ESTIMATION OF DISTANCE OF HUMAN FROM QUADCOPTER USING IMAGE PROCESSING METHOD FOR SURVEILLANCE PURPOSE

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2019

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled “ESTIMATION OF DISTANCE OF HUMAN FROM QUADCOPTER USING IMAGE PROCESSING METHOD FOR SURVEILLANCE PURPOSE 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 : --

Name : --

Date : --

APPROVAL

I hereby declare that I have checked this report entitled “ESTIMATION OF DISTANCE OF HUMAN FROM QUADCOPTER USING IMAGE PROCESSING METHOD FOR SURVEILLANCE PURPOSE” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

First I would like to express my gratitude to University Teknikal Malaysia Melaka (UTeM) for giving such an opportunity to learn from the professionals and facilities to use for learning and research. I sincerely thank UTeM for giving me such a wonderful yet meaningful time.

Next, I would like to voice out my appreciation to my final year project supervisor, Professor Madya Dr. Ahmad Zaki Bin hj. Shukor for his patience and guidance for this semester. He had help me faced problems regarding the project and also given me helpful suggestions on this topic. I am grateful for all he has done for me.

Last but not least, I would like to say thanks to all my friends and family who have provided me with useful tips and moral support throughout the time. I thank them for all the supports that they have given me either financial or informative.

ABSTRACT

A quadcopter is an unmanned aerial vehicle with four propellers to provide lift to fly and hover above ground. Quadcopter nowadays is a very common commercial item in everyday life. Some quadcopters are designed to do 3D or 2D mapping of a certain area or to take videos or just for entertainment purposes. Quadcopter is a very versatile item and is able to change into anything for example a quadcopter can also be used for security purposes to decrease the crime rate of our country. The objectives of this study is to design and develop a quadcopter with image processing system to have the ability to measure the distance of a human from the drone itself. The quadcopter is designed to be small in size and have a mini computer like Raspberry pi on top of it to compute the algorithm to calculate the distance of the human by using image processing technique through the camera which is setup on the drone. Human detecting algorithm YOLO and software Open CV is chosen to detect human and calculate the distance from the quadcopter. The results shows that the system is quite limited by the capabilities of the hardware. The system is only have an accuracy of more than 90 percent when the human is standing within a certain range. Both the accuracy of the distance sensing and human recognizing system is affected by the limitation of the hardware.

ABSTRAK

Quadcopter ialah salah satu kenderaan yang tidak ada penumpang di dalam. Quadcopter mempunyai 4 kipas yang pusing dengan cepat untuk membolehkan quadcopter terbang. Zaman sekarang Quadcopter merupakan benda kormersial yang senang diperolehi. Sesetengah orang menggunakan quadcopter untuk membuat pemetaan 3D dan 2D atau untuk merekodkan video. Quadcopter merupakan sesuatu yang serba boleh, ia juga boleh ditukar menjadi drone yang digunakan untuk pengawasan seseuatu tempat. Objektif kajian ini ialah untuk menrancang dan menciptakan drone yang boleh mengukur jaraknya dengan manusia yang bredekatan. Quadcopter ini dirancang mempunyai reka bentuk yang kecil dan mempunyai satu computer yang kecil diatasny untuk menjalankan sistem ukur jarak. Software seperti YOLO dan Opencv juga digunakan dalam project ini. Keputusan eksperiment menunjukkan bahawa sistem ini dihadkan oleh keupayaan perkakasan sistem. Ketepatan sistem ini untuk mengukur jaraknya dari manusia dan mengenali manusia telah dihadkan oleh perkakasan sistem. Ketepatan sistem ini boleh mencapai 90 peratus dalam jarak tertentu. Semua ini boleh diselesaikan dengan menggunakan perkakasan yang lebih baik.

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ESC	-	Electronic speed controller
UAV	-	Unmaned aerial vehicle

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CHAPTER 1

INTRODUCTION

1.1 Background

Unmanned Aerial Vehicle is a vehicle which is piloted without a pilot on board of the vehicle. UAVs trace their beginnings back to world war 1. UAVs have the ability to transmit or receive data or information to the battlefield. They can act as communications relays, neutralize targets, attack with onboard ammunitions or streaming real-time battle information back to friendly base.

Figure 1.1 Early design of UAV

Current day's Unmanned Aerial Vehicle (UAV) are widely used in every field, almost from military till the commercial purpose. Usage of UAV has decreased the burden on the human, where the manpower and risks during critical conditions (war fields) are reduced. Therefore the demand for the development of the unmanned aerial Vehicle is high.[2]

1.2 Motivation

echnologies nowadays is getting more and more advanced as humans are striving to obtain a better lifestyle. Looking through the past few years we are achieving more and more breakthrough in both scientific fields and technological field. This technological advancement is achieved in order to give us a better and more secure lifestyle. Things like fingerprint authentication to unlock a door or even a gate that will recognize a certain residence card are technologies that are made to provide a piece of mind to us. With technologies like this we can be reassured and focus in our daily lives instead of having to worry about the wellbeing of our property and our families.

Drone is one of the technologies with the most potential industry growing these days. Unmanned Aerial vehicles also known as drones are aircrafts that are navigated without any human pilot on board the vehicle [3]. Drones can either be navigated via control from ground or by using a Global Positioning System (GPS) tracking system. Drones come in different shape and sizes, some large drones that can carry up to 10kg of weight, some comes is a very small form factor such as DJI (Da Jiang Innovation) Spark. This drone is classified as a VTOL (Vertical Take-Off and Landing) drones which can take off, fly, hover and land vertically with the assist of gyro sensors and GPS system [4]. Companies like Amazon and Google also invested a lot in this industry as drone industry is going to be one of the main industry in the future with its versatility and potential.

All this efforts are put to prevent crimes like house burglary, domestic violence, sexual assault, stalking, kidnapping, robbery and others cases from occurring. Even with all of the technological advancement made the moral of humanity itself have proof to be stagnant throughout the years. The occurring rate of this crimes still have not decrease in any substantial amount. According to Malaysia 2018 Crime & Safety Report provided by United States Department Of State Bureau Of Diplomatic Security also known as OSAC shows that Malaysia experiences elevated levels of crimes especially in urban area which are densely populated. The most common crimes committed are petty theft such as purse snatching, pick pocketing, smash and grab thefts from vehicles and residential burglaries[5].

Residential break ins are common and single family homes are the most frequent target. This is because these kind of crimes are easy and generally non-confrontational and most of the deeds are done while the tenant are away from house. While it is not common to have any confrontation with the tenant, some burglars may encounter situation like this. When condition like this happens the burglars will detain the residents and threaten them with violence. In cases that the tenant fight back usually it does not end well as the burglar are more prepared that the tenants are. Gated high-rise apartment complexes which are "equipped" with 24-hour guards and electronic access have a considerable lower crime rate than other housing but at the expense of a higher price point consider to other housing area [6].

