COMPARISON OF MEASUREMENT ERROR BETWEEN SD AND HD WEBCAM IN A VISION SYSTEM

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BACHELOR OF ELECTRONIC ENGINEERING TECHNOLOGY (TELECOMMUNICATIONS) WITH HONOURS

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Faculty of Electrical and Electronic Engineering Technology

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Bachelor of Electronic Engineering Technology (Telecommunications) with Honours

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A project report submitted
in fulfillment of the requirements for the degree of
Bachelor of Electronic Engineering Technology (Telecommunications)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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2021

DECLARATION

I declare that this project entitled "Comparison of Measurement Error Between SD and HD Webcam in a Vision System" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Nurusolihah binti Zamri

Date : 13.02.2021

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronic Engineering Technology (Telecommunications)

Signature : ....

Supervisor Name : Ts. Khairul Anuar bin A Rahman ....

Date : ....

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DEDICATION

To my beloved parents and family for their love and encouragement.

To my kind lecturers for the fast four years of guidance.

Finally, to all my friends their backing and friendship over the years.

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ABSTRACT

Webcam has been used widely throughout these days especially in healthcare, video monitoring and security and more. In the industry sector, uses of the webcam are significant especially for the inspection system in measuring objects. It is important to ensure that the quality of product releases in good specification before reach the market. There are few features that must be have in the webcam in defecting the measurement error of the object. In this study, the comparison of SD and HD webcam will be made to determine which webcam is suitable to be used for measurement of object in a vision system. In order to identify the accuracy of the measurement error between SD and HD webcam, the focal length will be change from 8 cm to 10 cm with 0.5 mm increment. The coding will be tested first using the MATLAB software before running the simulation. These webcams then will capturing the object in getting the dimension of height and width. At the end of the experiment, the result of measurement error for both webcams will be compared so that the best webcam can be determined to be used in measurement error in a vision system.

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ABSTRAK

Kamera web telah digunakan secara meluas selama ini terutamanya dalam bidang kesihatan, pemantauan dan keselamatan video dan banyak lagi. Dalam sektor industri, penggunaan kamera web sangat penting terutama untuk sistem pemeriksaan dalam mengukur objek. Ini adalah penting untuk memastikan bahawa kualiti produk yang dihasilkan dengan spesifikasi yang baik sebelum ke luar pasaran. Terdapat beberapa ciri yang mesti ada dalam kamera web bagi mencatatkan kesalahan pengukuran objek. Dalam kajian ini, perbandingan antara kamera web SD dan HD akan dibuat untuk menentukan kamera web yang sesuai digunakan untuk kesalahan pengukuran dalam sistem penglihatan. Untuk mengenal pasti ketepatan ralat pengukuran antara kamera web SD dan HD, panjang fokus akan berubah dari 8 cm menjadi 10 cm dengan kenaikan 0.5 mm. Pengekodan akan diuji terlebih dahulu dengan menggunakan perisisan MATLAB sebelum menjalankan simulasi. Kamera web ini kemudian akan mengambil gambar objek yang mahu diukur. Kamera web ini kemudian akan menangkap objek dalam mendapatkan dimensi tinggi dan lebar. Pada akhir eksperimen ini, hasil ralat pengukuran untuk kedua-dua kamera web akan dibandingkan untuk menentukan kamera web terbaik untuk digunakan dalam menentukan kesalahan pengukuran

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter provides an overview of using SD and HD webcam in determining the measurement error. The problem background and problem statement are described next. This is followed by the objective and the focuses of this research which involves the study of the comparison measurement error using SD and HD webcam in a vision system. Problem Statement

1.2 Background

Before the presence of the webcam, many different measuring for collecting measurements of objects were done by using direct manual measurement in which the correct measurements are obtained with tapes, calipers and protectors. Although these methods are simple and inexpensive, the measurement duration is long and a high level of subject-matter cooperation is required in order to obtain accurate measurements. Some measurements, such as those around the eyes are difficult to obtain due to the risk or irritation or injury to the subject, particularly when the subject is unaware of the need to remain. The recent developments in multi-processing hardware and webcam in a vision system have sparked the webcam imaging technology in designing and creating innovative webcam for a wide variety of applications especially to overcome the problems that faced in measuring the object. However, different type of webcams have their own special capabilities in imaging quality. The webcam that has best performance will produce better image quality that can be used in getting the measurement of the object.

1.3 Problem Statement

There are difficulties that we had to face especially when going to measure the dimension of the object by using the direct manual measurement. This is because it is not too accurate and will give the greater measurement error of the object when compared to the actual dimension object. SD and HD webcams had been used in this project in order to get the more accurate measurement error of object. These webcams will be connected with the MATLAB software in order to measure the dimension width and height of the object. The accuracy of the measurement error between these webcam also will be determined by changing the focal length. The standard percentage error that have to be achieved must be less than 5%. As the analysis had been made and the result obtained, the percentage error of object that measured by both webcams will be compared and determined which webcam has the most accurate to the actual dimension of the object.

1.4 Objectives

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The objective of this project is:

- To analyze the measurement error between SD and HD webcam by using the MATLAB software.
- To identify the accuracy of measurement error between SD and HD webcam by changing the focal length.

1.5 Project Scope

The scope of this project is to study the comparison of measurement error between SD and HD webcam in a vision system. Both SD and HD webcam will be connected to MATLAB software in order to get the value for dimension of width and height of the objects. In determining the accuracy of the webcam in measuring the object, the measurement data for each object has been collected repeatedly 5 times at different focal length which is from 8cm to 10cm with 0.5mm increment. The measurement data will be compared and analyzed based on the calculation average of the percentage error. All the significant measurement will be observed and compared towards the actual measurements as a reference.

1.6 Project Outline

There are five chapters that have been divided in this report. Chapter 1 is introduction is introduction element which explains the context of the project, research goals, problem statement in getting idea in this research and the scope of the project. Chapter 2 briefly explained about the literature review related to the measurement error between SD and HD webcam in a vision system. This literature review as the source to achieve project understanding from different sources, such as articles, journals and books. Chapter 3 described the method, project flow chart and the summary of project software that are used in this project. In chapter 4, it consists of the result and analysis of experiments performed. The last chapter concludes the project did and recommends improvement for the upcoming project.

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CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will describe about the prior works related to the research about the SD and HD webcam camera in the vision system. In this chapter, it will able to help in understanding more about SD and HD webcam camera by analyses the research that have been done from the previous researcher.

2.2 Introduction of Inspection System

Inspection is most commonly an activity of coordinated analysis or structured evaluation to ensure it complies with specific standards. It is a method of testing component parts during production line inspection. During inspection and testing, if the product does not fall within the acceptability region, it will be rejected and the production management will have to take corrective steps in order to ensure that the product produced complies further with specified requirements and specifications. Inspection and testing play important tools for manufacturing processes as they help to monitor quality, reduce production costs, reduce failure losses and assign reasons for manufacturing defective products. Both inspection and testing processes are conducted before, during and after the production of the product to make sure the product's quality level complies with the specifications. This important aspect of the manufacturing system is also labour-intensive and time-consuming, not to mention the unavoidable risks of human error and resulting tiredness.

(Shi et al., 2019) proposed the Stainless Steel Precision Blanking Sheet Contour Online Inspection System for the defect measurements. In this research, a new method of online contour defect inspection is proposed for stainless steel precision blanking sheet to resolve problems in using the current method for detecting information: the recognition system is complex and the defect dimension measurement error is high. The blanking sheet images are obtained via the developed image collection system. The results of the image analysis show that the blanking sheet defect contour has the properties of correspondence and similarity. An improved algorithm for the detection of sequential similarities and the measuring algorithm is being established. The measurement tests show that the online inspection method is stable and accurate, and 0.0362mm is the maximum measurement error. The findings of this analysis will lay the groundwork for online precision machining inspection.

(LI et al., 2019) have suggested a Precision Assessment of High-Speed Railway Slab Intelligent Inspection. There are several problems with conventional railway slab evaluation approach with the rapid development of high-speed railway. The conventional method is slow, and its accuracy is restricted by the accuracy of specified railway slab inspection. Since the accuracy assessment of these systems is based on railway slab testing tools that are complex for operation, this research aim a new method for evaluating the accuracy of an intelligent slab inspection system by using the spatial deviation between the point cloud of a benchmark slab and the corresponding position. The experimental results show that the device can match the slab point cloud with its corresponding digital 3D model based on the actual point cloud processed by an intelligent slab inspection system.

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In placing more emphasis, (Ding et al., 2016) studied about A Method of Plastic Gear Inspection Based on Machine Vision. In this study, they founded an easier way to detect the defect of plastic gear which is difficult to measure because of its small size. So, they used a method based on machine vision to inspect plastic gear accurately and quickly. The researchers had used a CCD camera to captures the digital images of plastic gear and then pre-processed the image to produce a single pixel edge of the gear. The number of the tooth, circular pitch and diameters of the addendum circle and root circle is determined based on this tip, which is the basis for checking whether the gear is fit. The experimental results show this approach meets on-line inspection requirements.

2.3 Introduction of Vision System

A vision system or machine vision system is the image-based inspection automated that can commonly be used for robot guidance, automated inspection which is mostly used in the industrial or manufacturing application. The vision system can be used for measuring and sorting parts at high speed, able to measure and verify parts in the correct position and also to recognize the shape of parts. The machine vision system mainly used for online inspection can perform mundane, complex and consistency at a high speed. The vision system had played a big role, especially in the industrial and manufacturing field because it combines various technologies especially the design of these systems which most of the companies would definitely use this technology in order to implement better quality control and also for security purposes. Any defects and failures in the manufacturing process are detected rapidly and transmitted to the proper personnel so that regulated changes can be made to reduce waste or scrap in the manufacturing process and minimize costly downtime.

(Widiasri et al., 2019) proposed Design and Research on Computer Vision System (CVS) to measure egg volume and mass accurately and precisely without damaging the egg. The disc method had been used in this research in order to calculate the volume of an object with a circular cross-section such as an egg. CVS is designed to measure the volume using the disc method and calculate the egg mass using density and regression models, based on images captured in real-time or images that have been captured previously. Based on the

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results, CVS is the best method in measuring the volume and mass of egg quickly, accurate and precisely without damaging the egg.

(Jridi & Alfalou, 2017) had investigated the Multi-CPU/FPGA SoC (System on Chip) design flow and to transfer know-how and skills to rapidly design embedded real-time vision system. They take the facial detection and pre-treatments as a case study to be designed by using the Xilinx Zedboard platform. The last is the core element of the vision system which has been developed. The video acquisition is carried out using either standard webcam connected to the Zedboard via USB interface or several camera IP devices. Visualization of video content and intermediate outcomes are possible with the HDMI interface connected to an HD display.

2.4 Webcam

In this project, there are 2 different webcam that being used which are Standard Definition (SD) webcam and High Definition (HD) webcam.

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2.4.1 Standard Definition (SD) Webcam

Standard Definition webcam or SD webcam is a portable digital camera that can be connect directly to the computer or built into the hardware in order to display video images in real time. It can captures light from a small front lens by using a small grid of microscopic light detectors, which is similar to the digital camera. Besides, a webcam's maximum resolution is lower compared to the most handled video cameras. This is because it will minimize the higher resolutions during the transmission occurred. The lower resolution in the webcam enables it to be relatively cheap than the other video cameras.

The webcam does not have a built-in memory chip or flash memory because it does not need to save the images, since it is programmed to record and send them to a device instantly. For this reason, webcams have the USB cables that coming out of the back which can support it to send the images or video directly to a device. The USB cable provides power from the device to the webcam and takes the visual information recorded by the webcam image sensor.

A research about Evaluation of 3D-distance Measurement Accuracy of Stereo-Vision Systems were proposed by (Sophian et al., 2017). In this paper, a method of accuracy measurement of two stereo-vision systems was presented using a coordinate measuring machine (CMM) and a reference base. The results were also presented for systems using infrared cameras and webcams. After a calibration method, the two systems were used to evaluate the reference block measurements. The results indicate that the two system could be tested. The evaluation results show that the webcams are more reliable and precise, the leap motion controller can be used when a shorter measurement distance are needed.

