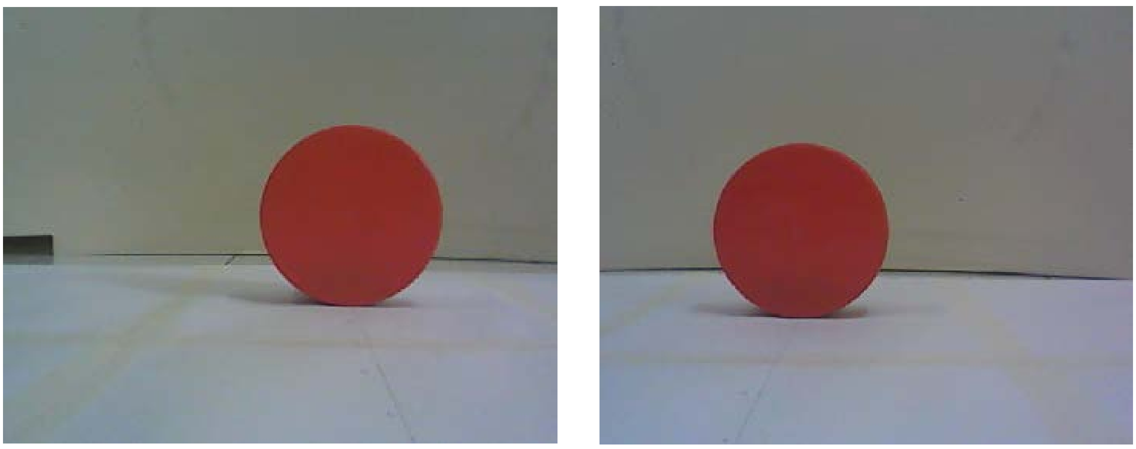


(a) (b)

Figure 4.16: Object detected at a 35cm from camera(a)Left side camera, and (b)Right side camera

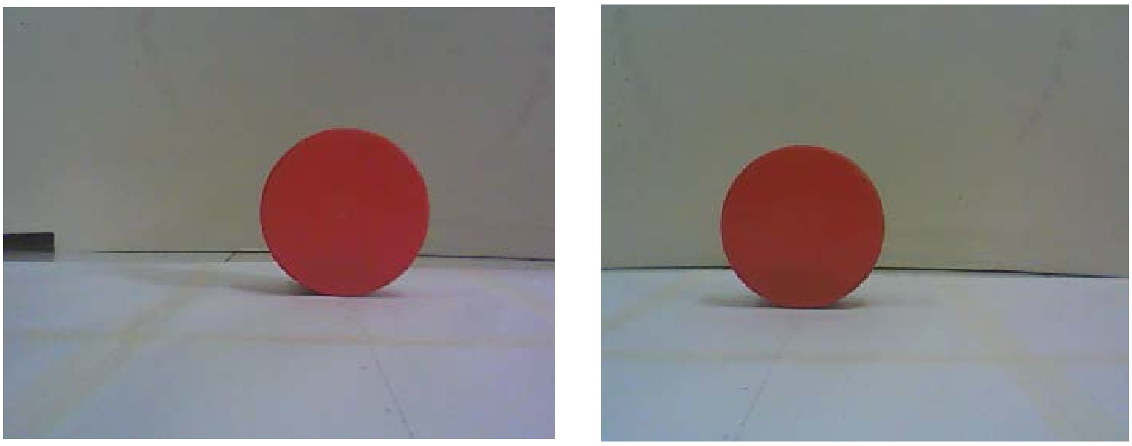
(a) (b)

Figure 4.17: Object detected at a 37.5cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.18: Object detected at a 40cm from camera(a)Left side camera, and (b)Right side camera

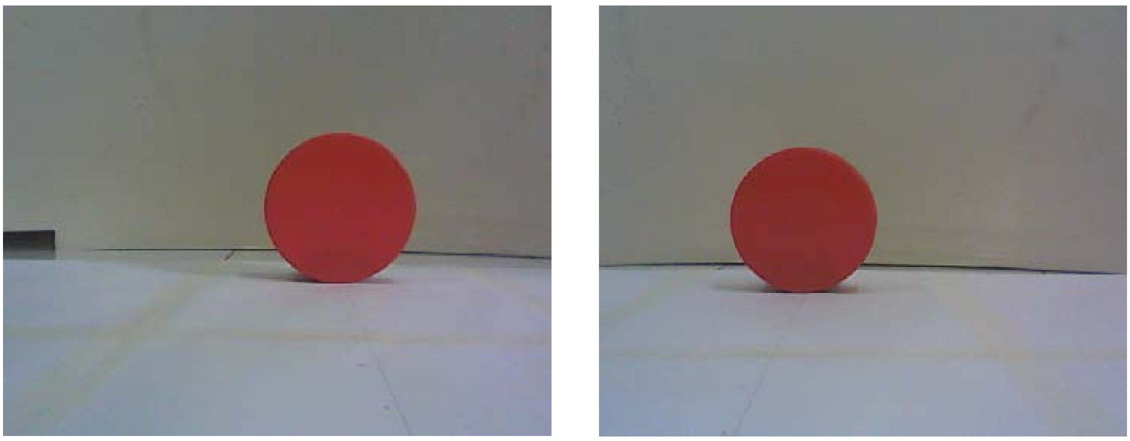


(a) (b)

Figure 4.19: Object detected at a 42.5cm from camera(a)Left side camera, and (b)Right side camera

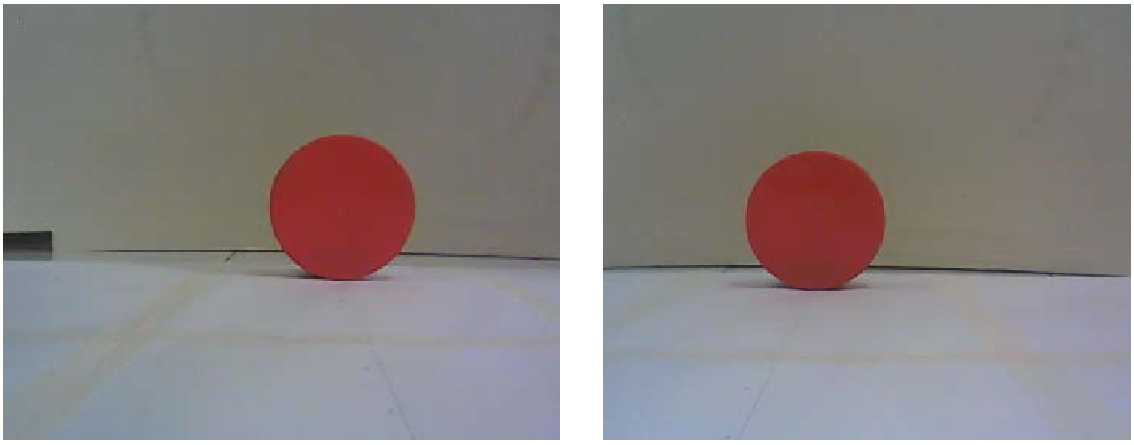
(a) (b)

Figure 4.20: Object detected at a 45cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.21: Object detected at a 47.5cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.22: Object detected at a 50cm from camera(a)Left side camera, and (b)Right side camera

Table 4.6: Area of detected object from right side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	22876.8
27.5	19111.1
30.0	15835.4
32.5	13500.8
35.0	11438.8
37.5	10011.7
40.0	8637.5
42.5	7563.0
45.0	6742.1
47.5	6037.4
50.0	5380.4

Table 4.7: Area of detected object from left side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	23477.8
27.5	19971.7
30.0	16035.7
32.5	13432.1
35.0	11516.3
37.5	10021.9
40.0	8686.2
42.5	7595.2
45.0	6810.8
47.5	6019.2
50.0	5405.6