Countries like the United States of America are investing a lot in drones causing the rise the of drones industry. Business Insider is an American financial and business news website published by Insider Inc. According to a report file by Business Insider during the year 2016 they expects sales of drones to surpass 12 billion USD in the year 2021, which is up by a compound annual growth rate (CAGR) of 7.6% from $8.5 billion in 2016. According to the report the growth will spread across three main industries which are consumer drones, enterprise drone (also known as commercial Drones) and government drones (mostly for defence and security). The graph below provided by Business Insider shows the value business services and labour[7].

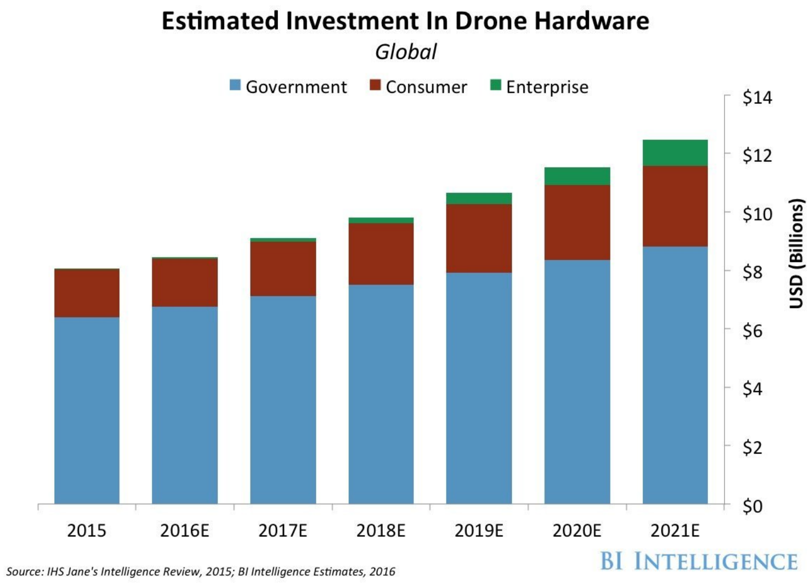


Figure 1.2: Estimated Investment In Drone Hardware [5]

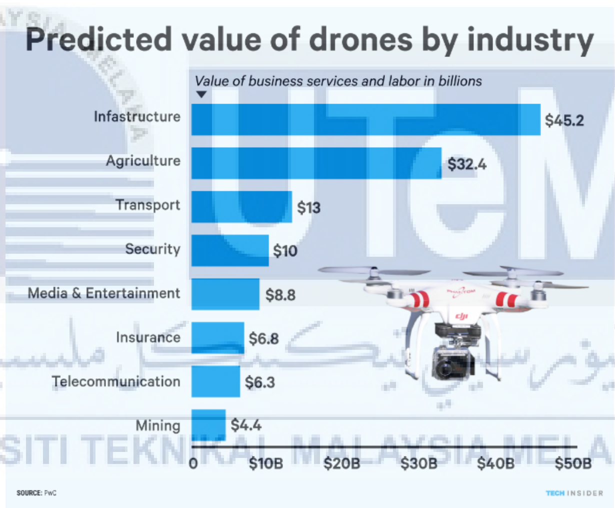


Figure 1.3: Predicted value of drones by industry [5]

The data provided from the graphs above shows that most of the drones focus on infrastructure industry while agriculture is second on the list with a value of 32.4 billion USD. Security is one of the top four main focus for drone industry with a value of 10 billion USD. Compare to the top two industry there is still some gap but with this upcoming trend I believe drone will play a big part in the drone industry.

There are reasons on why chose a drone for surveillance purpose instead of the more traditional static surveillance camera. This is because drone can be used to follow the culprit instead of a static camera which can only be at one place. Other than that the operator can also fly the drone to desired places and have a better view of the area whereas there are a lot of blind spot of a static camera. If the culprit has done his homework and found the blind spot then he can slip through with ease.

Therefore, from all the data and facts that are obtained above it motivates me to make use of the versatility of drones to create a more safe and secure living environment for everybody

1.3 Problem Statement

Nowadays drones industry is getting more and more successful all over the world. There are a lot more functions for drones other than playing with family or having a race with friends. Drones nowadays can deliver package up to a few kilograms of weight, track a specific person (user) for entertainment, takes photos or record video and many more. On the other hand robbery crime index 2017 in Kuala Lumpur rose to 1010 cases compared to 640 cases for the same period 2016 [8]. So by using drone for security surveillance we can kill two birds with one stone but it is not without its' difficulties.

The first difficulty is the power supply to the drone itself. This is a problem faced by most drone companies. Drones either quadcopter or a hexacopter require powerful motors to provide thrust to take off and to hover itself on the air so to compensate for the energy consumption it needs a high density and powerful battery. With a high energy density battery it can fly longer and a powerful battery (high ampere) it can take off with ease and carry heavier payload. The graph below shows the graph of flight time VS battery capacity. From this graph we can clearly see that with increasing of battery capacity the flight time also increase accordingly. But this relationship is not as simple as it seems since the payload of the drone also play a big part in this relationship. [9]

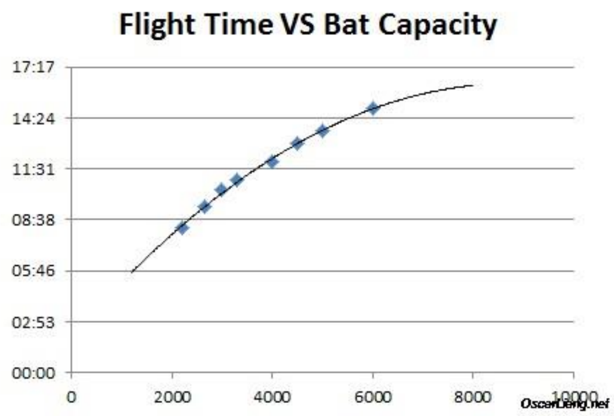


Figure 1.4: Flight time of drones VS battery capacity [9]

Second difficulty is the payload that a quadcopter can carry. The payload of a drone including its' weight is usually very small due to its small size and power consumption motor. The graph bellows shows the relationship of flight time of a drone against the payload. By analysing the graph we can conclude that the relationship between them is inversely proportional the higher the load the lower the flight time. Just as mention from above if we increase the battery capacity we can increase the flight time but at the same time we are also increasing the payload of the drone which will finally affect the flight time. This is one of the reasons why the chassis of a drone is often made of carbon fibre which are both strong and light which fit the criteria perfectly.

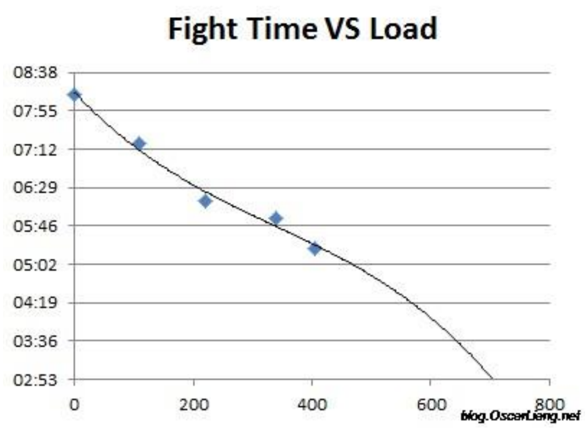


Figure 1.5: Flight time of drones VS load [7]

Next the cost for the battery itself is not cheap when compare to other batteries. For examples the normally used battery for drones are either rechargeable lithium polymer more lithium ion battery. Both of this batteries have high energy density but it come with a higher price when compare to a normal commercial batteries (AA or AAA). The graph below shows the value against battery capacity where the value is capacity per dollar so the higher the value the better it is. From the graph it shows that the higher end of the batteries does not have the best value.