Over the years, the robotics industry has continuously evolved at an exceptional pace. Now a days, there are robots that being used in agriculture or farming. An example of a robotic invention used in the farming sector is a fruit harvester or fruit picker. The research about Autonomous Fruit Harvester with Machine Vision has been made by (Almendral et al., 2018). In this research, an autonomous fruit harvester with a machine vision is being presented in detecting and picking or cutting an orange fruit from a tree. This system consists of a robotic arm with six degrees of freedom (6-DOF) mounted on a four-wheeled electric kart. The kart uses a ZED stereo camera to estimate a target’s range. The kart will stops when it is less than 65 cm to the tree and the robotic arm device will take over to check for and harvest orange fruits. This robotic arm is connected to its end- effector by a webcam and an ultrasonic sensor. The webcam is used to track orange fruits while the ultrasonic sensor provides feedback on the distance from the orange to the end- effector. As the result, the success rate of putting fruit into basket and harvesting is 85% and 80% respectively.

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Other than agriculture and farming, we can see that technologies of webcams also widely been used in the medical sector. Camera and imaging technologies have clearly advanced significantly in the last few decades and are now being used in many areas of the healthcare sector (e.g MRI scans and laparoscopic surgeries). Furthermore, the uses of webcams for telemedicine treatment has been used increasingly in our country. By using the telemedicine apps, patients does not have to wait for an appointment because they can be diagnosed by using this apps. These examples show that how important of the webcam in improving the medical service to the patients.

(Rahman et al., 2016) introduced a Real Time Heart Rate Monitoring from Facial RGB Colour Video Using Webcam of a laptop computer. The heart rate is determined through alteration of the facial skin's colour caused by blood circulation. Three different methods of signal processing such as Fast Fourier Transform (FFT), Independent Component Analysis (ICA) and Principal Component Analysis (PCA) have been implemented in video recordings on the colour channels, and the blood volume pulse (BVP) is extracted from the facial regions. The obtained results show that there is a high degree of agreement between the proposed experiments and reference measurements.

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Other than that, the advance of medical technology led to the birth of many revolutionary machines and tools designed to improve our health, especially to disabled or gifted individuals. For some disabled people like quadriplegia, the human eye-ball not only act as a vision system, but also a way of communicating information to others people (T.A Izzuddin et.al., 2016) Hence, a gaze tracking algorithm using night vision camera has been made to overcome the problems for these disabled people. The aim for this project is to use image processing captured by webcam with its Infra-Red (IR) to achieve robustness. This helps the algorithm to monitor the iris' position without affect in its color and the pupil's. Two image processing algorithms are used, each with its own trade-off between speed and precision. Research on both algorithms shows good tracking performance in spite of the trade-off described.

2.4.2 High Definition (HD) Webcam

HD webcam is the camera that able to record 720p or 1080p of recording which will produce a clearer video compare to the non HD webcam. Basically, HD webcam is often use for game streaming, when working and to make a video conferencing and more. The usage of high-resolution webcam is more necessary because the lower the resolution, the grainier the picture appears on the screen. This is because it can produce good image quality and reasonable design that fair nature allowing it to work well at home or at the office.

Typically, the existence of surveillance systems had played a role in the monitoring and evaluation task of threat detection by video capturing and recording function. Video surveillance technology has speeded up in terms of development because of the enhanced video quality and the price is continually dropping. The security service could achieve much better efficiency by extracting the information from high-quality 3D images, rather than traditionally relied on 2D images. Thus, (Abu Hassan et al., 2017) had made research to overcome this problem. In their research, they used a low-cost 3D sensor webcam, Logitech HD Webcam C270. All cameras had been tested using two approaches to acquire their intrinsic and extrinsic parameters. The 3D model/image is reconstructed from a pair of two-dimensional (2D) images in order to stimulate the dimension projection in a 3D frame. An experiment was conducted to test the sensor’s accuracy in 3D distance measurement by measuring the distance between the sensor and the target object within a range of 1 to 5.5 meters. As the result, the stereo camera can able to estimate a good distance within an acceptable error range.

Besides, many researchers had used HD webcam in their researches to detect the grape bunch in vineyards. A photogrammetric algorithm for multiple-view stereo vision has

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been developed by (Herrero-Huerta et al., 2015) in the development of 3-D color dot sets, point clouds, for field vines. Convex hulls and solid models were then used to measure volume and weights for the bunch. The researchers reported that a coefficient of determination about 0.77 between their approximate values and the biological characteristics (volume, weight, and the number of berries) measured. Yet, their approach lacks an automated system for the grape detection. Then, (Klodt et al., 2015) had suggested another interesting approach, which the intermediate solution approaches 2-D and 3-D: pairs of images are used to construct complex depth maps used in grape classification. A 3-D dependent approach has been proposed in this study. A novel software had generated point clouds, which combining visual odometer and multi-view stereo components. These components will produce dense, accurate and metric 3-D models for field vines, by capturing images via a simple consumer grade HD webcam. This research can also be supported by similar research done by (Santos et al., 2017). The researchers used the HD low cost webcam in capturing images for 3-D vineyard phenotyping. They used a novel interactive integrated software and multi-view components to build dense and accurate 3- D point clouds for vines, properly converted to millimeter scale. The result for geometrical properties and colour of these points shows that 93% of the accuracy of the classification procedure was used points belonging to grapes found.

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2.5 Important Webcam Features

The choice of the webcam is significant for the virtual experience to be as similar to the actual in-person experience as possible. The quality of webcam part and optimisation can lead into overall quality of experience. There are a few webcam characteristic that must be take noted:

i. Megapixels

The megapixels are the tiny dots of color that make the resulting visual image when combined. Megapixels play an important role especially in capturing a high-quality image. The more megapixels in the webcam, the more vivid image will produce.

ii. Resolution

The resolution of webcam plays important role especially in producing the high quality image. The lower the resolution on the screen, the grainier the picture that would appears.

Figure 2.1 Example comparison of high resolution image and low resolution image

Figure 2.2 Example resolution of the image

iii. Frame Rate

The frame rate of the webcam will determine how smooth the quality of the video. It can controls how many images per second can be displayed. For a standard webcam, the 30fps (frames per second) is more suitable to be used.

Figure 2.3 Example image for 60fps and 30fps

iv. Lens Quality

One of the important features in choosing the webcam is the lens. Normally, a standard webcam has a plastic lens while the glass lens is mostly for professional video production. A webcam with a glass lens is much better compared to the plastic lens because it can produce greater image clarity and detail.

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2.6 Comparison of SD and HD Webcam

Table 2.1 Difference between SD and HD webcam

Standard Definition (SD) webcam	High Definition (HD) webcam
Limited normally to about 480 pixels lines per frame	Has the capability to support up to 1080 lines per frame
Low quality of image	Produce more quality of image

2.7 Advantage and Disadvantage of SD and HD webcam

Table 2.2 Advantages of SD and HD webcam

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Standard Definition (SD) webcam	High Definition (HD) webcam
Low cost and convenience	High resolution, sharp detail image
More easy to use	Reduce noise in the image

Table 2.3 Disadvantages of SD and HD webcam

Standard Definition (SD) webcam	High Definition (HD) webcam
Tiny sensor, small	High cost
Lower resolution camera translate to lower image dimensions in pixels	Large memory card required because the image dimension in pixels bigger
Can be used to film inappropriate/illegal videos	High resolution cameras require high-quality lenses capable of resolving a lot of detail.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter will contribute to the methodology and process of this project. This methodology involves the process used for the research in attaining the objectives and achieve the best result. It consists of the introduction of the experiment, the procedure of experiment and the project flow chart. This chapter is an important part before proceed to the next chapter which in finding and analyzing will be implemented.

3.2 Introduction

The methodology comprises the theoretical analysis of the set of methods and principles associated with a knowledge branch. The purpose of this chapter is to describe the activities that will be done in this study at every stage. For this project, it is present to make a comparison of SD and HD webcam for measurement error in a vision system. This project will focus on determining which webcam is more accurate to be use in measuring the error.

The flow chart for the process of this project has been attached to this chapter. The flow chart is very important to explain the detailed sequence of operations processes in the project. It is generally drawn in the early stages as a guide in achieving the good result of the experiment. Each step in the process is represented by the different symbols which include a short description of the steps in the process.

In addition, the concept design of the experiment will be discussed in this chapter too. It will cover the software and hardware development that will be used to accomplish the goal of this project. The aspect for each part in this step in important because it will be determined whether the result is successful at the end of the project.

3.3 Process of Project

The process of this project also includes finding the idea to create an appropriate title, identifying the objective and defining the statement problem, conducting research such as reading a journal about the HD and SD webcam in a vision system, finding the appropriate hardware and software to be applied in this project and make a discussion in report project.

Firstly, the research about the SD and HD webcam and explanations about the inspection system, vision system, and the characteristic of the quality webcam will be made in the literature review. After making a research in literature review, the design of experiment will be done. In this part, all the coding must be tested in the MATLAB software before can proceed to the next stage. If the coding tested is not success, it must be rebuild again. If success, the simulation will be connected to the webcam. The webcams that will used in this part are SD and HD webcam. These webcams will captured the image of the object that want to be measured. When capturing the object, the ring light will be attached together with the webcam in order to make sure that the image captured is more clearly. The measurement error of the object for both webcams will be compared and it accuracy will be analyzed by changing the focal length. From this result, we can determine which webcam has the most accurate measurement to the actual dimension of the object.

After getting the analysis of the result, a discussion about this project will be made. In this section, the implementation of the project about will be discussed detailed. The

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explanations about what the factor that affecting the result will be included. Besides, the suggestion on overcome the problems that were facing in experimenting also will be discussed in the report.

The last part is concluding the report. The recommendation for the further enhancement of the system will be included in this part. The limitation of this project will also discussed in this part.