Table 4.8: Average area of detected object from both side of cameras

Actual Distance(cm)	Average Area of the Detected Object
25.0	23177.3
27.5	19541.4
30.0	15935.5
32.5	13466.3
35.0	11477.5
37.5	10016.9
40.0	8661.9
42.5	7579.1
45.0	6776.5
47.5	6028.3
50.0	5393.0

Table 4.9: Comparison between actual distance and theoretical distance

Actual Distance(cm)	Theoretical Distance(cm)
25.0	25.0
27.5	27.3
30.0	30.2
32.5	32.6
35.0	35.0
37.5	37.3
40.0	39.9
42.5	42.6
45.0	45.1
47.5	47.7
50.0	49.8

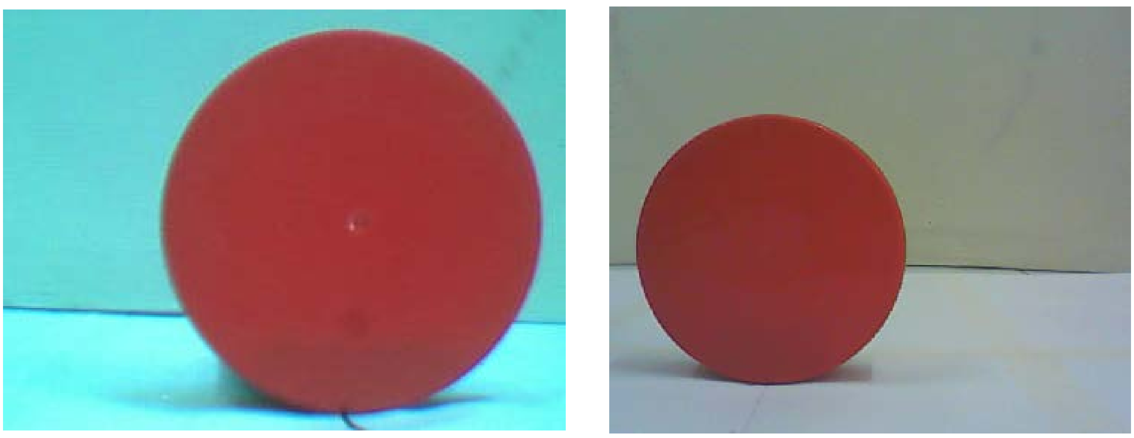
Table 4.10: Error distance calculation by using Equation 3.3

Actual Distance(cm)	Error Distance Calculation(%)
25.0	0.0
27.5	0.7
30.0	0.7
32.5	0.3
35.0	0.0
37.5	0.5
40.0	0.3
42.5	0.2
45.0	0.2
47.5	0.4
50.0	0.4

4.1.3 Experiment 3: Stereo Vision Technique Using Two Different Camera By Placing The Object In Between The Two Camera

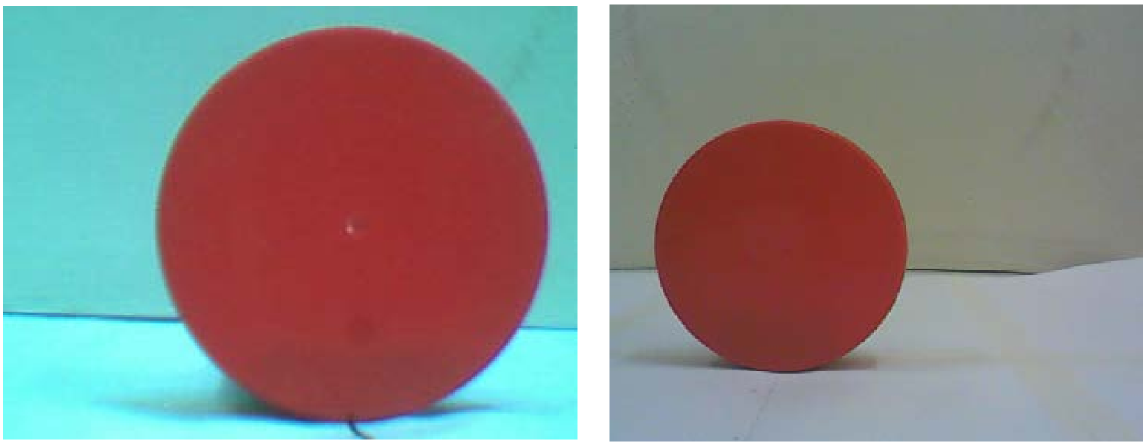
This experiment is conducted by using two different type of camera that has different resolution of video recording. The right side camera is a Logitech C270 3 Mega Pixel USB 2.0 HD Webcam, and the left side camera is a Standard USB Camera which have 5MP of picture capture. Although the left side camera has low quality of video recording, th data collected from this side of camera shows that it can detect more area of object compare to the right side camera. In other word, the right side camera collect the exact value of area of the object and more accurate. The procedure for this experiment is the same as Experiment 1 and 2. Figure 4.23 until Figure 4.32 are the picture show the object from both side of the camera which is presented side by side accordingly to the specific distance to compare the image presentation.

Table 4.11 shows the area of detected object from right side of the camera. Table 4.12 shows the area of the detected object from left side of the camera. Table 4.13 shows the average area of the detected object from both side of the cameras. Each of the area detected is tabulated accordingly to the specific distance that already being marked. Table 4.14 shows the comparison between the actual distance and theoritical distance. The theoretical distance is calculated by using the formula from Equation 3.2. Table 4.15 shows the error distance calculation by using Equation 3.3.



(a) (b)

Figure 4.23: Object detected at a 25cm from camera(a)Left side camera, and (b)Right side camera

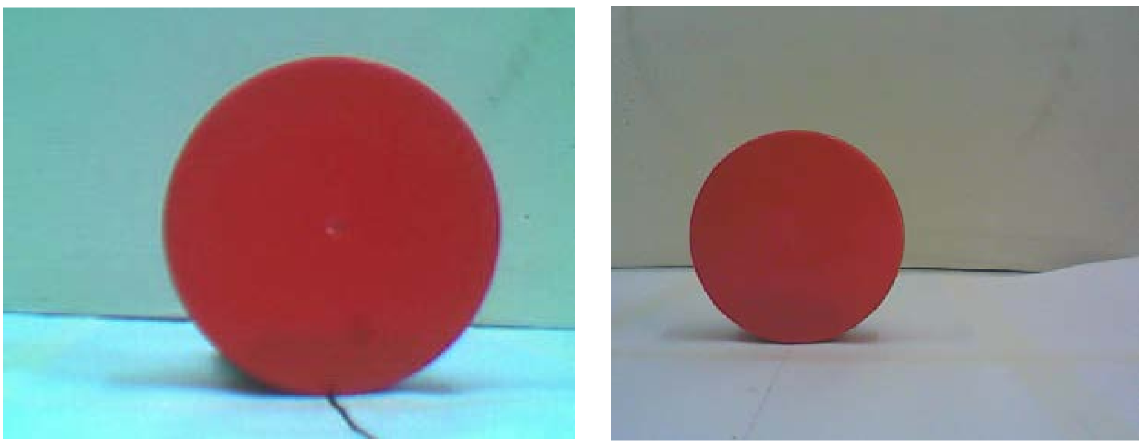


(a) (b)

Figure 4.24: Object detected at a 27.5cm from camera(a)Left side camera, and (b)Right side camera