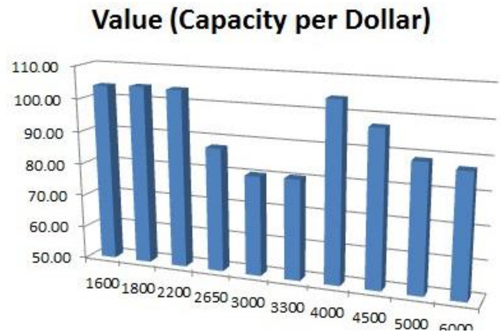


Figure 1.6: Value VS battery capacity [7]

Other than the drone itself the system for the distance estimation also has its' own difficulties. First the computing power of the system on the drone. Since image processing method require a certain processing prowess to be able to run at a noticeable rate but the weight of the computer is limited by the payload that can the drone can manage. So this is one of the reason why there are not many DIY drones with artificial intelligent or image processing drone on the market. Most of them are from company which have cutting edge technology and ability to do it.

Next, there are also other ways of sensing the distance apart from image processing method. Method like using ultrasonic sound to calculate the movement of human to estimate the distance is not as accurate. Heat sensor and infrared camera is also a viable method to estimate the distance but it may not be as accurate as image processing method.

So through this research, I will design a system to estimate human distance using drone and will overcome the factors affecting it.

1.4 Objectives

The objectives:

1. To design and development the distance sensing quadcopter using raspberry pi and camera.
2. To code an algorithm that can sense the distance of human from quadcopter by using image processing technique.
3. To evaluate and compare the accuracy of the distance sensing of quadcopter with real distance measured with measuring tape.

1.5 Scope

A list of focused segment for the project is as follow:-

1. To write an algorithm to use open CV to detect recognize human.
2. To write an algorithm to estimate (by calculation form computer on the ground) the distance of humans from the quadcopter.
3. To evaluate the reliability of the system to detect human and estimate the distance within the range from 3 meters to 12 meters.
4. To test the accuracy of the system in different lighting condition.
5. To test the accuracy of the system in both indoors and outdoors.
6. To test the ability to detect human with them moving at different speeds.

CHAPTER 2

LITERATURE REVIEW

This chapter describes the background of computer vision system and its working mechanism. The different types of setup and image acquisition method are discussed and explained. The advantages differences and limitation of the different method are also discussed and summarized. Different types of designs for quadcopter and flight controllers are also discussed and summarized in this chapter.

2.1 Theory

This section discussed about the theory behind the technology used.

2.1.1 Computer vision

What is computer vision? As human we perceive the world around us as a three-dimensional with no difficulties. We can tell the shape and translucency of a certain object we can even interpret the intensity of the lighting and the shading easily. Researchers in computer vision have been doing research and developing, in parallel, mathematical techniques for recovering the three dimension shape and appearance of object in imagery. With the techniques available now we can computer a partial three-dimensional model of and environment form a sets of overlapping pictures. We can even track a person moving against a complex background with considerable high accuracy. In computer vision we are trying to describe the things we see and to reconstruct its properties. Computer vision is implemented in a lot of different fields nowadays for examples machine inspection, 3d model building, medical imaging, motion capture and surveillance. [10]

2.1.2 Digital Image processing

The field of digital image processing refers to the processing of digital image by using a digital computer. Image processing can be differentiate into three level of process which are the low-level process, mid-level process and the high-level process. Low level process involve primitive operation such as to reduce noise in images, contrast enhancement and image sharpening. Mid-level processing includes segmentation of image description of image to change their form to a form that a computer can process and classify an object. A mid-level processing is basically feeding the computer with images while it output attributes and characteristic of the pictures. High-level processing if the final and most complicated process in image processing. This process deals with "understanding" of a bunch of recognized object as in image analysis and performing cognitive functions normally associated with vision. We can see that in real life it is often to mix all the level of processes in area if recognition of individual or object in an image. This is called digital image processing. Making sense of an image may be viewed as being in the field of image analysis or computer vision depending on the level of understanding and complexity [11].

2.1.3 Image acquisition

The first stage of any vision system is the image acquisition stage. Only after the image has been acquired that various method of processing and be applied to the image to perform all the vision tasks that are required by the user. There are also different kinds of method for image acquisition. For example, using a single sensor, using sensor strips and using sensor array. For image acquisition using single sensor the idea is: incoming energy is directed to the sensor but first it must pass through a filter only after then it can go to the sensing material and the information received is then converted into voltage waveform so that it can be processed and analysed. Sensor strips is basically the same mechanism as single sensor but all the sensors are aligned in a line and all the output wave form are connected and shared such as shown in the Figure 2.1. Sensor array is almost the same but the sensors are connected in an array instead of just forming a line. [10]

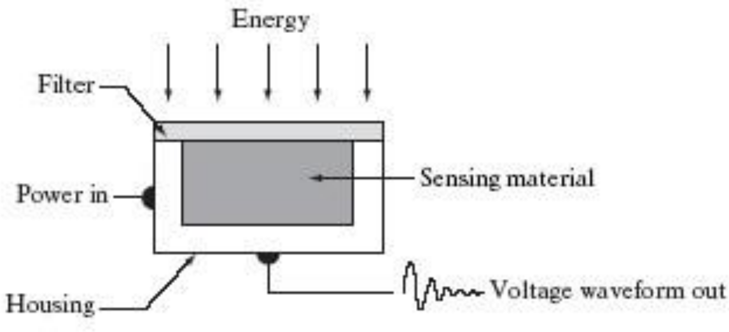


Figure 2.1: Single sensor [8]

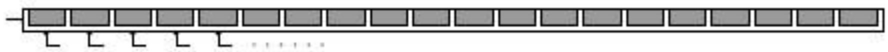


Figure 2.2: Line sensor [8]

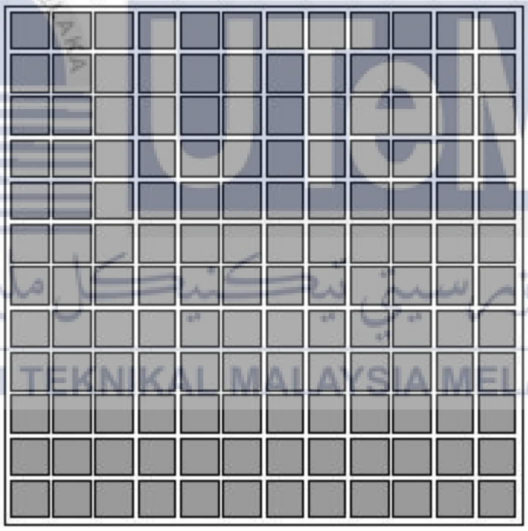


Figure 2.3: Array sensor [8]

2.1.4 Recognition

Recognition is defined as the identification of something which has been previously seen, heard, known, tasted or others. By using image processing for objects, face or even human is to allow computer to “understand” or “make sense” of a certain part or segment of the image and identify and classify as one the “known” classification. Recognition in image processing can be broken down into several categories. There are problems that involve quick scanning of an image and to determine where a match can occur which is called object detection. We can look for the characteristic features and verify that they align in a geometrically plausible way. The most challenging one is recognition in general category which is to classify the objects in the picture in their own category; for example, human, items and scenery[10].