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3.3.1 Flowchart Process

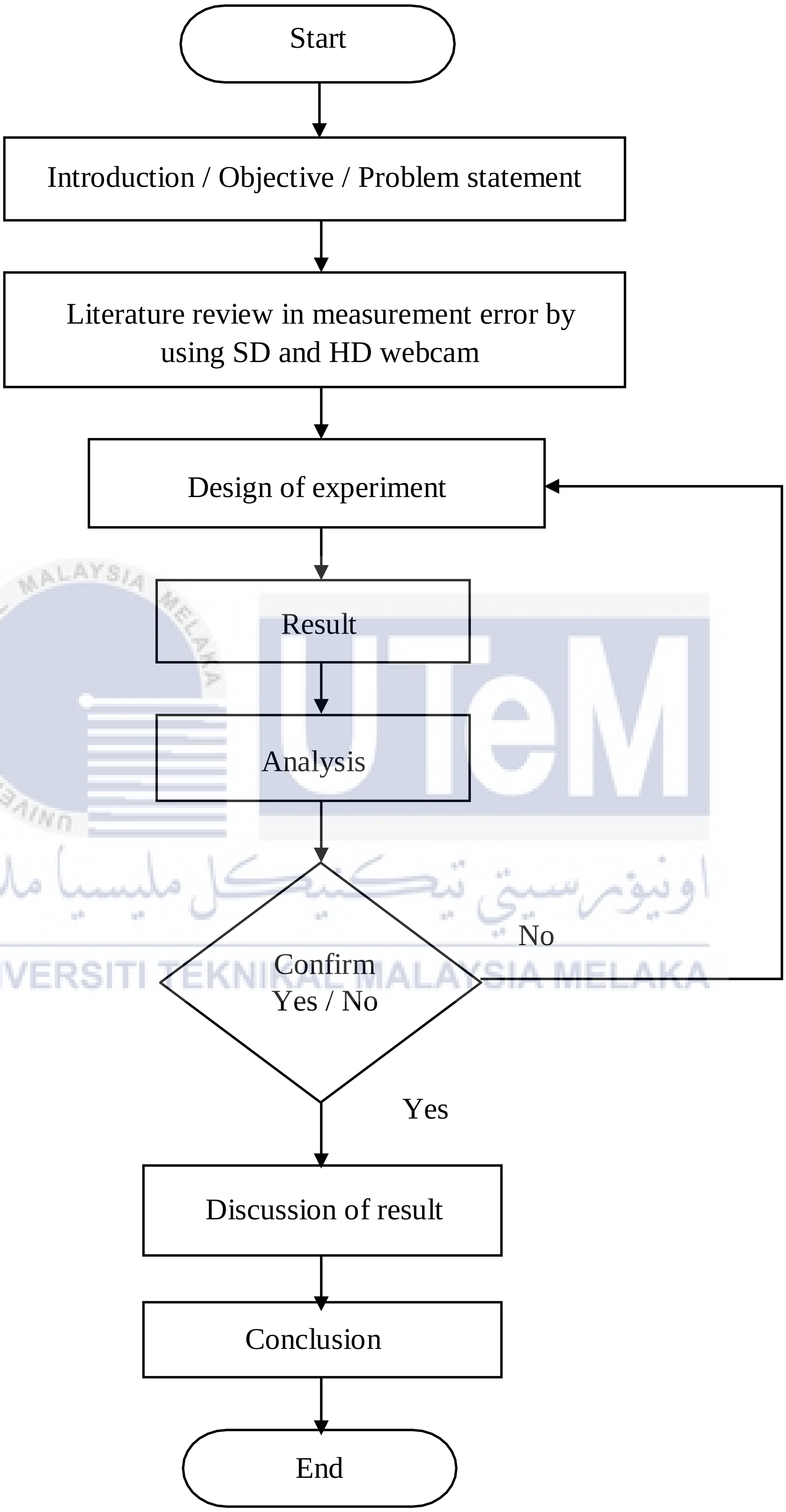

Figure 3.1 Flowchart of the project

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3.3.2 Flowchart of Process

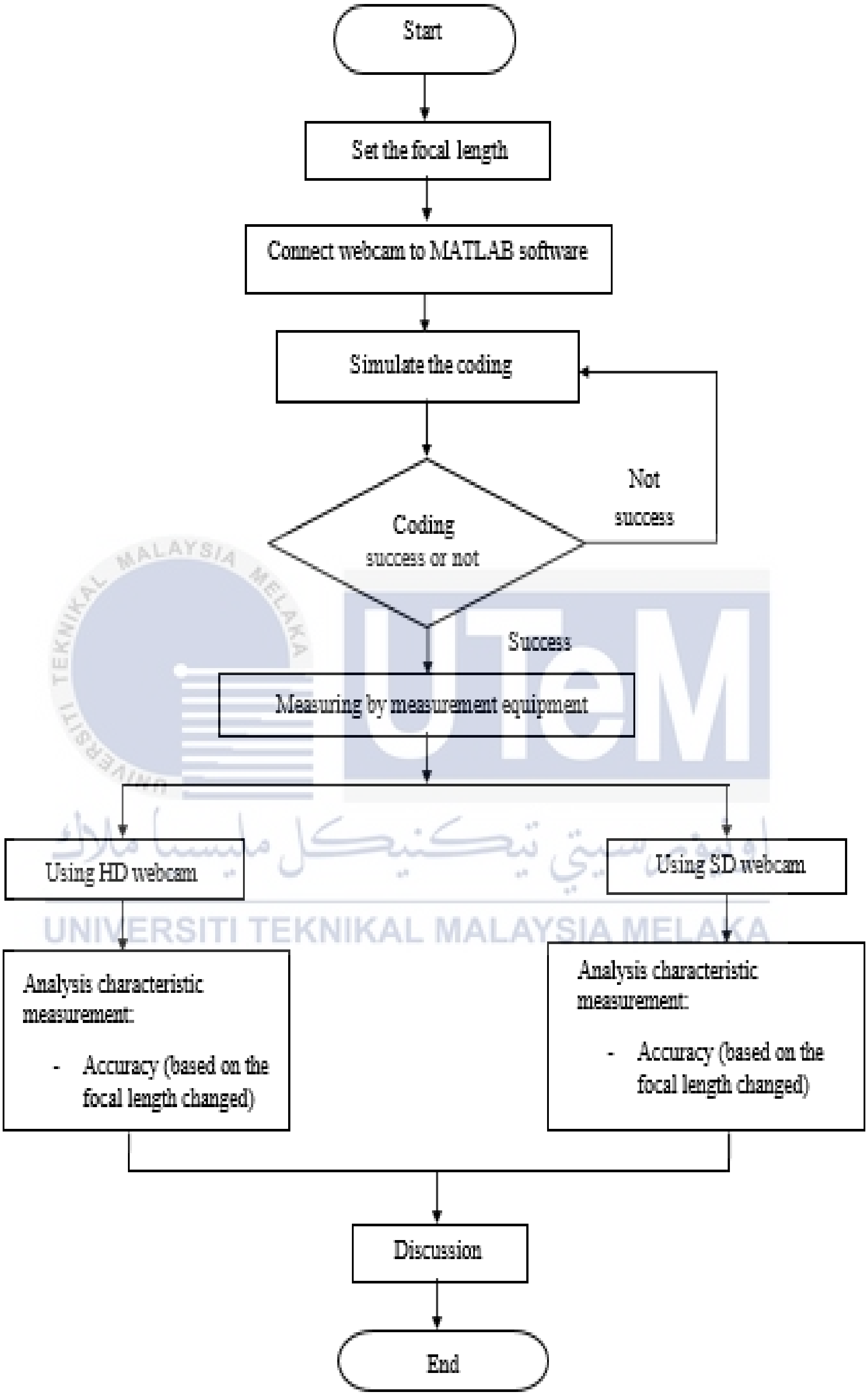

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Figure 3.2 Flowchart of Process

3.4 Implementation of the study

The comparison of using SD and HD webcam for measurement error in a vision system can be done by following the flowchart that has been designed. It is important to follow the step in the flowchart to obtain a successful result. By understanding the project title, the goal of this study can be achieved and the problem statement that needs to be answered in measured a product, it can help the student in more clearly understanding the basic of the study before proceeding it to the next chapter.

3.4.1 Image Acquisition

The first stage of any vision system is the image acquisition process. The aim of image acquisition is to produce an optical image into an array of numerical data that can be manipulated on a computer later before any processing of video or image can begin. Image acquisition can be achieved by a suitable webcam. In this study, the SD and HD webcam has been used in capturing the image of the object.

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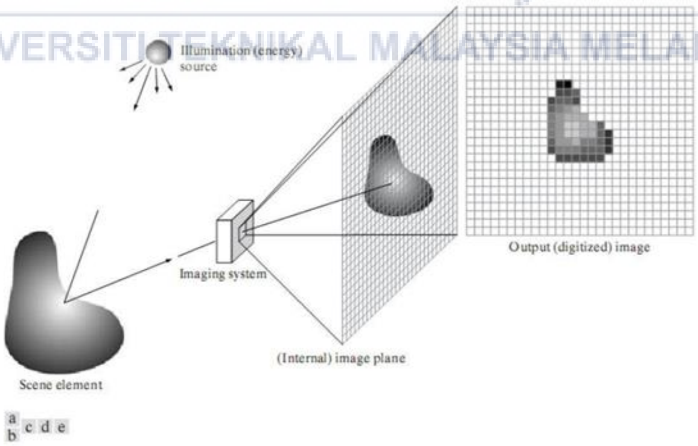

Figure 3.3 Example process of image acquisition

3.4.2 Algorithm Development

At this stage, the coding is used to determine the value of measurement error between SD and HD webcam based on accuracy and precision. To implement the coding, some article or journal will be used as a reference.

3.4.3 Testing and Simulation

Once the coding has been developed to determine the value of measurement error for the object, the simulation will be run to test the simulation in order to get the analysis for the result. The value of measurement error using SD and HD webcam will be analyzes based on accuracy and precision. From the result, it can be determined either one better to use for the measurement system.

3.4.4 Report

After getting the result and analysis of the project, the report will be written. The discussion of the result will be included in the report. In this section, the analysis of the measurement error of the object between SD and HD webcam will determine which webcam is the best to produce a good quality image.

3.5 Software Development

In this study, the software that will be used is MATLAB software. MATLAB software can be used for the measurement of the object which is required in this project.

3.5.1 MATLAB Software

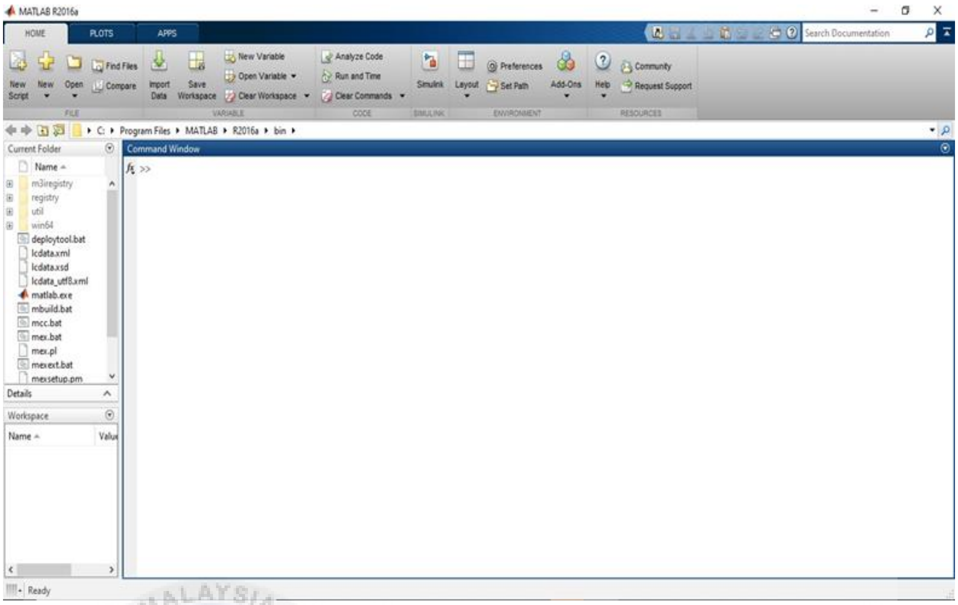

Figure 3.4 Main window in MATLAB

In this software, the coding will be inserted in order to determine the measurement of the object. Once the coding has been created in this software, the simulation will be run and the measurement of the object will be achieved.

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3.6 Hardware Development

This part briefly explained the webcam that will be used to capture the visual images of the object. For this study, there are two types of webcam that will be used which are SD webcam and HD webcam. The further uses of the webcams will be explained in this part.

3.6.1 SD Webcam

The SD webcam that will be used for this project is the CMOS image sensor, which is dominant for low-cost cameras. The maximum resolution ratio that can be reached by this webcam is 640 × 480 with frame rate 30 fps. Besides, the lens is rotatable, which can be adjusted 360 degrees left and right, and 30 degrees up and down.

Figure 3.5 SD Webcam

3.6.2 HD Webcam

HD webcam has been widely used nowadays because it has good quality for image and the price also reasonable. The HD webcam will used also CMOS type and has the digital image resolution 50 Megapixels. The webcam lens can be adjusted to get the sharpness of the picture.

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Figure 3.6 SD Webcam

3.7 Expected Result

The expected result from this experiment is to get the measurement of object by using the SD and HD webcam. By getting the result, the accuracy and precision of measurement error between these webcams can be analyze. From that, the best webcam can be determine which is good in terms of image resolution in the measurement error.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview

This chapter will explain the detailed analysis of the measurement error between SD and HD webcam by using the MATLAB software. The implementation of the simulation for this project also will be discussed more. In this section, more information will be implemented according to the strategy planned from the previous chapter in the flow and phase of development of this project. For this chapter, both webcams will be used to measure the dimension of size in 2- D size. The image is acquired in real-time from the webcam and the system will show the segmentation step by step. After getting the result, the measurement of the object will be analysed and compare in determining the accuracy of the measurement.