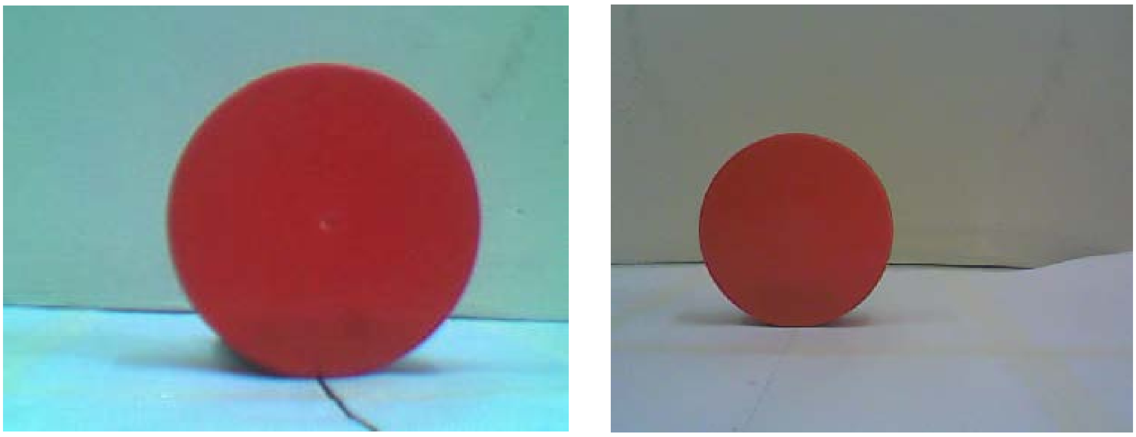
(a) (b)

Figure 4.25: Object detected at a 30cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.26: Object detected at a 32.5cm from camera(a)Left side camera, and (b)Right side camera

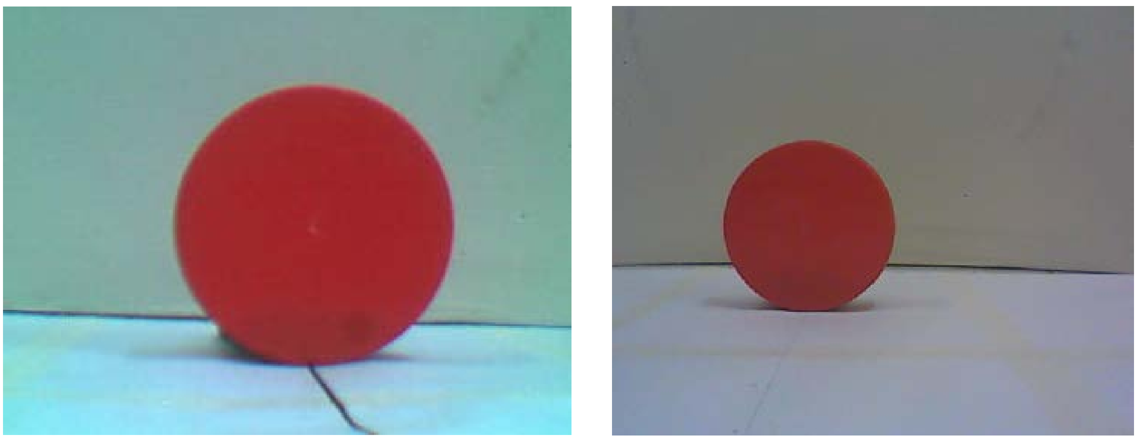


(a) (b)

Figure 4.27: Object detected at a 35cm from camera(a)Left side camera, and (b)Right side camera

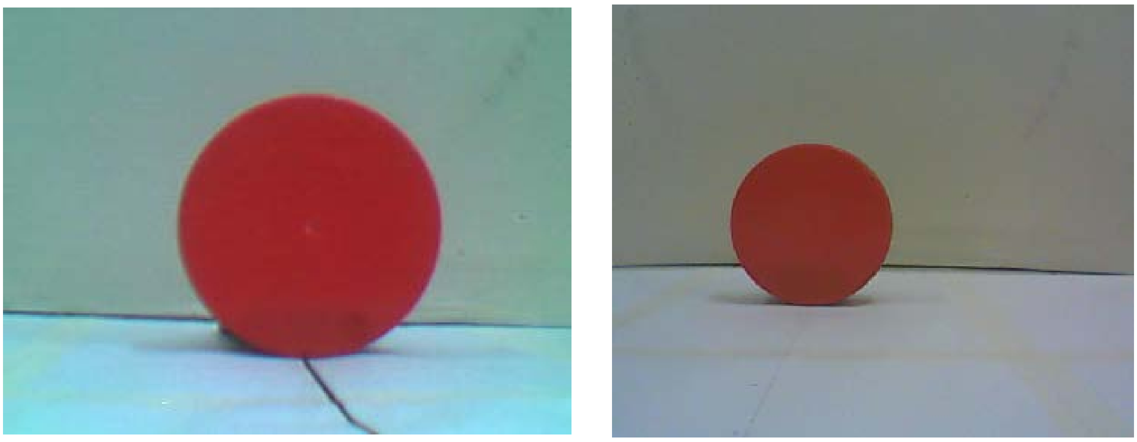
(a) (b)

Figure 4.28: Object detected at a 37.5cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.29: Object detected at a 40cm from camera(a)Left side camera, and (b)Right side camera

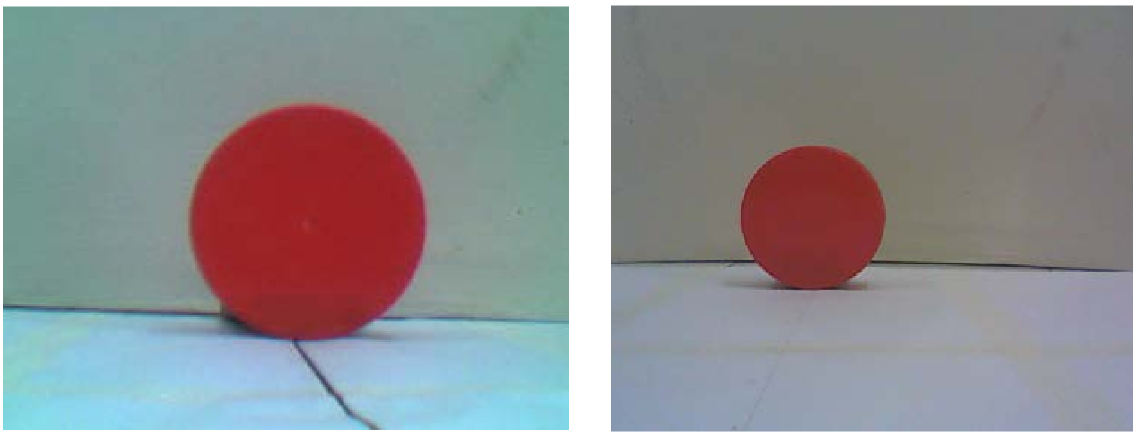


(a) (b)

Figure 4.30: Object detected at a 42.5cm from camera(a)Left side camera, and (b)Right side camera

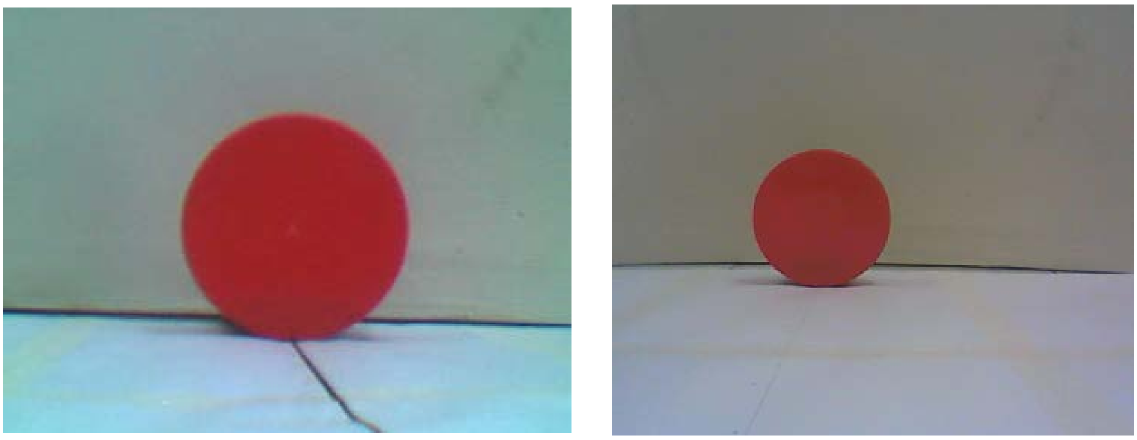
(a) (b)