2.2 Type of techniques used in image processing for human recognition and distance sensing.

There are various techniques four human detection and distance sensing. Four methods will be explained in this section which are,

A) Image processing (camera) method to detect human and distance sensing.
B) Radar method to detect human and distance sensing
C) Ultrasonic to detect human and distance sensing
D) Thermal infrared camera to detect human and distance sensing

2.2.1 Image processing (camera) method to detect human and distance sensing

Image processing is a method that requires a camera to take images and then process the images and obtain the information required from it either it is object identification or distance sensing. Computer vision is not often used for object detection [12] but this system is actually very useful and reliable.

Using a single camera to act as the "eye" of the system to capture image is very common. The complexity of a single camera system is not hard to setup and is less complex compared to other systems. It is also considerably cheap to setup when compared with other systems. It also saves electricity because it is possible to achieve by using low power camera like USB webcam[13]. But it is also mentioned that with a higher specification camera a result with high accuracy system can be obtained [14]. So the specification of the system can be easily customized to suit the needs of the user even a single camera, very high accuracy can be obtained if it has a high performance hardware.

Recent works has started to use multiple camera for their system. Stereo vision system is proposed as it can accurately measure the distance and size of object in view [15].

The setup of the cameras for some experiment is as shown as below.

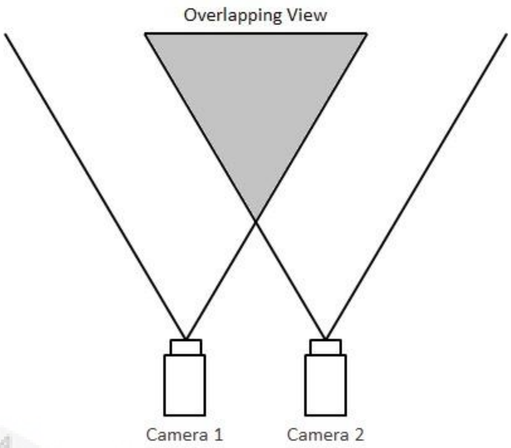


Figure 2.4: Setup used in the experiment. [15]

It is said that by setting up the camera like this they will create an overlapping view. It is more accurate in measuring both height and width by using this overlapped view to process compared to the normal single camera view[15]. Stereo vision mapping is very sensitive to errors because the process of collapsing the data from 3D to 2D introduces errors in the form of points to be propagated into the map[12]. by using stereo vision the system utilized a simpler algorithm in order to achieve a higher processing speed. But the system depends strictly on constant environment lighting and if there are more items in front of the cameras it will cause the frame rate drop by a significant number[15][16]. From the information above, there are some things that we can improve on to get a better result such as improving the hardware and the algorithm to have a higher frame rate in a shorter time.[15] By increase the number of cameras the accuracy will also increase directly proportional to the accuracy of the distance measured. Another type of camera is also proposed in their work which is to introduce a 360 degree camera [16].

2.2.2 Radar method to detect human and distance sensing

The word radar stands for "radio detection and ranging". A radar system works in UHF which is ultra-high frequency electromagnetic waves also known as microwave. Radar can be used to precisely determine the distance between radar and object that the signal reflected [17]. There are many industries that needs a high accuracy system like this for their application such as industrial liquid level measurement system or control purposes in construction machines [18][19]. radar is highly accurate and environmentally insensitive which mean it will not do any harm to the environment [18]. Even though radar has a very high precision in distance measurement but we can not recognize or know what are we sensing since we do not have a visual on the object.

2.2.3 Ultrasonic to detect human and distance sensing

Ultrasonic by contrast works with not electromagnetic waves, but with sound waves. Ultrasonic is basically a sound wave that have a frequency of 20,000 hertz and above. For vision system the vision image must be under the influence of light while on the other hand ultrasonic does not rely on light and can detect the object information and distance from the sensor plus it is cheap to purchase and easy to obtain in real life [20]. In addition, ultrasonic sensor has a lower side effect to human than some sensors that are using electromagnetic waves[21]. With these advantages it can be use for robotic system but at the same time it has an algorithm which is harder to apply in robotic system because of its long duration for calculation[22]. The recognition rate using ultrasonic sensors to sense object has an accuracy of 92.2% based on the research made by others [20]

2.2.4 Thermal infrared camera to detect human and distance sensing

Thermal infrared camera is a camera which is able read the temperature of a certain area. We are able use this data to know where there is an object or not. For examples detecting UAV (unmanned aerial vehicle) during night time is quite a challenge since the computer vision needs a certain level of lighting to operate in optimum condition. Thermal infrared camera can detect small variations in heat which we can used it to recognise object [23]or human. Since human has a certain rage of temperature thus it is possible to use this technology in the field of surveillance and security [24].There are also difficulties faced in the human detection method by using thermal infrared camera which are cause by various dressing style, accessories, body type and the background [25].

Figure 2.5: Image capture by using infrared camera[25]

2.3 Different design of drones

There are some key feature to consider when design a drone. These are some of the feature.

A) Frame design used in different type of quadcopter

B) Material used for the frame of the quadcopter

C) Flight controller used for the quadcopter

2.3.1 Frames design

The frame is the main structural part of an UAV(unmanned aerial vehicle)[26]. There are many types of frame used in quadcopter nowadays. Different frames of quadcopter have different type of characteristics and are suitable for different job. Even though the frame comes in different shapes and sizes but it typically follows a certain pattern. The patterns split mainly into three kinds of frames which are the “X” frame, the “Plus” frame and the “H” frame[27]. There is the “X” frame which have a high stability and is easier to control. This is because the perpendicular distance between each motor is equal therefore it has the same level of stability on all axis. There is also the “Plus” frame which is just “X” frame turned 45 degree but this setup enables the pilot to have a finer control over the quadcopter in exchange for its stability[27]. The

“H” frame is somewhere in between “X” frame and “Plus” frame. Some people choses “H” frame because it has less interference to ultrasonic sensors from the motors and has wider angles of obstacle detection[27]. There are other types of frame other than this three but they are mostly the variant types of this three.