4.2 Project Execution

As a core method of doing the project, the implementations of the project function as an important indicator where the progress was carried out according to the plan in the previous chapters. Several steps must be taken before initiating this project, such as the faults and main points, and the possibilities upon this project must be defined.

4.3 Setup of Project

In order to start this project, the data measurement of object for contact measurement must be do first before proceed with the non-contact measurement which are SD and HD webcam. Then, this project will be proceed in making the preparation for the hardware setup. The webcam USB cable will be connect to the computer. The connection between the

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webcam and computer must be successful because if it does not linked properly, it will give the effect on the output result. Then, the MATLAB software is used to acquire the image of object and get the measurement in real-time. A code was created in MATLAB software in order to acquire the image and get the dimension for height and width. After the software setup completed, the webcam camera is attached to the ring light and it will be bend towards 90o. The webcam must be make sure to be placed in parallel towards the surface and must be in the centre of the ring light.

4.4 Measurement Tools

4.4.1 Ruler

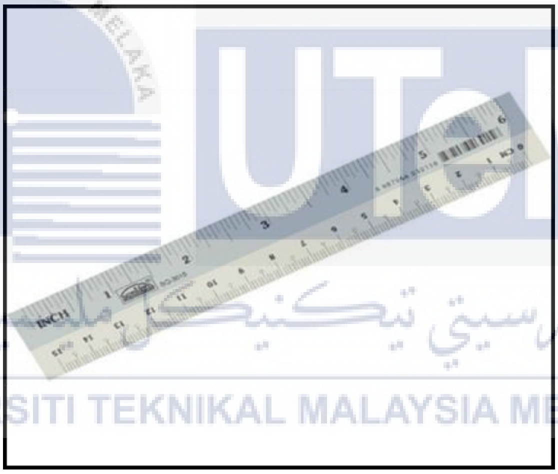

Figure 4.1 Ruler was used as the contact measurement tool

4.4.2 Vernier Calipers

For this project, the digital vernier calipers has been used in getting the measurement of the objects.

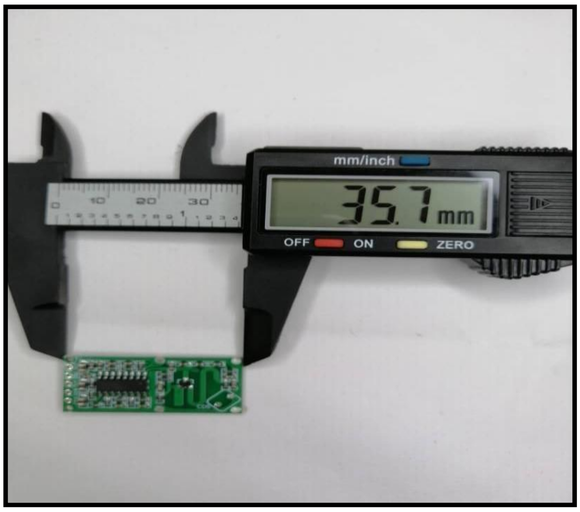

Figure 4.2 Vernier calipers was used as the contact measurement tool

4.4.3 SD Webcam

One of the non-contact measurement tools that has been used in this project is the SD webcam. This webcam offering the resolutions of 640 x 480 with the frame rate of 320 x 240 which can be up to 30 frame/sec.

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Figure 4.3 SD Webcam as the non-contact measurement method

4.4.4 HD Webcam

Figure 4.4 HD Webcam as the non-contact measurement method

4.5 Measurement of Objects

In this project, three objects had been chosen as the measurement tools in getting the measurement for each items. Table below shows detailed measurements of the objects:

Table 4.1 Specification size for objects that been used

Object	Specification size
20 cent coin	 **Width = Height = Diameter = 20.6 mm**

Microwave Radar-Human Motion Sensor AOVO6	 **Width = 35.9008 mm, Height = 17.3 mm**
GRV-Light Grove-Light Sensor v1.2 G2C02	 **Width = 23.7 mm, Height = 20.0 mm**

4.6 MATLAB Simulation

In this part, a detailed explanation of the coding and simulation will be discussed. SD and HD webcam will be connected to the laptop in getting the measurement of the object in real-time. The MATLAB software had been used to simulate the coding for this project. The object that wants to be measure will be put under the webcam, which has been attached to the ring light. The measurements of the objects will be recorded to analyse and compare in determining which webcam has a more accurate measurement.

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4.6.1 Coding

The webcam tools have been used for this project. Webcam tools are used to acquire images and videos from the webcam. The use of a webcam list is to recognize the camera's port. Each camera's port is different, and it is to determine which camera device wants to be used. The figure below shows that the webcam is in port 2, which is for the external webcam while port 1 is for the laptop webcam.

```
camList = webcamlist;

cam = webcam(2)
%preview(cam);
```

Figure 4.5 Webcam code in the MATLAB

Based on the simulation of the coding, the command window in MATLAB will show out the webcam properties based on the webcam that is connected with the laptop. This command window also shows the height and width measurement of the object in real-time. As we run the simulation, the webcam will detect the object that will be measured and gives the height and width of the object as shown in figure 4.7.

```
Command Window
cam =
  webcam with properties:

                    Name: 'USB2.0 PC CAMERA'
    AvailableResolutions: {'640x480'  '352x288'  '320x240'  '176x144'  '160x120'}
              Resolution: '640x480'
               Sharpness: 3
                Contrast: 148
              Brightness: 128
   BacklightCompensation: 1
                   Gamma: 4
                     Hue: 0
              Saturation: 90
```

Figure 4.6 Webcam properties in the command window

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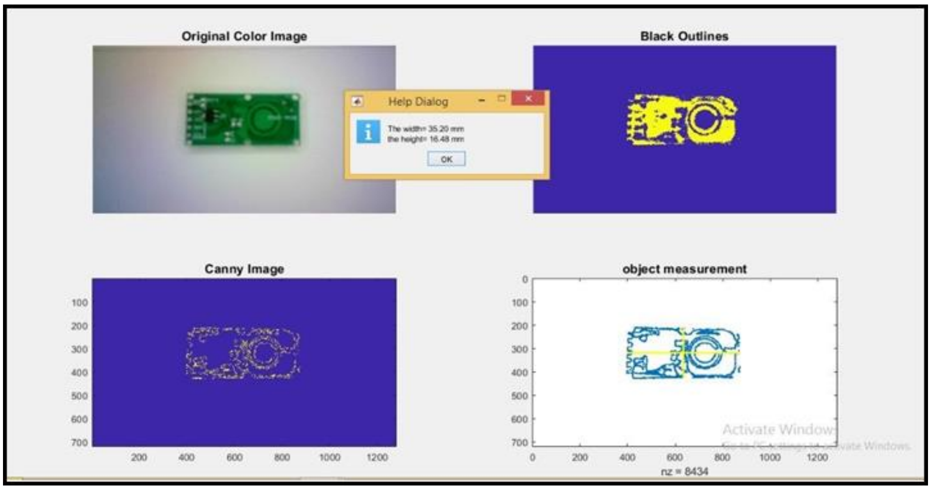

Figure 4.7 Example measurement of object

4.7 Project Analysis

In this part, the error of the contact and non-contact measurement that were obtain from the MATLAB software will be investigate. The measurement error for each objects will be calculated in percentage and compared with the actual data. The formula below shows the calculation for percentage error:

$$Error\ (\%) = \left(\frac{MATLAB\ measurement - Actual\ measurement}{Actual\ Measurement}\right) x\, 100$$

4.7.1 Data Measurement of Contact Measurement Method

In this part, ruler and digital vernier calliper had been used as a contact measurement tools in order to measure the width and height of objects. The data measurements for both contact measurement tools had been collected as much as 5 times.

4.7.1.1 20 cent coin

Table 4.2 Data of contact measurement for 20 cent coin

Actual size	Width = 20.6 mm, Height = 20.6 mm							
Measurement tools	Ruler				Vernier callipers			
Dimension of object	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
1	20.0	2.91	19.8	3.88	20.3	1.46	20.4	0.97
2	19.8	3.88	20.0	2.91	20.4	0.97	20.4	0.97
3	20.0	2.91	20.0	2.91	20.4	0.97	20.5	0.49
4	19.8	3.88	20.0	2.91	20.5	0.49	20.4	0.97
5	20.0	2.91	19.8	3.88	20.4	0.97	20.5	0.49
6	20.0	2.91	20.0	2.91	20.5	0.49	20.5	0.49
7	20.0	2.91	20.0	2.91	20.5	0.49	20.4	0.97
8	20.0	2.91	20.0	2.91	20.5	0.49	20.5	0.49
9	20.0	2.91	20.0	2.91	20.4	0.97	20.5	0.49
10	20.0	2.91	20.0	2.91	20.5	0.49	20.5	0.49

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4.7.1.2 Microwave Radar-Human Motion Sensor AOVO6

Table 4.3 Data of contact measurement for Microwave Radar-Human Motion Sensor AOVO6

Actual size	Width = 35.9008 mm, Height = 17.3 mm							
Measurement tools	Ruler				Vernier callipers			
Dimension of object	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
1	35.0	2.51	16.9	2.31	35.7	0.56	17.0	1.734
2	35.1	2.23	16.5	4.62	35.9	0.002	17.1	1.156
3	35.0	2.51	16.6	4.05	35.8	0.28	17.0	1.734
4	35.0	2.51	16.7	3.47	35.8	0.28	17.2	0.578
5	35.2	1.95	16.7	3.47	35.9	0.002	17.2	0.578
6	35.0	2.51	16.8	2.89	35.9	0.002	17.3	0
7	35.1	2.23	16.5	4.62	35.9	0.002	17.3	0
8	35.0	2.51	16.6	4.05	35.8	0.28	17.2	0.578
9	35.0	2.51	16.6	4.05	35.7	0.56	17.3	0
10	35.1	2.23	16.7	3.47	35.7	0.56	17.2	0.578

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4.7.1.3 GRV-Light Grove-Light Sensor v1.2 G2C02

Table 4.4 Data of contact measurement for GRV-Light Grove-Light Sensor v1.2 G2C02

Actual size	Width = 23.7 mm, Height = 20.0 mm							
Measurement tools	Ruler				Vernier callipers			
Dimension of object	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
1	22.0	7.17	19.4	3.0	23.6	0.42	19.9	0.5
2	22.5	5.06	20.0	0	23.6	0.42	19.9	0.5
3	22.5	5.06	20.0	0	23.7	0	19.8	1.0
4	22.5	5.06	19.2	4.0	23.6	0.42	20.0	0
5	22.0	7.17	19.4	3.0	23.8	0.42	20.0	0
6	22.5	5.06	19.5	2.5	23.7	0	19.9	0.5
7	22.5	5.06	20.0	0	23.7	0	20.0	0
8	22.5	5.06	19.5	2.5	23.6	0.42	19.7	1.5
9	22.5	5.06	19.4	3.0	23.6	0.42	19.9	0.5
10	22.5	5.06	20.0	0	23.7	0	19.7	1.5

4.7.2 Data measurement for non-contact measurement method

4.7.2.1 20 cent coin

Table 4.5 Data of non-contact measurement for 20 cent coin

Actual size	Width = 20.6 mm, Height = 20.6 mm							
Webcams	SD Webcam				HD webcam			
Focal Length	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
8.0	22.22	7.86	24.19	17.43	21.56	4.66	21.69	5.29
	22.47	9.08	24.19	17.43	21.56	4.66	21.69	5.29
	22.47	9.08	24.69	19.85	21.56	4.66	21.69	5.29
	22.22	7.86	24.69	19.85	21.56	4.66	21.69	5.29
	22.22	7.86	24.69	19.85	21.56	4.66	21.69	5.29
8.5	22.09	7.23	23.36	13.40	23.79	15.49	19.95	3.16
	22.09	7.23	23.36	13.40	23.79	15.49	19.95	3.16
	21.86	6.12	23.36	13.40	23.79	15.49	20.02	2.82
	21.86	6.12	23.43	13.73	23.79	15.49	19.95	3.16
	21.86	6.12	23.43	13.73	23.79	15.49	19.95	3.16
9.0	21.20	2.91	22.54	9.42	20.65	0.25	20.65	0.25
	21.20	2.91	22.54	9.42	20.65	0.25	20.65	0.25
	21.20	2.91	22.54	9.42	20.65	0.25	20.65	0.25
	21.15	2.67	22.35	8.50	20.68	0.39	20.65	0.25
	21.15	2.67	22.54	9.42	20.65	0.25	20.65	0.25