Figure 4.31: Object detected at a 45cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.32: Object detected at a 47.5cm from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.33: Object detected at a 50cm from camera(a)Left side camera, and (b)Right side camera

Table 4.11: Area of detected object from right side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	22886.2
27.5	19120.6
30.0	15845.5
32.5	13560.5
35.0	11440.2
37.5	10015.5
40.0	8650.8
42.5	7570.2
45.0	6755.6
47.5	6045.5
50.0	5377.2

Table 4.12: Area of detected object from left side of camera

Actual Distance(cm)	Area of the Detected Object
25.0	35448.0
27.5	33753.5
30.0	28023.3
32.5	23992.7
35.0	21275.5
37.5	18475.5
40.0	16486.4
42.5	14667.2
45.0	13086.8
47.5	11805.6
50.0	10664.2

Table 4.13: Average area of detected object from both side of cameras

Actual Distance(cm)	Average Area of the Detected Object
25.0	29167.1
27.5	26437.1
30.0	21934.4
32.5	18776.6
35.0	16357.9
37.5	14245.5
40.0	12568.6
42.5	11118.7
45.0	9921.2
47.5	8925.6
50.0	8020.7

Table 4.14: Comparison between actual distance and theoretical distance

Actual Distance(cm)	Theoretical Distance(cm)
25.0	21.9
27.5	23.3
30.0	25.8
32.5	27.9
35.0	29.8
37.5	31.8
40.0	33.6
42.5	35.5
45.0	37.4
47.5	39.3
50.0	41.4

Table 4.15: Error distance calculation by using Equation 3.3

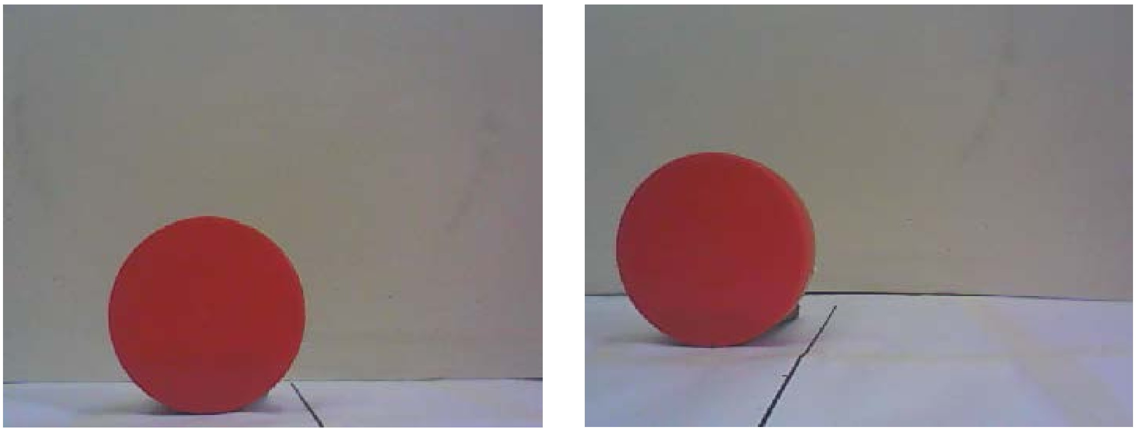
Actual Distance(cm)	Error Distance Calculation(%)
25.0	12.4
27.5	15.3
30.0	14.0
32.5	14.2
35.0	14.9
37.5	15.2
40.0	16.0
42.5	16.5
45.0	16.9
47.5	17.3
50.0	17.2

4.1.4 Experiment 4: Stereo Vision Technique Using Two Identical Camera By Placing The Object Randomly In Between The Two Camera

Experiment 4 is conducted in order to find the random distance of the object. Both of the camera used is the same type which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam. The object is placed in random distance and the theoritical distance is calculated. The actual distance is 34cm for Random 1, 39cm for Random 2, and 37cm for Random 3. Figure 4.34, 4.35, and 4.36 are the picture show the object from both side of the camera which is presented side by side accordingly to the Random distance to compare the image presentation.

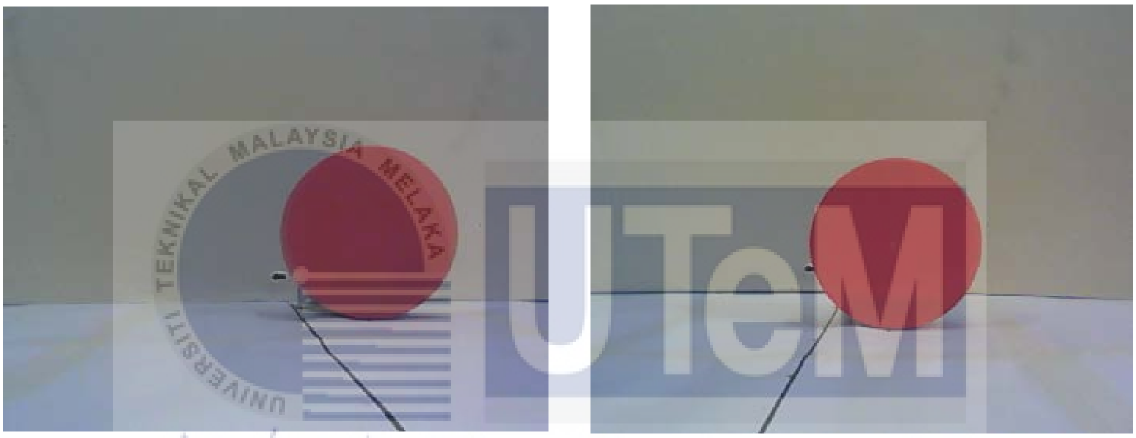
Table 4.16 shows the area of detected object from right side of the camera. Table 4.17 shows the area of the detected object from left side of the camera. Table 4.18 shows the average area of the detected object from both side of the cameras. Each of the area detected is tabulated accordingly to the specific distance that already being marked. Table 4.19 shows the comparison between the actual distance and theoritical distance. The theoretical distance is calculated by using the formula from Equation 3.2. Table 4.20 shows the error distance calculation by using Equation 3.3.

This experiment is slightly different with other experiment because of the angle and orientation of the camera. In order to measure and locate the position of the object accurately, the angle and orientation of both camera must exactly at the same position and orientation. The stereo vision system is same with the human eye concept. When the angle orientation and angle of the camera is not at the same spot for both side, it will cause paralax error when to determine the position of the object. This error could give the invalid result for the discussion because either one of camera reading maybe could not read the exact data of the object detected.