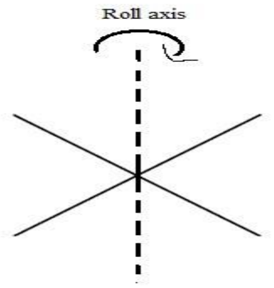
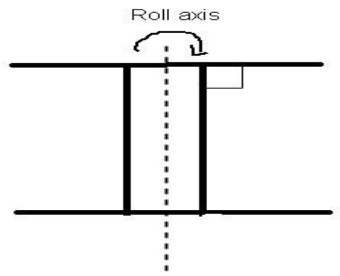


Figure 2.6: X type[27]



H type[27]

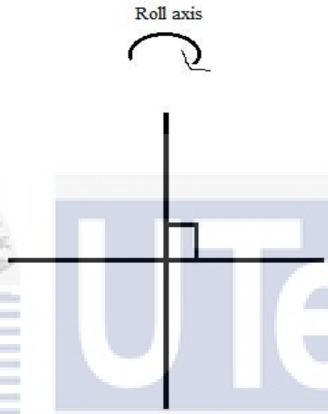


Figure 2.8: Plus type[27]

2.3.2 Material used for the frame of the quadcopter

From the journal studied it is found that there are different type of materials used for different part of the frame. For example, one of the journal stated that they uses fibreboard as their center plate which houses all the electronics and batteries. This is because of its omni directional fibres which are able to damp the vibration created by the motor during flight. Others use 3D printed material such as ABS or PLA which are easy to use and is able to form into any shape the user requires as long as the user have the CAD drawing[28]. 3D printed parts are also light and have some strength to it. Some of the journal stated that they used CNC- milled aluminium as a part of their frame in order to have a strong and durable body. But metals are still considered quite heavy as frame material. There are even cases that uses carbon fibre composite in order to achieve both strength and are lightweight at the same time[29][30]. Carbon fibre is both stronger than steel but lighter than 3D printed material but at a higher price.

2.3.3 Flight controller unit

A flight controller unit is the brain of the quadcopter. There are different kinds of flight controller in the market nowadays. Some of the flight controller mentioned in papers are Pixhawk 2, Futaba R617FS Receiver and HT-Hawk flight control board[31]. Each have its own advantages and disadvantages. Pixhawk is a flight controller with a lot of inputs and outputs it can support various I/O including GPS, range finder and even a mini computer[32]. But for small sized drone it is not suitable as the size of Pixhawk is not small and consider as a heavy payload. Plus It has less input and output but it is sufficient for a normal flight. the price for Pixhawk is not cheap compared to the other flight controller used by others. On the other side the Futaba R617FS is much more affordable and is small in size, which is very suitable for small size drone[27]. This flight controller is more than enough for a normal flight.

Figure 2.9: Pixhawk 2 [30]

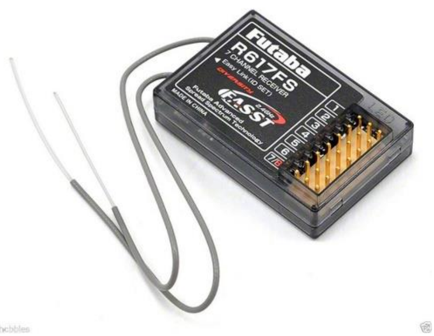


Figure 2.10: Futaba R617FS [25]

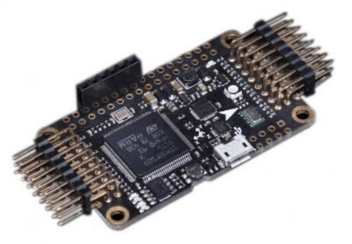


Figure 2.11: HT-Hawk flight control board [29]

2.4 Criteria Comparison

Human detection and Distance measurement(sensing)		
Camera (image processing) [10,11,12,13,14]	Dual camera	
	Advantages	Disadvantages
	- Utilizes a simpler program - Moderate accuracy (less than 10 percent) - Harder to setup - Able to identify and classify what it senses	- More expensive when considered with the single lens - Depends on the constant environment lighting - Performance restricted by hardware capabilities
	Single camera	
	Advantages	Disadvantages
	- Accuracy is high (error up to 2 percent of 20 meters) - Energy saving - Cheaper choice - Easy setup - Able to identify and classify what it senses - Small and can be set up on a small	- Depends on the constant environment lighting - Performance restricted by hardware capabilities

	computer (Raspberry Pi)	
Radar [15,16,17]	Advantages	Disadvantages
	- Will be less affected by temperature - Has high accuracy - Has high consistency - Work in both day and night - Environmental friendly	- Not able to see what it senses
Ultrasonic [18,19,20]	Advantages	Disadvantages
	- Less accurate when compare to radar. - No need for reference signal of the transmitted signal - Work in both day and night - Cheap - Not harmful to human like electromagnetic waves	- will be affected by temperature - Not able to see what it senses - Not able to sense object with sound absorbent material - Harder algorithm
Thermal infrared [21,22,23]	Advantages	Disadvantages
	- Work in both day and night - Very high accuracy in detect	- Very Expensive - Size not suitable for small projects

	a certain object or living thing as it has accuracy of up to millikelvin. - able to differentiate and classify things	- Performance greatly effected by the distance from the camera
Drone design		
Frame design[24,25]	H type	
	Advantages	Disadvantages
	- Moderate Stable	- Slow
	X type	
	Advantages	Disadvantages
	- Stable - Easier for beginner	- Slow
	Plus type	
	Advantages	Disadvantages
	- More precise control	- Not stable - Not suitable for beginner
Frame material[26,27,28]	Carbon fibre	
	Advantages	Disadvantages
	- Stronger than steel - Light - Can withstand high temperature	- Hard to process - Expensive
	3D printed material (PLA/ABS)	
	Advantages	Disadvantages
	- Easy to process - Moderately light - Moderately strong	- Cannot withstand high temperature

	- Can be any shape the user wants	
	Aluminium	
	Advantages	Disadvantages
	- Strong - Can made into any shape	- Heavy - longer to process - conductive
Flight controller [25,29,30]	Pixhawk 2	
	Advantages	Disadvantages
	- There are a lots of input and outputs port - Support all kinds of accessories - Need certain software to use	- Expensive
	Futaba R617FS	
	Advantages	Disadvantages
	- Easy to setup - Cheap - Can be use on the go - Suitable for simple usage	- Less input and output ports
	HT-Hawk flight control board	
	Advantages	Disadvantages
	- Moderate number of ports - Moderate size	- Expensive - Difficult to use

2.5 Summary

The discussion of the different type of method for distance measurement has been done. The reviews on different types of quadcopter body design was also done. A table is constructed to compare the different types of distance measure method and quadcopter body design.

From the literature reviews made there are research that uses image processing method to measure the distance of object or human some even use the technique for surveillance but they are mostly non-mobile camera that are fixed to a certain location. My research will attempt to make use of this image processing technique and apply it on to a quadcopter.