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9.5	20.36	1.17	20.34	1.26	17.44	15.34	17.65	14.32
	20.36	1.17	20.34	1.26	17.44	15.34	17.72	13.98
	20.36	1.17	20.22	1.84	17.51	15.00	17.65	14.32
	20.40	0.97	20.22	1.84	17.51	15.00	17.58	14.66
	20.40	0.97	20.22	1.84	17.51	15.00	17.65	14.32
10.0	19.10	7.28	19.70	4.37	16.25	21.12	16.11	21.80
	19.10	7.28	19.70	4.37	16.11	21.80	16.04	22.14
	19.10	7.28	18.67	9.37	16.18	21.46	16.04	22.14
	18.78	8.83	18.67	9.37	16.18	21.46	16.04	22.14
	18.78	8.83	18.67	9.37	16.18	21.46	15.97	22.48

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Table 4.6 Data of average measurement and average measurement error at different focal length for SD and HD webcam

Actual size	Width = 20.6 mm, Height = 20.6 mm							
Webcams	SD Webcam				HD webcam			
Focal length (cm)	Average measurement		Average measurement error		Average measurement		Average measurement error	
	Width (mm)	Height (mm)	Width (%)	Height (%)	Width (mm)	Height (mm)	Width (%)	Height (%)
8.0	22.32	24.49	8.35	18.88	21.56	21.74	4.66	5.53
8.5	21.95	23.39	6.56	13.53	23.79	19.99	15.48	2.30
9.0	21.18	22.50	2.814	9.24	20.65	20.65	0.24	0.24
9.5	20.38	20.27	1.09	1.61	17.48	17.64	15.14	14.37
10.0	18.97	19.08	7.9	7.37	16.17	16.03	21.50	22.18

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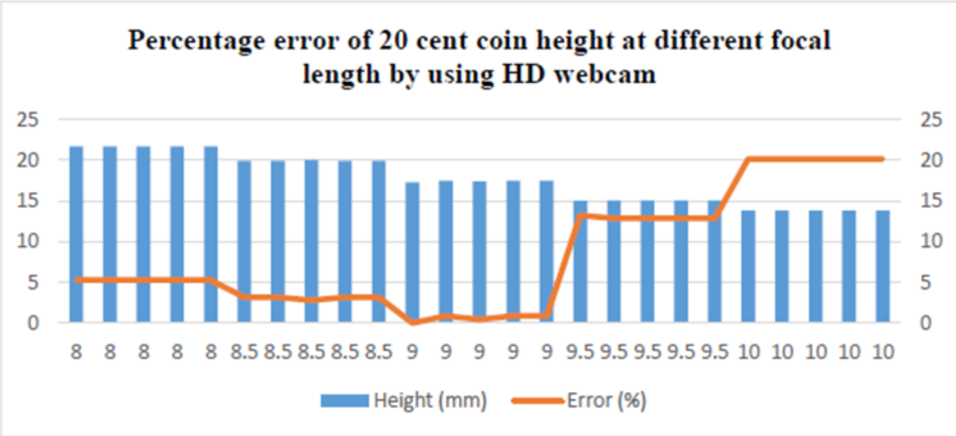

Figure 4.8 Percentage error of 20 cent coin width at different focal length by using SD webcam

Graph in figure 4.8 shows the percentage error for width of the 20 cent coin that was measured by the SD webcam approached and achieve 0% at the focal length 9.5 cm while the others was stated at ± 0%.

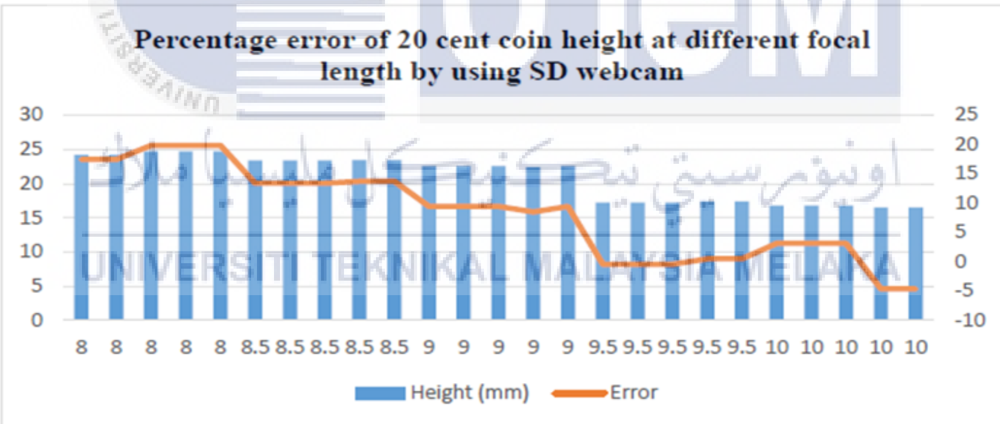

Figure 4.9 Percentage error of 20 cent coin height at different focal length by using SD webcam

Graph in figure 4.9 shows the percentage error for height of 20 cent coin that was measured by the SD webcam approached and achieve 0% at the focal length 9.5 cm. The others was stated at ± 0%.

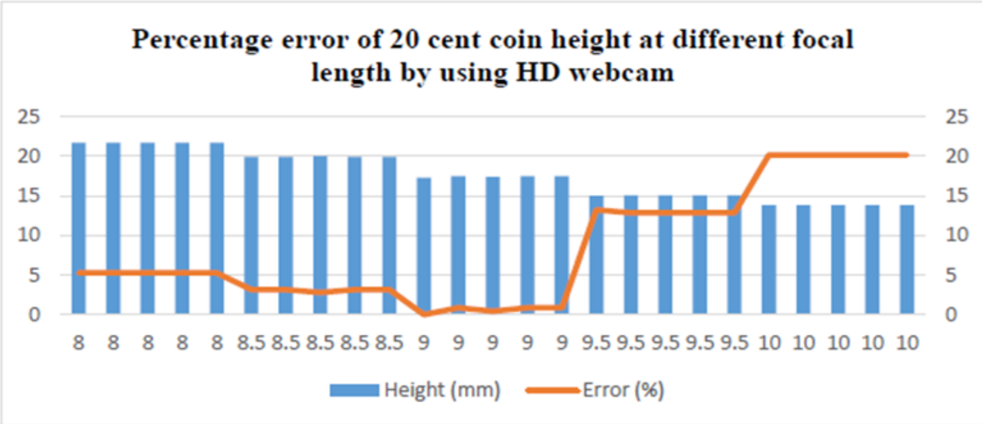

Figure 4.10 Percentage error of 20 cent coin width at different focal length by using HD webcam

Graph in figure 4.10 shows the percentage error for height of 20 cent coin that was measured by the HD webcam achieve 0% at the focal length 9.0 cm. The others was stated more than 0%.

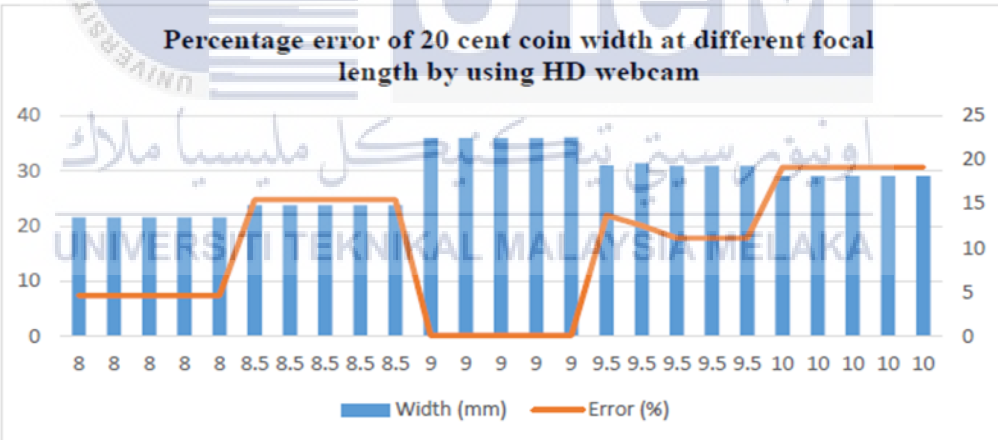

Figure 4.11 Percentage error of 20 cent coin height at different focal length by using HD webcam

Graph in figure 4.11 shows the percentage error for height of 20 cent coin that was measured by the HD webcam achieve 0% at the focal length 9.0 cm. The others was stated more than 0%.

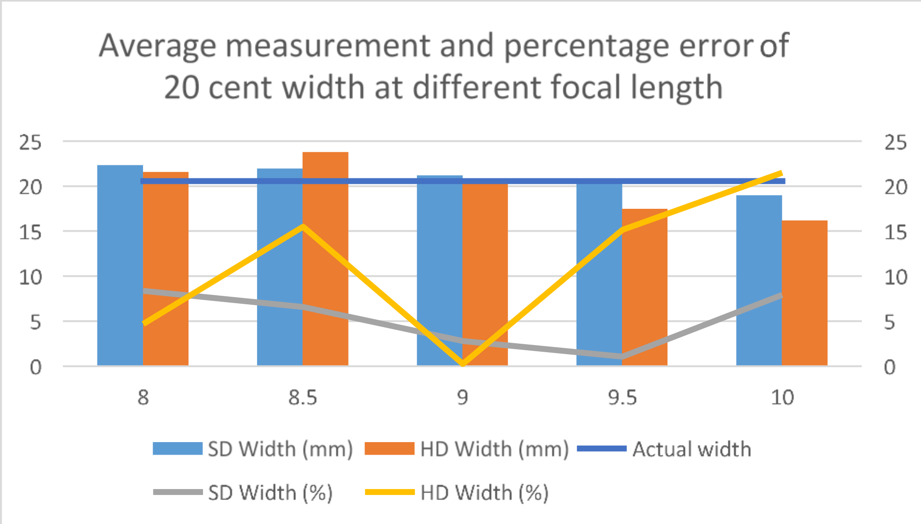

Figure 4.12 Average measurement and percentage error of 20 cent width at different focal length with different webcam

Figure 4.12 shows the average measurement and percentage error of 20 cent coin width with the different focal length. From the figure, it shows that the 9.0 cm focal length has the least measurement error where it measures at width 20.65 mm with 0.24% percentage error for HD webcam. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 1.09% percentage error.

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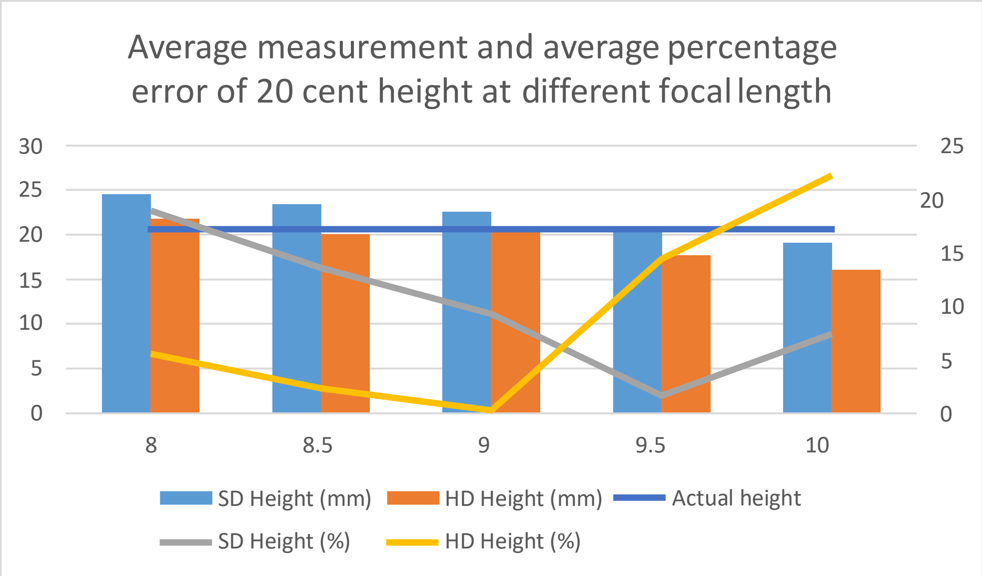

Figure 4.13 Average measurement and percentage error of 20 cent height at different focal length with different webcam

Figure 4.13 shows the average measurement and percentage error of 20 cent coin height with the different focal length. It shows that the HD webcam has the least measurement error measurement error at 9.0 cm focal length where it measures at height 20.65 mm with 0.24% percentage error. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 1.61% percentage error.