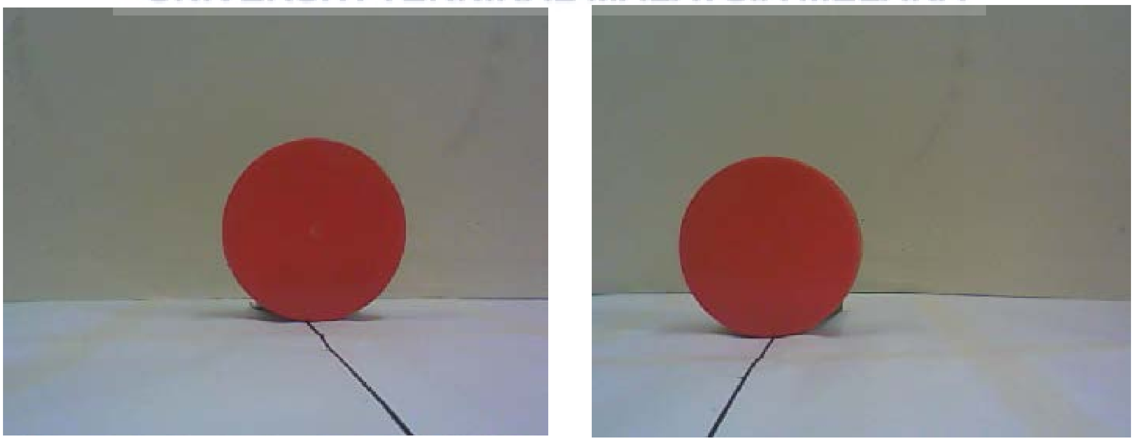
(a) (b)

Figure 4.34: Object detected at a random distance 1 from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.35: Object detected at a random distance 2 from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.36: Object detected at a random distance 3 from camera(a)Left side camera, and (b)Right side camera

Table 4.16: Area of detected object from right side of camera

Actual Distance(cm)	Area of the Detected Object
Random1	10444.0
Random 2	8110.0
Random 3	9325.0

Table 4.17: Area of detected object from left side of camera

Actual Distance(cm)	Area of the Detected Object
Random1	10947.0
Random 2	8116.0
Random 3	9309.0

Table 4.18: Average area of detected object from both side of cameras

Actual Distance(cm)	Average Area of the Detected Object
Random1	10695.5
Random 2	8113.0
Random 3	9317.0

Table 4.19: Comparison between actual distance and theoretical distance

Actual Distance(cm)	Theoretical Distance(cm)
Random1	36.2
Random 2	41.2
Random 3	38.5

Table 4.20: Error distance calculation by using Equation 3.3

Actual Distance(cm)	Error Distance Calculation(%)
Random1	6.5
Random 2	5.6
Random 3	4.1

4.1.5 Experiment 5: Stereo Vision Technique Using Two Different Camera By Placing The Object Randomly In Between The Two Camera

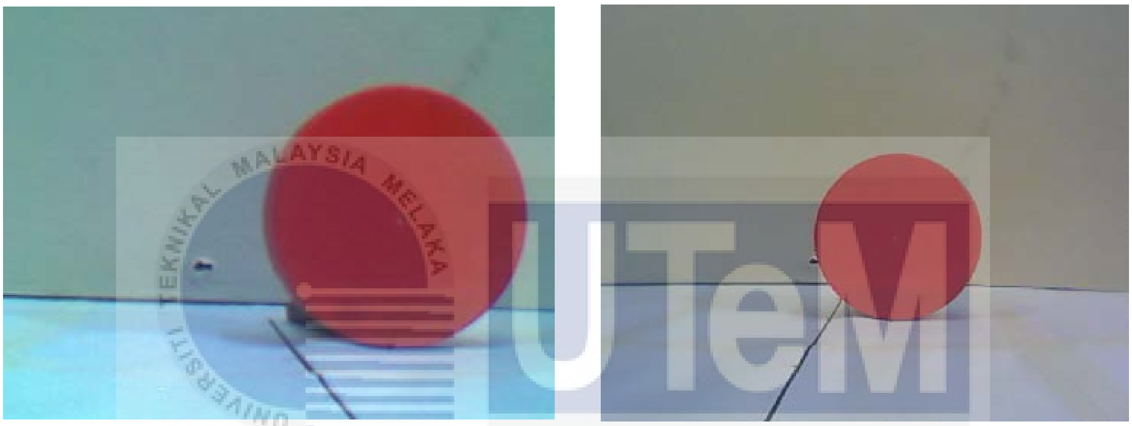
Experiment 5 is conducted in order to find the random distance of the object. Both of the camera used is the different type which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam for right side camera and Standard USB Camera 5MP for left side. The object is placed in random distance and the theoritical distance is calculated. The actual distance is 34cm for Random 1, 39cm for Random 2, and 37cm for Random 3. Figure 4.34, 4.35, and 4.36 are the picture show the object from both side of the camera which is presented side by side accordingly to the Random distance to compare the image presentation.

Table 4.16 shows the area of detected object from right side of the camera. Table 4.17 shows the area of the detected object from left side of the camera. Table 4.18 shows the average area of the detected object from both side of the cameras. Each of the area detected is tabulated accordingly to the specific distance that already being marked. Table 4.19 shows the comparison between the actual distance and theoretical distance. The theoritical distance is calculated by using the formula from Equation 3.2. Table 4.20 shows the error distance calculation by using Equation 3.3.

In this experiment, the different type of camera used is not recommended because each different type of camera resolution could not capture the exact number of picture of the object detected. This could give an invalid result for the distance measurement distance. This experiment is the example of the human eyes who have a different level of dim for both side of the eyes. This can be proved when a human closed one of his eyes to locate the exact position and distance of the object. When a human has a eyes dim disease, they have to wear a spectacles in order to balance the level of focusing the object.

(a) (b)

Figure 4.37: Object detected at a random distance 1 from camera(a)Left side camera, and (b)Right side camera



(a) (b)

Figure 4.38: Object detected at a random distance 2 from camera(a)Left side camera, and (b)Right side camera

(a) (b)

Figure 4.39: Object detected at a random distance 3 from camera(a)Left side camera, and (b)Right side camera

Table 4.21: Area of detected object from right side of camera

Actual Distance(cm)	Area of the Detected Object
Random1	10452.0
Random 2	8115.0
Random 3	9346.0

Table 4.22: Area of detected object from left side of camera

Actual Distance(cm)	Area of the Detected Object
Random1	22606.0
Random 2	15279.0
Random 3	17955.0

Table 4.23: Average area of detected object from both side of cameras

Actual Distance(cm)	Average Area of the Detected Object
Random1	16529.0
Random 2	11697.0
Random 3	13650.5

Table 4.24: Comparison between actual distance and theoretical distance

Actual Distance(cm)	Theoretical distance(cm)
Random1	29.7
Random 2	34.7
Random 3	32.4

Table 4.25: Error distance calculation by using Equation 3.3

Actual Distance(cm)	Error Distance Calculation(%)
Random1	12.6
Random 2	11.0
Random 3	12.4

4.2 Analysis Of Data For Stereo Vision Implementation Experiments

4.2.1 Experiment 1: Stereo Vision Technique Using Two Identical Camera Placed In Front Of The Object

From the experiment, the object is placed in front of the camera in order to test camera resolution when it detect full body of object at straight line. The use of Logitech C270 3 Mega Pixel USB 2.0 HD Webcam is actually very accurate because of it video recording resolution. By using this camera, it can detect the area of the object better than any other type of camera. Although it cost very expensive but the result is very impresive.

The data collected from this experiment is tabulated accordingly to the specific distance measured. The data from both side of the camera then is finalized as an average so that the experiment is conducted based on stereo vision technique. The average value is defined as the data from the third imaginary camera which located in between the two side of cameras. From the average area of the object detected, the theoretical distance can be calculated by using the Equation 3.2. The average area of the object detected is defined as variable 'y' and being substituted into the Equation 3.2. Then, the equation is solved by finding the root of variable 'x'. Although the equation is in cubic root, which mean it gives three answer, but there is only one absolute value for the theoritical distance. The value defined as the distance detected from both of the camera.