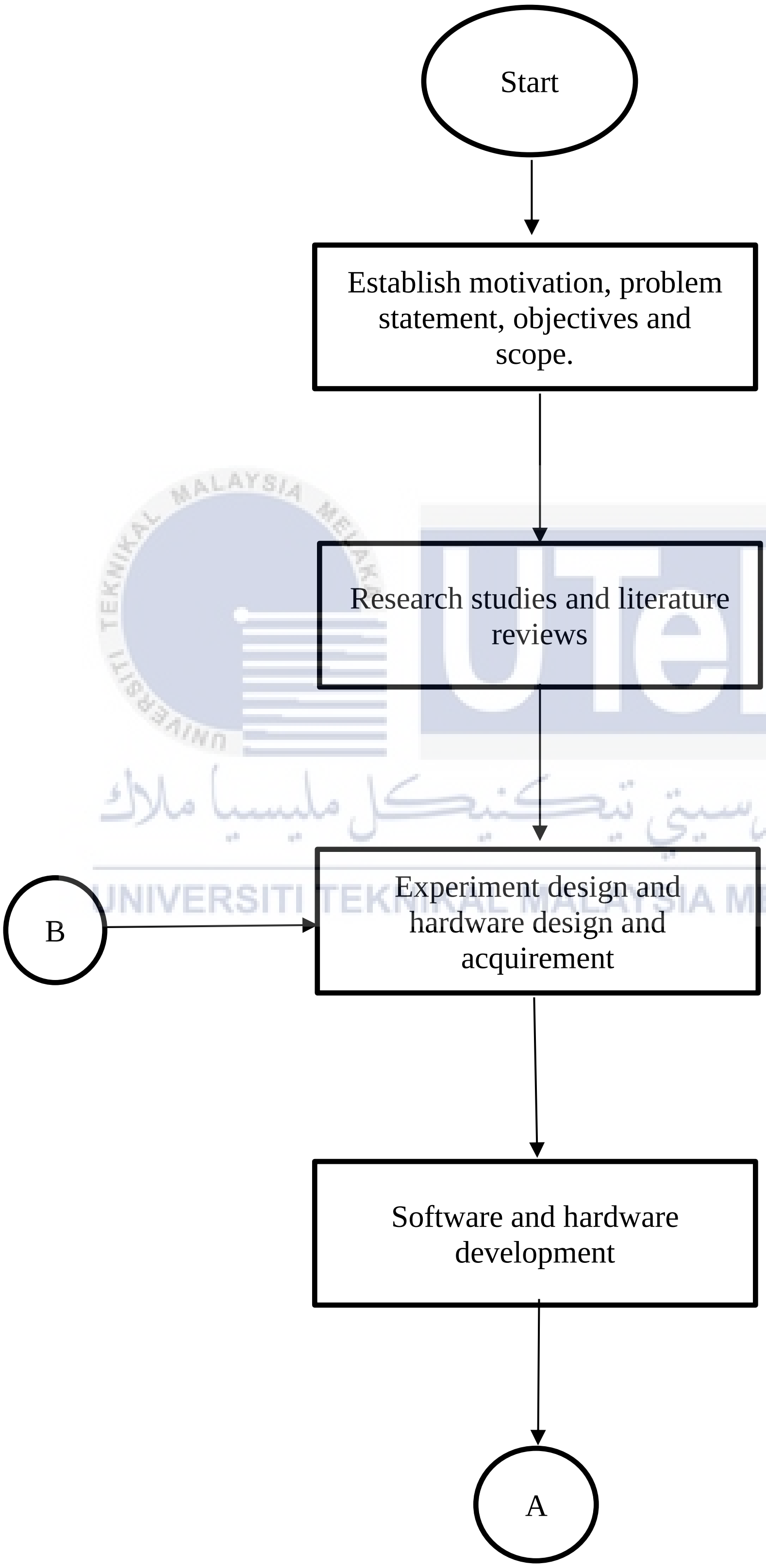
CHAPTER 3

METHODOLOGY

In this chapter, the method used for designing a distance sensing drone for surveillance are being described and discussed. The system will be based on image processing techniques. Different experiments will be designed to evaluate the performance of the designed drone to achieve the objectives and scope of the project. The theory used, materials proposed components and tools used are being listed out and being discuss in this chapter.

3.1 Project overview

The flowchart shows the overview sequence of the project.