4.7.2.2 Microwave Radar-Human Motion Sensor AOVO6

Table 4.7 Data of non-contact measurement for microwave radar-human motion sensor AOVO6

Actual size	Width = 35.9008 mm, Height = 17.3 mm							
Webcams	SD Webcam				HD webcam			
Focal Length	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
8.0	38.82	8.13	20.56	18.84	38.44	7.08	18.76	8.44
	38.82	8.13	20.56	18.84	38.44	7.08	18.76	8.44
	38.82	8.13	20.56	18.84	38.44	7.08	18.76	8.44
	38.77	7.99	20.62	18.84	38.44	7.08	18.76	8.44
	38.77	7.99	20.62	18.84	38.44	7.08	18.76	8.44
8.5	37.55	4.59	19.74	14.10	35.72	0.50	17.51	1.21
	37.55	4.59	19.74	14.10	35.72	0.50	17.44	0.81
	37.55	4.59	19.67	13.70	35.72	0.50	17.51	1.21
	37.55	4.59	19.67	13.70	35.72	0.50	17.51	1.21
	37.55	4.59	19.67	13.70	35.72	0.50	17.51	1.21
9.0	36.72	2.28	18.93	9.42	35.94	0.11	17.30	0
	36.72	2.28	18.93	9.42	35.94	0.11	17.45	0.87
	36.66	2.11	18.80	8.67	35.94	0.11	17.38	0.46
	36.66	2.11	18.80	8.67	35.94	0.11	17.45	0.87

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	36.66	2.11	18.80	8.67	36.01	0.11	17.45	0.87
9.5	35.72	0.50	17.22	0.46	30.97	13.73	15.00	13.23
	35.72	0.50	17.22	0.46	31.39	12.56	15.07	12.89
	35.72	0.50	17.22	0.46	30.90	11.14	15.07	12.89
	35.80	0.28	17.39	0.52	30.90	11.14	15.07	12.89
	35.80	0.28	17.39	0.52	30.90	11.14	15.07	12.89
10.0	34.22	4.68	16.76	3.12	29.02	19.16	13.81	20.17
	34.22	4.68	16.76	3.12	29.02	19.16	13.81	20.17
	34.22	4.68	16.76	3.12	29.02	19.16	13.81	20.17
	34.16	4.84	16.50	4.62	29.02	19.16	13.81	20.17
	34.16	4.84	16.50	4.62	29.02	19.16	13.81	20.17

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Table 4.8 Data of average measurement and average measurement error at different focal length for SD and HD webcam

Actual size	Width = 35.9008 mm, Height = 17.3 mm							
Webcams	SD Webcam				HD webcam			
Focal length (cm)	Average measurement		Average measurement error		Average measurement		Average measurement error	
	Width (mm)	Height (mm)	Width (%)	Height (%)	Width (mm)	Height (mm)	Width (%)	Height (%)
8.0	38.8	20.58	8.07	18.84	38.44	18.76	7.08	8.44
8.5	37.55	19.70	4.59	13.86	35.75	17.50	0.42	1.17
9.0	36.68	18.85	2.18	8.97	35.95	17.40	0.14	0.58
9.5	35.75	17.29	0.412	0.48	31.10	15.06	13.37	22.71
10.0	34.20	16.66	4.74	3.72	29.02	13.81	19.16	10.75

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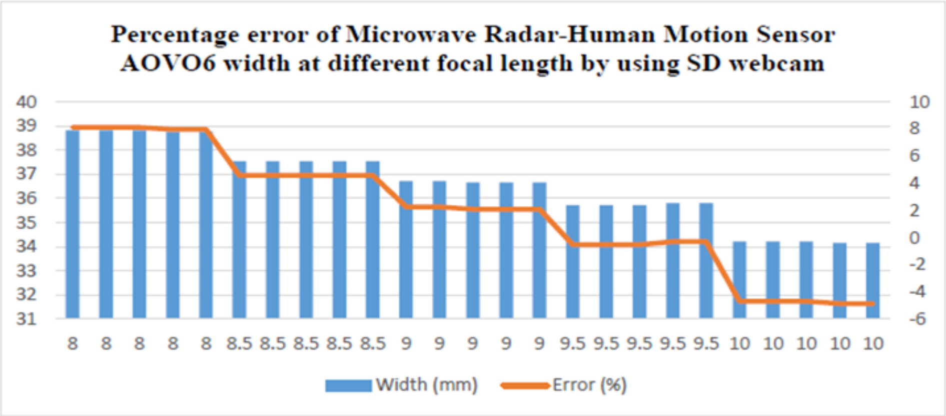

Figure 4.14 Percentage error of Microwave Radar-Human Motion Sensor width at different focal length by using SD webcam

Graph in figure 4.14 shows the percentage error for width of microwave radar-human motion sensor that was measured by the SD webcam achieve 0% at the focal length 9.5 cm. The others was stated at ± 0%.

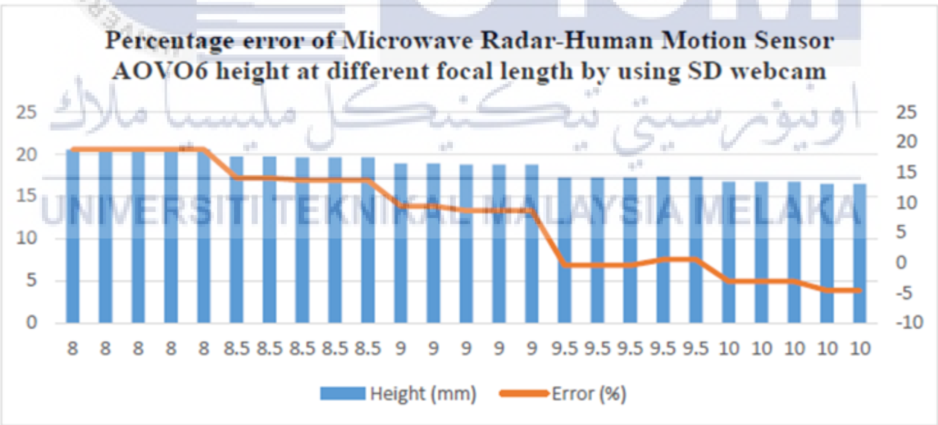

Figure 4.15 Percentage error of Microwave Radar-Human Motion Sensor height at different focal length by using SD webcam

Graph in figure 4.15 shows the percentage error for height of microwave radar-human motion sensor that was measured by the SD webcam achieve 0% at the focal length 9.5 cm. The others was stated at ± 0%.

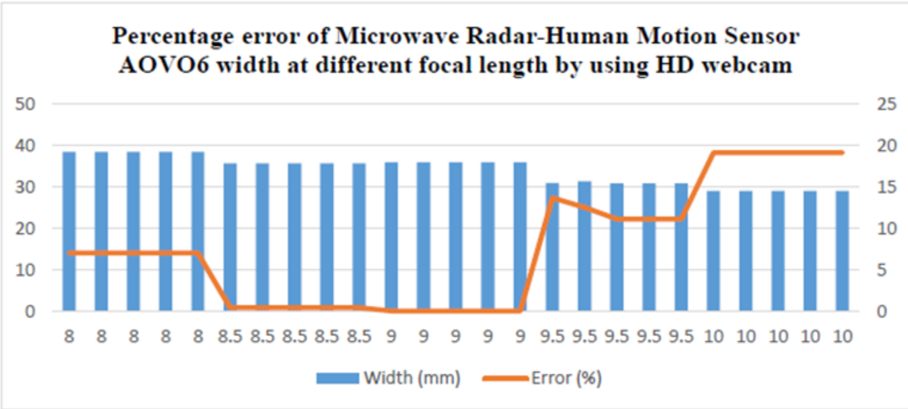

Figure 4.16 Percentage error of Microwave Radar-Human Motion Sensor width at different focal length by using HD webcam

Graph in figure 4.16 shows the percentage error for height of microwave radar-human motion sensor that was measured by the HD webcam achieve 0% at the focal length 8.5 cm and 9 cm. The others was stated at more than 0%.

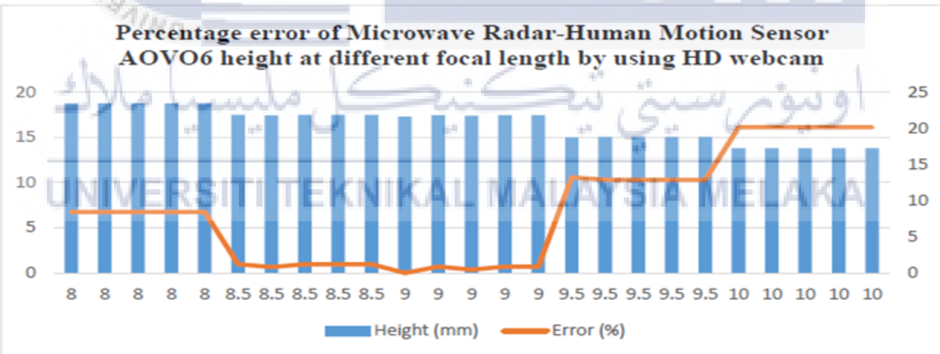

Figure 4.17 Percentage error of Microwave Radar-Human Motion Sensor height at different focal length by using HD webcam

Graph in figure 4.17 shows the percentage error for height of microwave radar-human motion sensor that was measured by the HD webcam achieve 0% at the focal length 8.5 cm and 9 cm. The others was stated at more than 0%.

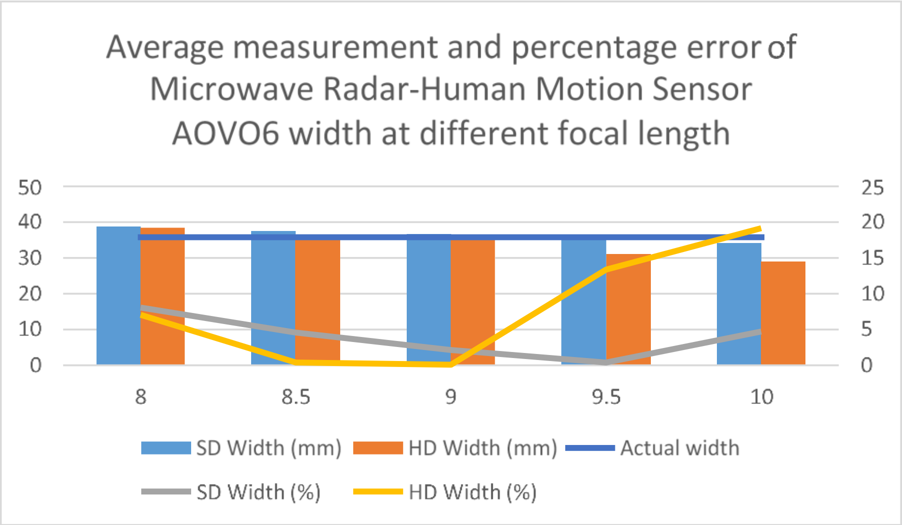

Figure 4.18 Average measurement and percentage error of Microwave Radar-Human Motion Sensor AOVO6 width at different focal length with different webcam

Figure 4.18 shows the average measurement and percentage error of microwave radar- human Motion Sensor AOVO6 width with the different focal length. It shows that the HD webcam has the least measurement error measurement error at 8.5cm and 9.0 cm focal length where it measures at width 35.9008 mm with 0.42% and 0.14 % respectively. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 0.412% percentage error.