After all the theoretical distance is calculated, the Equaion 3.3 is used to calculated the error in distance measurement to test whether the Equation 3.2 is suitable to use as a distance measurement algorithm. The error of distance calculation is tabulated in Table 4.5. The results show that the highest error calculation is not more than 4.2% which indicates that the Equation 3.2 is accurate to measure the distance of the object.

4.2.2 Experiment 2: Stereo Vision Technique Using Two Identical Camera By Placing The Object In Between The Two Camera

Experiment 2 is about placing the object in between the two cameras but both the cameras is still detect full body of the object. If the object is not detected fully, then the result will not valid. The camera used in this experiment is same with Experiment 1 which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam. This experiment is the main objective of the project in order to test the validity of the Equation 3.2. In this experiment, the object is located in between the cameras. The average data from both camera is calculated and being tabulated in Table 4.8. The data from this table is used to calculate the theoritical distance of the object. The Equation 3.2 is used to obtain the theoretical distance of detected object and all theoretical distance is tabulated in Table 4.9.

This experiment is the most important in any other experiments conducted because it indicated the real world distance measurement system by using stereo vision technique. It is exactly as the implementation of the human eyes. A human need both of the eyes to locate and measure the distance of the object accurately. If one of the eyes is not functioning well, it will result a parallax error in order to estimate the actual distance of the object. The average area of object detected is known as the data collected from the third imaginary camera which located in between both side of the cameras. The experiment procedure is very important to be explained clearly in order to reduce technical error when conducting the experiment.

The error distance calculation is done by using Equation 3.3. The error of distance is tabulated in Table 4.10 to verify the validity of Equation 3.2 for distance measurement. From the result of error calculation, the theoritical distance calculated in this experiment is very accurate because of the error distance calculation is not more than 0.7%. This proved that the Equation 3.2 is very accurate for distance measurement system by using stereo vision technique.

4.2.3 Experiment 3: Stereo Vision Technique Using Two Different Camera By Placing The Object In Between The Two Camera

Experiment 3 is different from Experiment 1 and 2. This is because this experiment used two different type of camera which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam for right side camera and Standard USB Camera 5MP for left side camera. The area of object detected for both of the camera is already tabulated in Table 4.11 and 4.12. The area detected from left side camera is different from right side of camera because of the different camera video recording resolution.

The area detected from left side camera is bigger than right side camera. This is because of different pixel detected from different type of camera resolution. The used of different type camera resolution effected the area of detected object. In this experiment, the average from both side camera is slightly different from the Experiment 1 and 2 because of area of detected object from left side and left side camera is different. Table 4.13 shows the average area of detected object from both side of cameras.

Table 4.14 is a comparison between actual distance and theoretical distance that already being calculated by using Equation 3.2. The actual and theoretical distance in this experiment is not in close range because of different type of camera resolution used. The error of distance calculation is already being calculated and tabulated in Table 4.15. This experiment main purpose is to investigate whether the different type of camera resolution used will effected the error distance calculation. The smallest error of distance measurement calculation is 12.4% and the biggest error of distance measurement calculation is 17.3%. This result proved that different type of camera resolution used affect the area of detected object.

4.2.4 Experiment 4: Stereo Vision Technique Using Two Identical Camera By Placing The Object Randomly In Between The Two Camera

Experiment 4 is conducted for random object distance detection. Three random distance is chose as actual distance which are 34cm, 39cm and 37cm. The object is placed at this distance randomly in between both side of camera. This experiment used same type of camera which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam. The average area of object detected is calculated from both side of camera in order to make it as a reading from the third imaginary camera. Table 4.19 shows the actual and theoretical distance from the data gained from average area of detected object. The theoretical distance is calculated by using Equation 3.2 and error of distance measurement is calculated by using Equation 3.3 and being tabulated in Table 4.20. From the error distance calculation result, the error percentage is in between 4.1% and 6.5%. This error occured when there is a displaced of camera position when conducting the experiment. As a precaution, both side of camera location must be fixed and do not have any movement that can effect the reading of the data.

4.2.5 Experiment 5: Stereo Vision Technique Using Two Different Camera By Placing The Object Randomly In Between The Two Camera

Experiment 5 is same with the Experiment 4 in procedure, but the difference is the type of camera used. This experiment used two different type of camera which is Logitech C270 3 Mega Pixel USB 2.0 HD Webcam for right side camera and Standard USB Camera 5MP for left side camera. In this experiment. both side of camera collected different range of data because of the different type of camera resolution used. Experiment 5 has similarity in reading value with Experiment 3 because both used different type of camera resolution. Table 4.25 shows the result of error distance calculation percentage. In this result, the highest error percentage is 12.6% and the lowest error percentage is 11.0%. This error is quite large for distance measurement system. In order to decrease the error distance measurement percentage, the same type of camera resolution must be used to obtain same reading range.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

From the study of the previous chapter, a results from all experiment has already being discussed and analysis from the data has been analysed. The results obtained from the equation is accepted and can be used to measure the distance of specific object detection. In this chapter, the conclusion and recommendation of the project will be stated.

5.2 Conclusion

As a conclusion, the proposed equation for distance measurement system can be accepted as well it only provide a small percentage of error distance calculation. Based on the literature review that already being discussed in Chapter 2, a research for methodology is conducted in order to answer all the objectives stated in Chapter 1. From methodology proposed in Chapter 3, the Equation 3.2 is developed in order to measure the theoretical distance of the object. The Equation 3.2 provided an accurate calculation to obtain the value of theoretical distance. In other word, the result obtained from Equation 3.2 can be used in distance measurement system. The Equation 3.3 is used to calculate the validity of Equation 3.2 by calculating the percentage error. The data from experiments conducted is accepted as a stereo vision technique implementation. The data from the experiments is valid to used as a reference to develop a hardware design of automatic distance measurement portable device.

The analysis from the data is already being analysed and briefly explained the error of the experiments. In a nutshell, the Equation 3.2 and 3.3 is acceptable for distance measurement system. Based on the objectives that already stated in this study, all of the objective is already answered by proposing three different methodology. The Methodology 1 is already being conducted to answer Objective 1. The Methodology 2 is already being conducted to answer Objective 2. The Methodology 3 is already being conducted to answer Objective 3. In conclusion, all three objectives is achieved in this study. For the next section, the recommendation for the project will be explained in order to develop a portable device for automatic distance measurement system.

5.3 Recommendation

In the future study, the body design is going to be used to develope a hardware body by using a 3D printing. The design of the body is already done by designing it using a SolidWork software. The development of an automatic distance measurement device is based on the portable battery used to power up the device and the LCD is used to show the distance of the object detected.

5.3.1 Body Design of the Device

The design body of the device is basically like a pistol shape that has a button and two cameras on top of the device body. The function of the button is to power on the device and all the electronic components inside of the body of the device. Inside the device, a Raspberry Pi board is placed together with a multi camera adapter. The Raspberry Pi board is power on by using a portable powerbank baterry. Two camera is connected with the Raspberry Pi board by using a multi camera adapter. A two cameras is placed side to side on top of the device. The algorithm to produce a stereo camera will be develop. On top of the device body, an LCD is placed to show the distance of the object calculate by using distance measurement algorithm.

5.3.2 Specification of the body design

The body design of the device is drawn by using a SolidWorks software. Figure 5.1 shows the top view of the device from the SolidWorks drawing. Figure 5.2 shows the front view of the device from the SolidWorks drawing. Figure 5.3 shows the side view of the device from the SolidWorks drawing.