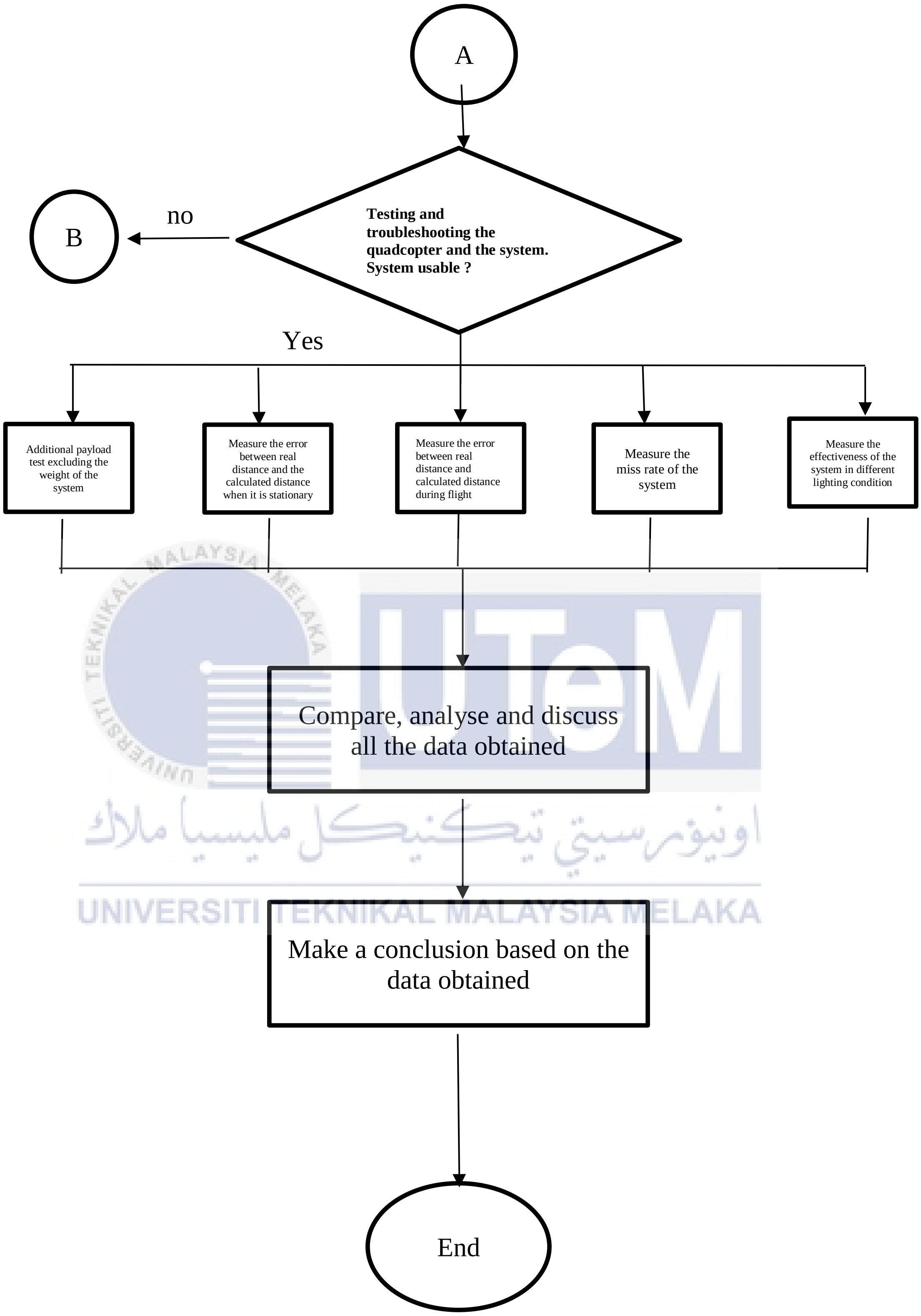


Figure 3.1: Project overview flowchart

3.2 Progress log

Table 3.1: Progress log

No	Item	Date
1	FYP titles are uploaded and we choose from the list.	29 August 2018
2	The titles and the supervisor for the everyone is announced during the first FYP briefing.	5 September 2018
3	Changing and registration of FYP titles.	7 September 2018
4	FYP 1 talk on Abstract	12 September 2018
5	FYP 1 talk on problem statement	19 September 2018
6	Research and write motivation subchapter	20 September 2018
7	Discussion on motivation subchapter with supervisor.	21 September 2018.
8	FYP 1 talk on literature review	26 September 2018
9	Objectives and scope	28 September 2018
10	Problem statement	29 September 2018
11	Journal seeking and research	1 October 2018
12	FYP 1 talk on methodology Discussion on chapter1 and 2 with supervisor	2 October 2018
13	Correction on chapter 1	5 October 2018
14	Meet with supervisor to check on the confirmation for chapter 1	11 October 2018
15	Looking for journal and conference paper	13 October 2018
16	Writing literature review	20 October 2018

17	Meet with supervisor to check on theoretical part on literature review	26 October 2018
18	Writing literature review	28 October 2018
19	Meet with supervisor to check on completed literature review	2 November 2018
20	Rewrite literature review and write methodology, results and discussion	Mid-term break week
21	Assemble and arrange the draft for FYP 1	12 November 2018
22	Meet with supervisor to show the finish draft for checking	14 November 2018
23	Pass up draft for FYP 1	17 November 2018
24	Seminar for FYP 1	23 November 2018
25	Choose the remaining components needed for the project	30 November 2018
26	Design and draw the design drone in Solidworks	9 December 2018
27	Search for the components	16 December 2018
Semester 2 FYP 2		
1	Program coding and research	18 February 2019
2	Program testing	4 March 2019
3	Raspberry pi live stream program	11 March 2019
4	Connect the live stream with the human detection program	18 March 2019
5	Drone assembly	25 March 2019
6	3D print the design for the system	2 April 2019
7	System and drone assembly	9 April 2019
8	Install drone firmware and calibrate all the sensors for drone	15 April 2019
9	Test flight	23 April 2019
10	Calibration for the system	30 April 2019

11	Carry out experiment and record the data	2 May 2019
12	Analyse the data obtained	7 May 2019
13	Complete the draft for FYP report to supervisor	10 May 2019
14	Correction for final report	20 May 2019
15	Submit corrected FYP report to panel	24 May 2019
16	FYP 2 presentation	28 May 2019
17	Submit Final Report corrected (Hardcover) and CD	17 June 2019

3.3 Hardware Components

Motor

Figure 3.2: Motor with 960kv rating

The motor for the drone is specially chosen to meet the requirements that is needed. The motor that is chosen is a brushless motor that have a speed of 960 kv. The motor is to be paired with a 10 inches propeller with 3.8 inches pitch that can have upward thrust of 0.7kg and 2.8kg in total of 4 motors. This will be enough to carry the whole system.

ESC (electronic speed controller)

Figure 3.3: Electronic speed controller

ESC is an electronic circuit that is used to control and regulate the speed of an electric motor. Some also provide reversing dynamic braking for the motor. The specification of ESC is determined by the motor chosen if a motor with 20 amp is chosen thus esc with 20 amp is chosen.

Flight controller unit

Figure 3.4: Pixhawk 1 flight controller unit

Flight controller unit is the main control unit that controls the drone movement through the 4 motors. All inputs from the controller (operator) will be transmit through radio frequency and received by a receiver in the flight controller unit. There are a lot of types of flight controller unit in the market now. The flight controller unit proposed is a very versatile item. It has on board accelerometer, gyroscope and barometer and has enough input and output ports for quadcopter application. It can also support rangefinder and GPS accessories.

Raspberry Pi

Figure 3.5: Raspberry pi

Raspberry Pi 3 is chosen as the mini computer on board. Since Raspberry Pi 3 have WIFI on board so we can stream data down to a faster computer to do all the calculation for distance sensing.

Camera

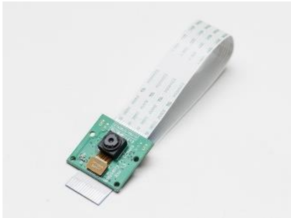


Figure 3.6: Pi camera for raspberry pi

The camera chosen must be small with standard resolution. This is because the higher the resolution the more accurate the results is. But it will also cost more so it must be standard specs with a moderate price. This camera is chosen as is has standard specs and small in size which is suitable for this project.

Technique chosen for manufacturing is 3D printing

3D printing

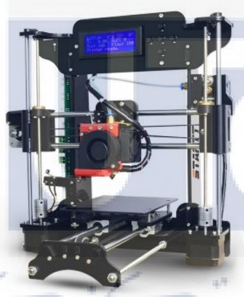


Figure 3.7: 3D printer

3D printing technique is used to make the frame of the drone. This because the drone is custom made drone to suit the needs of this project. Commercial drones are more general and are not build for this kind of application not efficient for our use and are not cheap. 3D printing also enable us to create a model specifically to suit our need so no resources are not wasted.

Material chosen

Figure 3.8: PLA 3D filament

The material chosen for the frame of the drone is made up of PLA which is a kind of polymer typically used as filament for 3d printers. PLA is moderately strong and is very light which is suitable because a drone flight capability greatly depends on the payload that it will carry, thus the lighter the drone the better it is. The better choice material for drones is carbon fibre which are the main stream in the drone industry now. This material is both lighter than plastic and stronger than steel in the weight to strength ratio. But carbon fibre requires a special process to make it and we simply do not have the financial support and the techniques to fabricate the material itself.

3.4 Image processing technique and software chosen

YOLO: Real- time image processing is an algorithm to calculate and detect the objects in images. YOLO stand for "you only look once" which is the technique used for the algorithm. YOLO looks at the whole image once and then goes through the library or network once and detects and classify the objects. Earlier detection frameworks, looked at different parts of the image multiple times at different scales then repurpose image classification to detect objects which is very slow and inefficient. With YOLO the speed to process an image is greatly increased and thus it is so popular.