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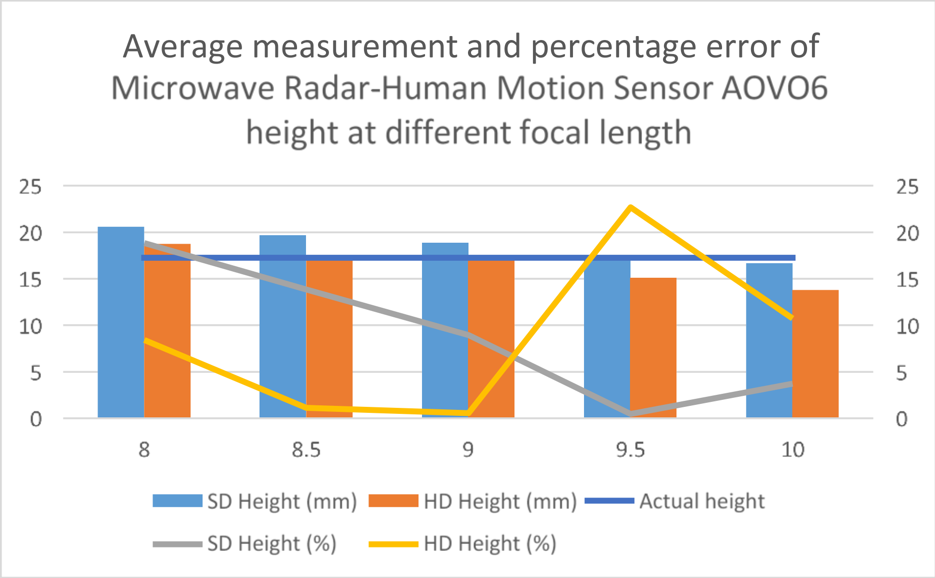

Figure 4.19 Average measurement and percentage error of Microwave Radar-Human Motion Sensor AOVO6 height at different focal length with different webcam

Figure 4.19 shows the average measurement and percentage error of microwave radar- human Motion Sensor AOVO6 width with the different focal length. From the figure above, it shows that the HD webcam has the least measurement error measurement error at 8.5cm and 9.0 cm focal length where it measures at height 17.3 mm with 1.17% and 0.58% respectively. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 0.48% percentage error.

4.7.2.3 GRV-Light Grove-Light Sensor v1.2 G2C02

Table 4.9 Data of non-contact measurement for GRV-Light Grove-Light Sensor v1.2 G2C02

Actual size	Width = 23.7 mm, Height = 20.0 mm							
Webcams	SD Webcam				HD webcam			
Focal Length	Width (mm)	Error (%)	Height (mm)	Error (%)	Width (mm)	Error (%)	Height (mm)	Error (%)
8.0	26.23	10.68	23.37	16.85	21.56	9.03	21.69	8.45
	26.23	10.68	23.37	16.85	21.56	9.03	21.69	8.45
	26.23	10.68	23.24	16.2	21.56	9.03	21.76	8.80
	26.12	10.21	23.24	16.2	21.56	9.03	21.76	8.80
	25.12	10.21	23.24	16.2	21.56	9.03	21.76	8.80
8.5	25.47	7.47	22.65	13.25	23.79	0.38	19.95	0.25
	25.47	7.47	22.65	13.25	23.79	0.38	19.95	0.25
	25.38	7.09	22.65	13.25	23.79	0.38	20.02	0.1
	25.38	7.09	22.65	13.25	23.79	0.38	19.95	0.25
	25.38	7.09	22.48	12.4	23.79	0.38	19.95	0.25
9.0	24.78	4.55	21.55	7.75	23.72	0.08	20.07	0.35
	24.78	4.55	21.55	7.75	23.72	0.08	20.07	0.35
	24.67	4.09	21.46	7.3	23.72	0.08	20.07	0.35
	24.67	4.09	21.46	7.3	23.72	0.08	20.07	0.35
	24.67	4.09	21.46	7.3	23.72	0.08	20.15	0.75

9.5	23.81	0.46	20.12	0.6	20.58	13.16	17.44	12.8
	23.81	0.46	20.12	0.6	20.51	13.46	17.44	12.8
	23.81	0.46	20.12	0.6	20.58	13.16	17.44	12.8
	23.77	0.29	20.09	0.45	20.58	13.16	17.44	12.8
	23.77	0.29	20.09	0.45	20.58	13.16	17.44	12.8
10.0	22.23	6.20	19.34	3.3	18.90	20.25	15.90	20.5
	22.23	6.20	19.34	3.3	18.97	19.96	15.84	20.8
	22.20	6.33	19.34	3.3	18.97	19.96	15.90	20.5
	22.20	6.33	19.25	3.89	18.97	19.96	15.84	20.8
	22.20	6.33	19.25	3.89	18.97	19.96	15.84	20.8

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Table 4.10 Data of average measurement and average measurement error at different focal length for SD and HD webcam

Actual size	Width = 23.7 mm, Height = 20.0 mm							
Webcams	SD Webcam				HD webcam			
Focal length (cm)	Average measurement		Average measurement error		Average measurement		Average measurement error	
	Width (mm)	Height (mm)	Width (%)	Height (%)	Width (mm)	Height (mm)	Width (%)	Height (%)
8.0	25.59	23.29	10.49	16.46	21.56	21.75	9.03	8.75
8.5	25.42	22.62	7.24	13.08	23.79	20.06	0.38	0.30
9.0	24.71	21.50	4.27	7.48	23.72	20.09	0.08	0.45
9.5	23.79	20.11	0.39	0.54	20.57	17.44	13.21	12.80
10.0	22.21	19.30	6.28	3.54	18.96	15.85	20.0	20.75

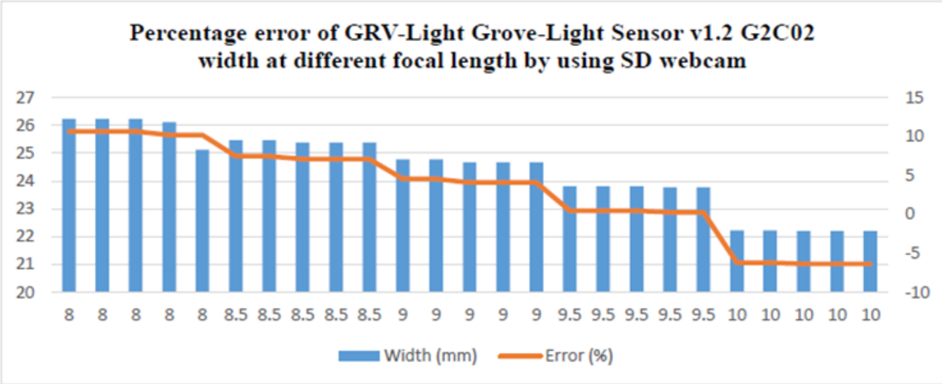

Figure 4.20 Percentage error of GRV-Light Grove-Light Sensor width at different focal length by using SD webcam

Graph in figure 4.20 shows the percentage error for width of GRV-Light Grove Light sensor that was measured by the SD webcam achieve 0% at the focal length 9.5 cm. The others was stated at ± 0%.

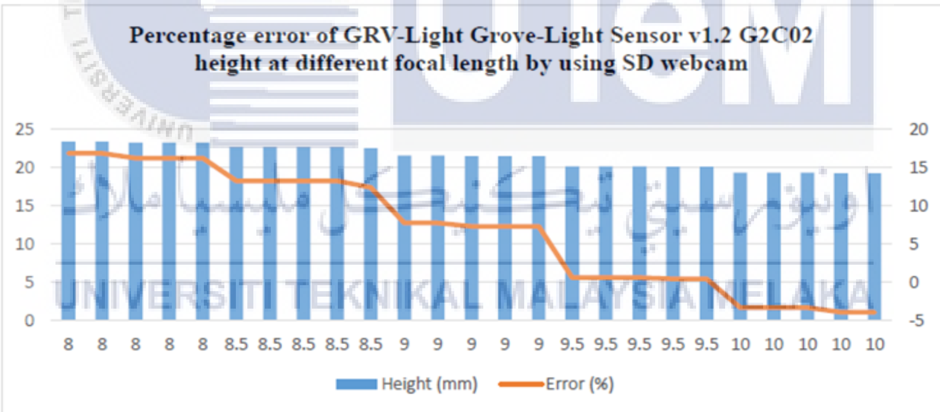

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Figure 4.21 Percentage error of GRV-Light Grove-Light Sensor height at different focal length by using SD webcam

Graph in figure 4.21 shows the percentage error for width of GRV-Light Grove Light sensor that was measured by the SD webcam achieve 0% at the focal length 9.5 cm. The others was stated at ± 0%.

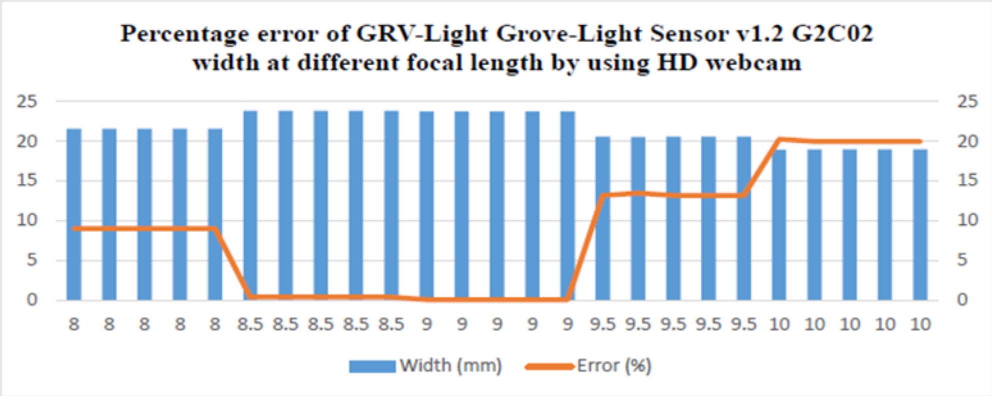

Figure 4.22 Percentage error of GRV-Light Grove-Light Sensor width at different focal length by using HD webcam

Graph in figure 4.22 shows the percentage error for width of GRV-Light Grove Light sensor that was measured by the HD webcam achieve 0% at the focal length 8.5 cm and 9 cm. The others was stated more than 0%.

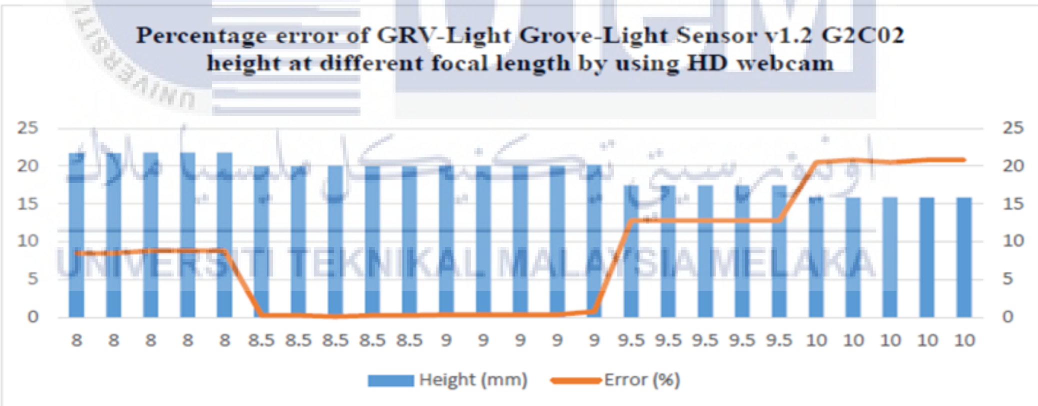

Figure 4.23 Percentage error of GRV-Light Grove-Light Sensor height at different focal length by using HD webcam

Graph in figure 4.23 shows the percentage error for width of GRV-Light Grove Light sensor that was measured by the HD webcam achieve 0% at the focal length 8.5 cm and 9 cm. The others was stated more than 0%.