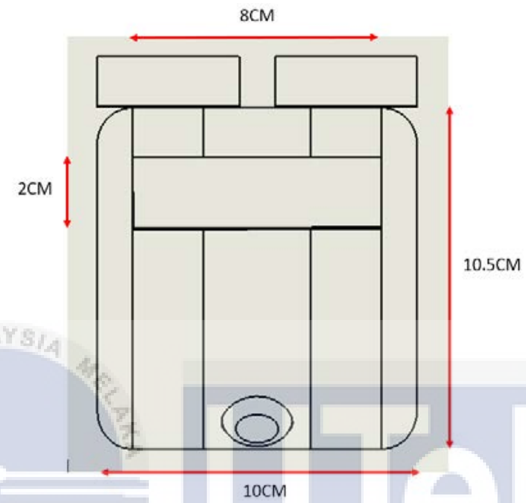


Figure 5.1: The top view of the body design of the device.

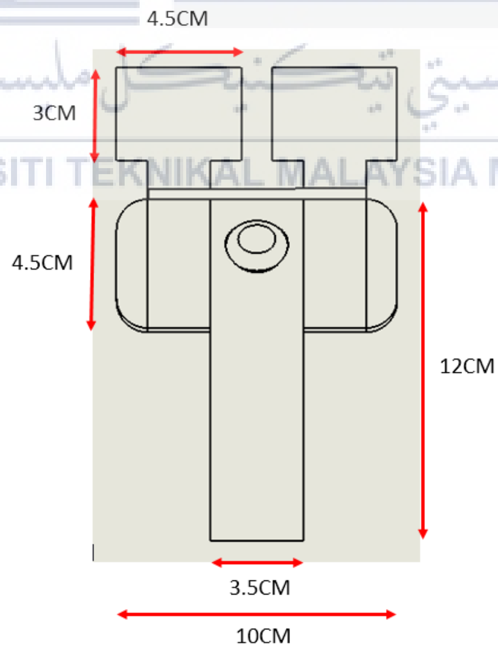


Figure 5.2: The front view of the body design of the device.

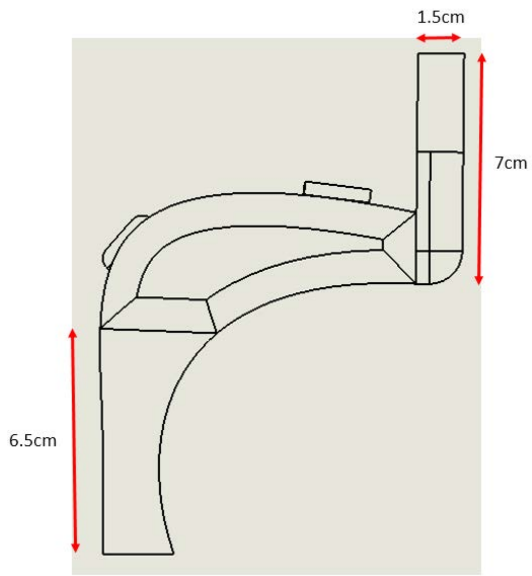


Figure 5.3: The side view of the body design of the device.

A few materials has been selected to develope a hardware body of the device. For the first part which is the handler, the material used is custom plastic. Custom plastic is chose because it benefit on its weight which is light and durable. Magnesium alloy is chose as the main body material because of its properties. Eventually, many DSLR cameras used magnesium alloy as the main body material because of its durable in extreme condition of weather. Stainless steel is chose to design the power button of the device to make it long lasting as the button will be pushed many time to capture the picture. Figure 5.4 shows the body design materials that is used to develope the body of the device. Figure 5.5, 5.6, and 5.7 shows the tables properties of material selected to develope the body of the device.

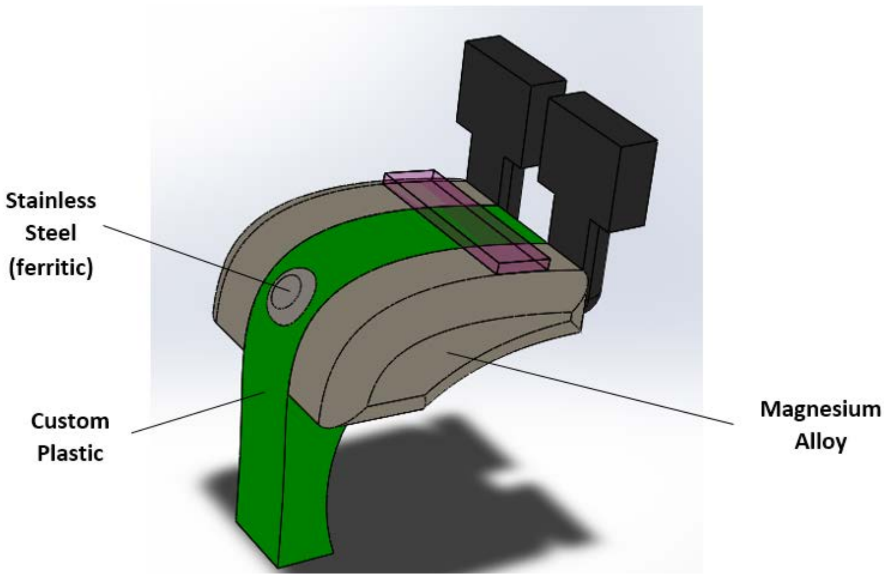


Figure 5.4: Body design materials.

MATERIAL PROPERTY	VALUE	UNITS
Elastic Modulus	2000	N/mm^2
Shear Modulus	318.9	N/mm^2
Mass Density	1020	kg/m^3
Tensile Strength	30	N/mm^2

Figure 5.5: The plastic properties for handler.

MATERIAL PROPERTY	VALUE	UNITS
Elastic Modulus	45000	N/mm^2
Shear Modulus	17000	N/mm^2
Mass Density	1700	kg/m^3
Tensile Strength	NA	N/mm^2

Figure 5.6: The magnesium alloy properties for main body of the device

MATERIAL PROPERTY	VALUE	UNITS
Elastic Modulus	200000	N/mm^2
Shear Modulus	77000	N/mm^2
Mass Density	7800	kg/m^3
Tensile Strength	513.614	N/mm^2

Figure 5.7: The stainless steel (ferritic) for power button.

5.4 Summary of the thesis

Chapter 1 explained the introduction of this research project, Chapter 2 is about the literature review from the jurnal and conference about the topics that related to thus research project, Chapter 3 is a proposed methodology that are going to be used in the future study of this research project, and Chapter 4 is about the result that explained the data analysis from the experiments conducted.

In Chapter 1, the motivation, problem statement, objectives, and scopes of the project is being stated to briefly introduce the introduction of the research project. In Chapter 2, the literature review is explained by focusing a discussion about the main topic or subject that related to this research project. In Chapter 3, the proposed methodology is already explained by using a stereo camera system as the main role on capturing the image. The image is detected by using a proposed image detection method. In Chapter 4, the experiments data and analysis, and colour and shape based simulation using a stereo camera technique is simulated by using an OpenCV software and Raspberry Pi board.

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APPENDICES

APPENDIX A

UML DIAGRAMS

Gantt chart for Final Year Project 1.