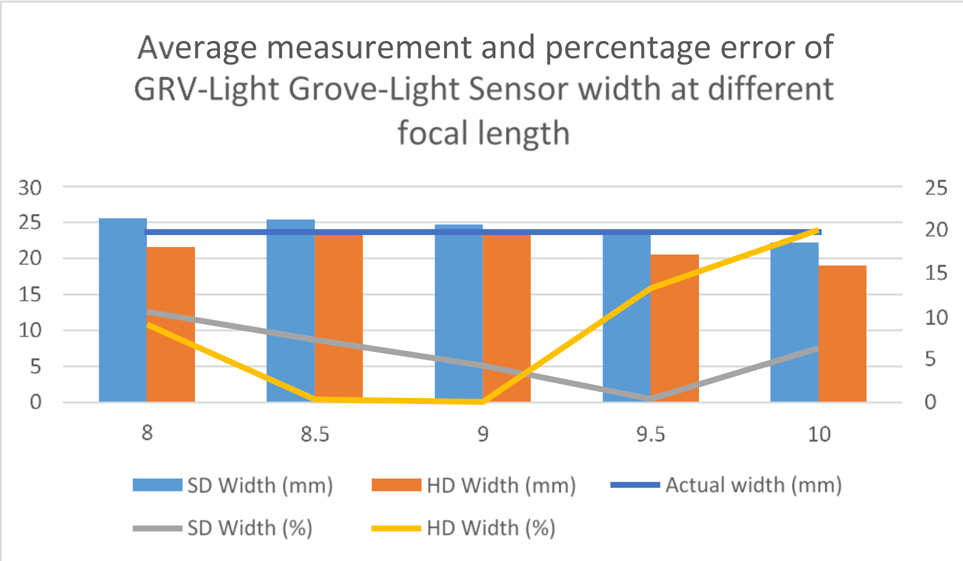

Figure 4.24 Average measurement and percentage error of GRV-Light Grove-Light Sensor width at different focal length with different webcam

Figure 4.24 shows the average measurement and percentage error of GRV-Light Grove- Light Sensor width with the different focal length. From the figure above, it shows that the HD webcam has the least measurement error measurement error at 8.5cm and 9.0 cm focal length where it measures at width 23.7 mm with 0.38% and 0.08% respectively. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 0.39% percentage error.

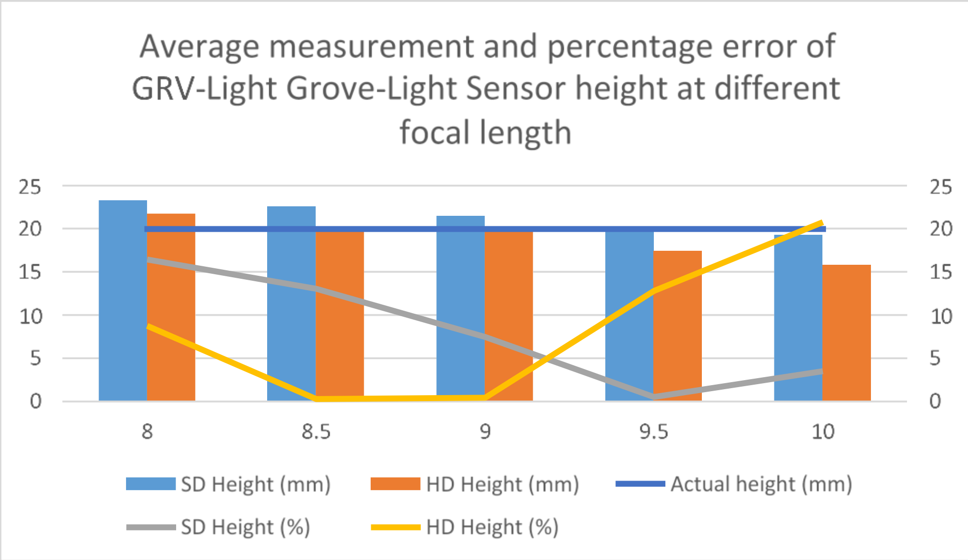

Figure 4.25 Average measurement and percentage error of GRV-Light Grove-Light Sensor width at different focal length with different webcam

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Figure 4.25 shows the average measurement and percentage error of GRV-Light Grove- Light Sensor height with the different focal length. From the figure above, it shows that the HD webcam has the least measurement error measurement error at 8.5cm and 9.0 cm focal length where it measures at height 20.0 mm with 0.3% and 0.45% respectively. Meanwhile for SD webcam, it shows that the 9.5 cm focal length has the least measurement error where it has 0.54% percentage error.

4.8 Discussion

Based on the analysis result for the comparison of measurement error between the SD and HD webcam, it shows that the measurement of the objects by using the HD is more accurate compared to the SD webcam, which is almost achieve with the actual measurement value for each objects. The percentage error of the objects that achieved by the HD webcam is less compared to the SD webcam. The standard percentage error that have be achieved must be at ± 5%. From the collected data, it showed that SD webcam has less accuracy of measurement compared to the HD webcam due the greater of error.

In this project, the measurement data for each object has been collected repeatedly 5 times with different focal length which is from 8 cm to 10.0 cm at 0.5mm increament. From the collected data, it shows that SD webcam has the close value to the actual size of the object at the focal length 9.5 cm. Meanwhile for the HD webcam, the data showed that the actual size of the object was closely at the focal length 8.5 cm and 9 cm. From the analysis, we can conclude that if the distance of the camera lens with the object measured increase, the noise will become increases and the reading measurement of the object will not detect accurately. This is due to the line that measure the object was not detected the white line that produced by the canny edge detection. The way of object captured by the camera is also significant in ensuring that the image had no noise to produce a better filtering image Besides, the noise that appeared during measured the object also may due to the unclear background. This problem can be solved by using a black or white background.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Overview

In this chapter, the results and the review of the project implementation that has been completed will be concluded. It will covered of the overall about this project, which is from introduction to recommendation. The objective of this project also must be achieved based on the results that has been collected.

5.2 Conclusion

As the conclusion, the webcam has played an important role especially in the inspection system nowadays. These webcams can be used for many ways and easy to use for many type of object appearance and easy to get. This project has achieved the main objective, which is to analyze the measurement error between SD and HD webcam. From the analysis results that got from the previous chapter, it showed that the HD webcam has more accurate measurement compared to the SD webcam. Besides, the second objective also has been achieved which is to identify the accuracy of measurement error at the different focal length.

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5.3 Recommendation of Project

For this project, there are few recommendation and improvement that can be implemented for the future used:

i. Used the higher resolution of webcam that can provide better quality image in order to get the better accuracy measurement.

ii. Implement the coding of MATLAB so that it can measured the small object likes microchips.

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APPENDICES

APPENDIX A Coding

```
clc;    %Clear the command window.
close all;    %Close all figures(except those of imtool.)
imtool close all;    %Close all imtool figures if you have the Image
Processing Toolbox.
clear;    %Erase all existing variables. Or clearvars if you want.
workspace;    %Make sure the workspace panel is showing.
format long g;
format compact;
fontSize=13;

camList = webcamlist;
cam = webcam(2)
%preview(cam);

frames = 50;

while 1

try

rgbImage=snapshot(cam);    %Reads the image from location
[rows,columns,numberOfColorBands]=size(rgbImage);

subplot(2,2,1);    %Display the original color image.
imagesc(rgbImage);
axis image;
axis off;
title('Original Color Image','FontSize',fontSize);

%Extract the individual red,green and blue color channels.
redChannel=rgbImage(:,:,1);
greenChannel=rgbImage(:,:,2);
blueChannel=rgbImage(:,:,3);

%Find the black outlines.
thresholdValue=100;
blackOutlines=redChannel<=thresholdValue&greenChannel<=thresholdValue&blueCha
nnel<=thresholdValue;

subplot(2,2,2);    %Display the image blackoutline.
imagesc(blackOutlines);
axis image;
axis off;
title('Black Outlines','FontSize',fontSize);


binaryImage=imfill(blackOutlines,'holes');


subplot(2,2,3);
zoom on
```

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```
image(binaryImage);
BW=edge(binaryImage);    %detects edge in the greyscale image(only in gray
scale)
[r1,c1]=find(BW);
a=edge(BW,'canny');
%imshow(a);
imagesc(a);
axis image;
axis off;
title('Canny Image','FontSize',fontSize);
%imshow(BW)
%spy(BW);
axis on;
x2=max(c1);
x1=min(c1);
distance_x=x2-x1;
distancex_mm=(distance_x*0.072475400)
y2=max(r1);
y1=min(r1);
distance_y=y2-y1;
distancey_mm=(distance_y*0.073595400)

a=[(y2-y1)/2]+y1;
b=[(x2-x1)/2]+x1;

subplot(2,2,4);
axis on;

spy(BW);

%imshow(BW)
title('object measurement','FontSize',fontSize);

%Enlarge figure to full screen.
set(gcf,'units','normalized','outerposition',[0 0 1 1]);

%Draw a line between point 1 and 2 for x
line([x1,x2],[a,a],'Color','y', 'LineWidth',2);

%Draw a line between point 1 and 2 for y
line([b,b],[y1,y2],'Color','y', 'LineWidth',2);

% message=sprintf(The diameter is %0.02f pixels',thelength);
message=sprintf('The width= %0.02f mm\nthe height= %0.02f
mm',distancex_mm,distancey_mm);
uiwait(helpdlg(message));

str1=sprintf('width=%0.02f mm',distancex_mm);
%text(1,20,str)
str2=sprintf('height=%0.02f mm',distancey_mm);
%text(1,55,str)
text1='Width= ';
XLength=[text1 num2str('%0.0f',distancex_mm)];
text1='Height= ';
YLength=[text1 num2str('%0.0f',distancey_mm)];
```

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```
text(x2,y1+20,str1);
text(x2,y1,str2);

catch
end

end


clc;    %Clear the command window.
close all;    %Close all figures(except those of imtool.)
imtool close all;    %Close all imtool figures if you have the Image
Processing Toolbox.
clear;
```

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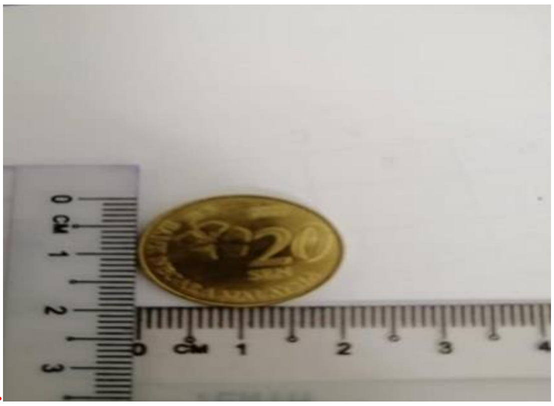
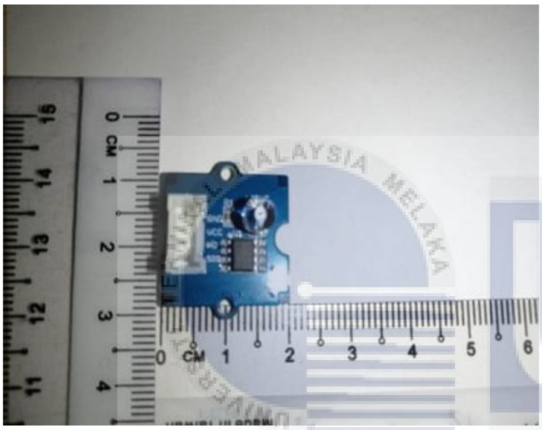
APPENDIX B List of Figures





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