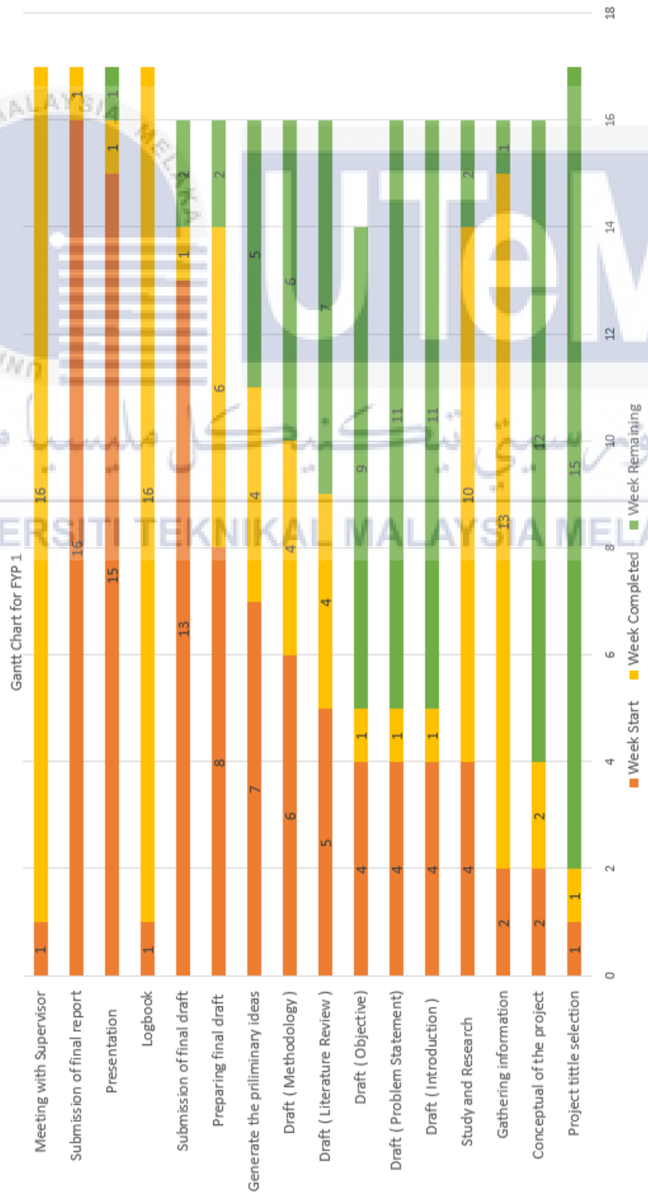

Figure A.1: The Gantt Chart for the Final Year Project 1

Gantt chart for Final Year Project 2.

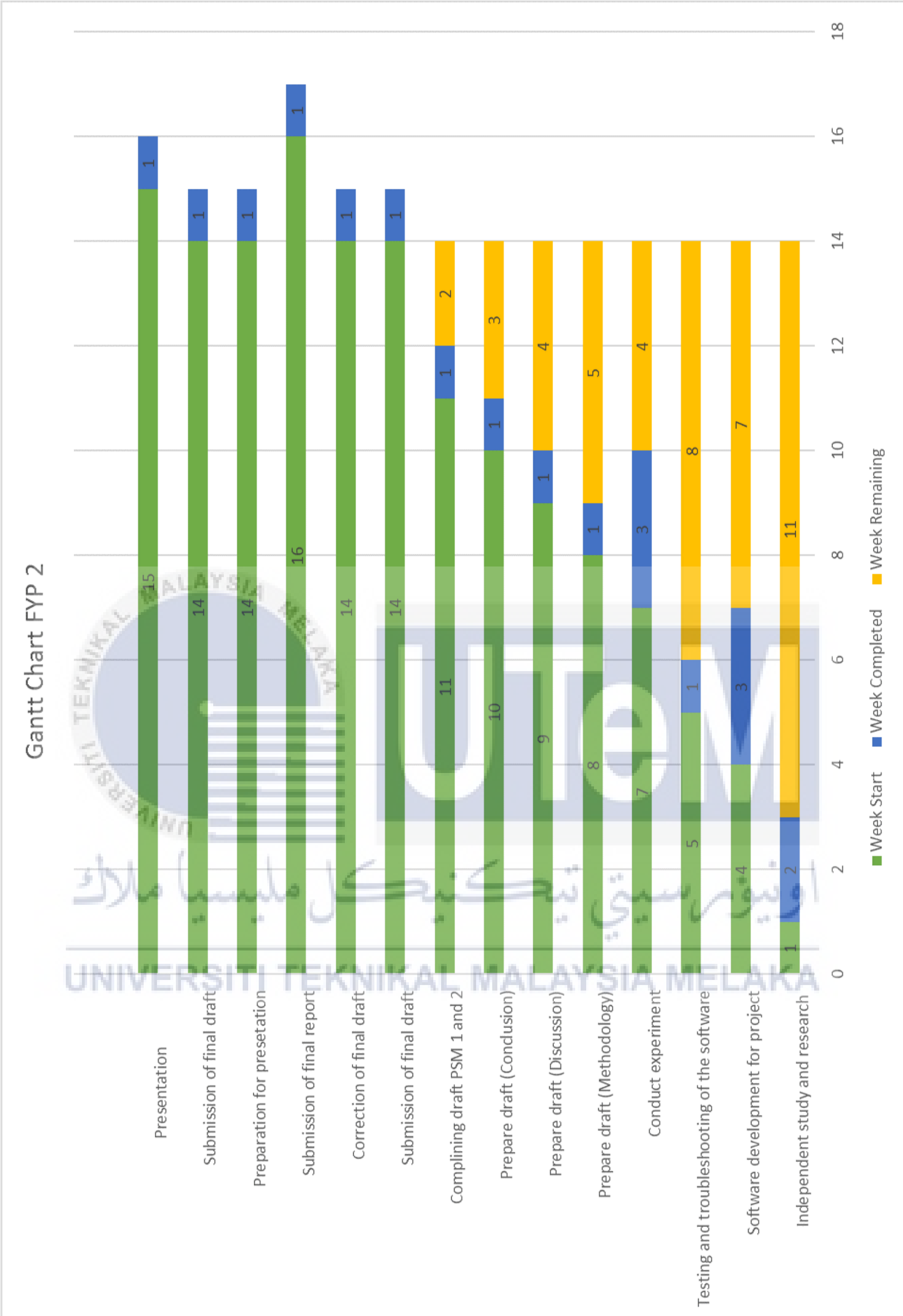

Figure A.2: The Gantt Chart for the Final Year Project 2

Code for Colour And Shape Based Detection

```
import cv2.cv as cv
import cv2 as cv2
import time
import numpy as np
import RPi.GPIO as gpio



Hmin = 0
Hmax = 179
Smin = 131
Smax = 255
Vmin = 100
Vmax = 235


rangeMin = np.array([Hmin, Smin, Vmin], np.uint8)
rangeMax = np.array([Hmax, Smax, Vmax], np.uint8)

minArea = 50


cv.NamedWindow("Entrada")
cv.NamedWindow("HSV")
cv.NamedWindow("Thre")
cv.NamedWindow("Erosao")


capture = cv2.VideoCapture(0)

width = 520
height = 520


if capture.isOpened():
  capture.set(cv2.cv.CV_CAP_PROP_FRAME_WIDTH, width)
  capture.set(cv2.cv.CV_CAP_PROP_FRAME_HEIGHT, height)

while True:
    ret, entrada = capture.read()
    imgHSV = cv2.cvtColor(entrada,cv2.cv.CV_BGR2HSV)
    imgThresh = cv2.inRange(imgHSV, rangeMin, rangeMax)
    imgErode = cv2.erode(imgThresh, None, iterations = 3)
    moments = cv2.moments(imgErode, True)
    area = moments['m00']
    if moments['m00'] >= minArea:
       x = moments['m10'] / moments['m00']
       y = moments['m01'] / moments['m00']
       print(area)
       Pixel(area)

    else:
        Stop()

    cv2.imshow("Entrada",entrada)
    cv2.imshow("HSV", imgHSV)
    cv2.imshow("Thre", imgThresh)
    cv2.imshow("Erosao", imgErode)



    if cv.WaitKey(10) == 27:
        break
cv.DestroyAllWindows()
gpio.cleanup()
```