Figure 3.9: YOLO

OpenCV stands for "Open source Computer Vision library". It is an open source computer vision and machines learning software library. OpenCV was made to provide a common infrastructure for computer vision application and to accelerate the use of machine perception. It provides the graphical user interface to run image processing algorithm such as YOLO so that we can see what is going on through the screen.

The programming language chosen is Python. Python is an interpreted high-level programming language. This language is designed to be readable and straight forward as a result, developers can save more time in thinking. This language is broadly adopted and supported in a lot of people, operating system and platform so that is why it is chosen.

3.5 Hardware fabrication

The hardware parts of the system is designed and drawn in solidworks software. The designed parts is then printed out by using a 3d printer. The figure below shows the design drawn in Solidworks.

Figure 3.10: Camera stand for Raspberry Pi

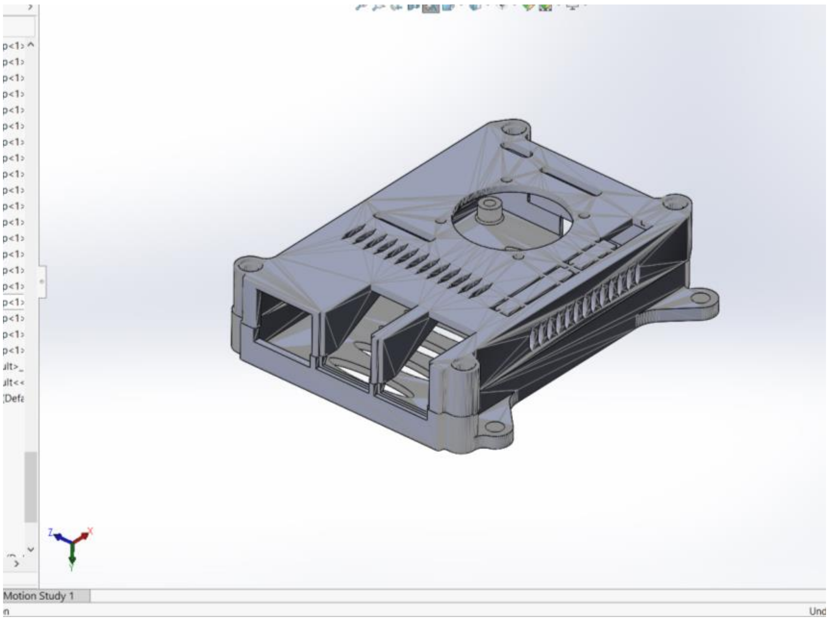


Figure 3.11: Casing for Raspberry Pi

Figure 3.12: Upper plate to hold Raspberry Pi

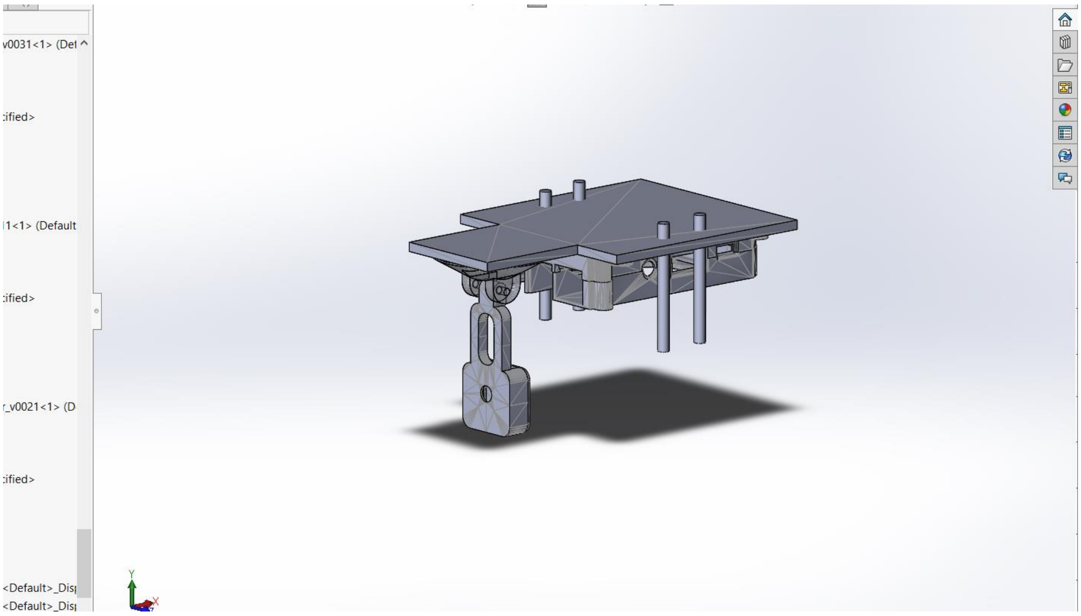


Figure 3.13: Assembled system (solidworks)

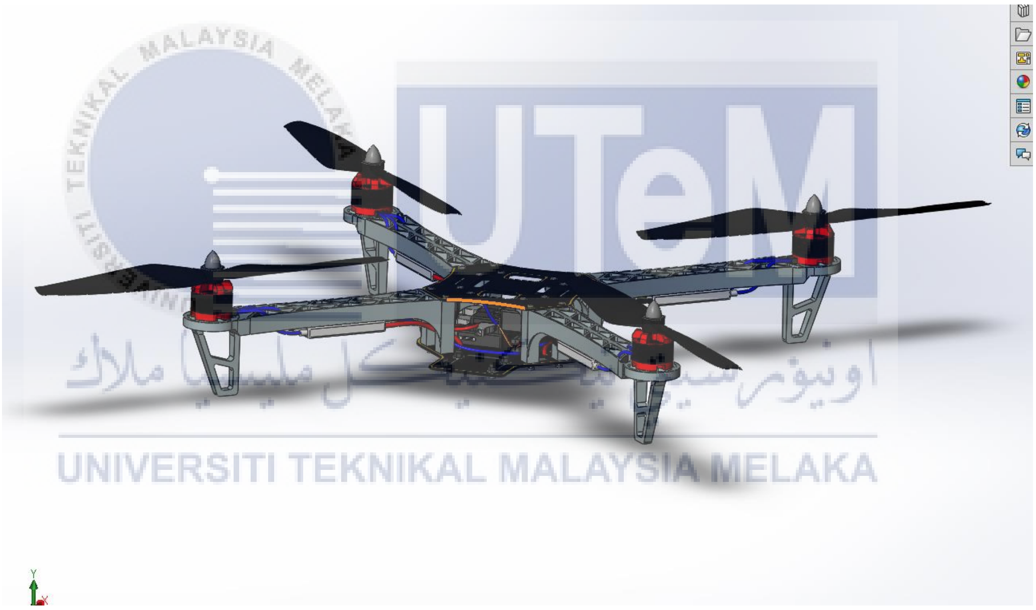


Figure 3.14: Drone design (solidworks)

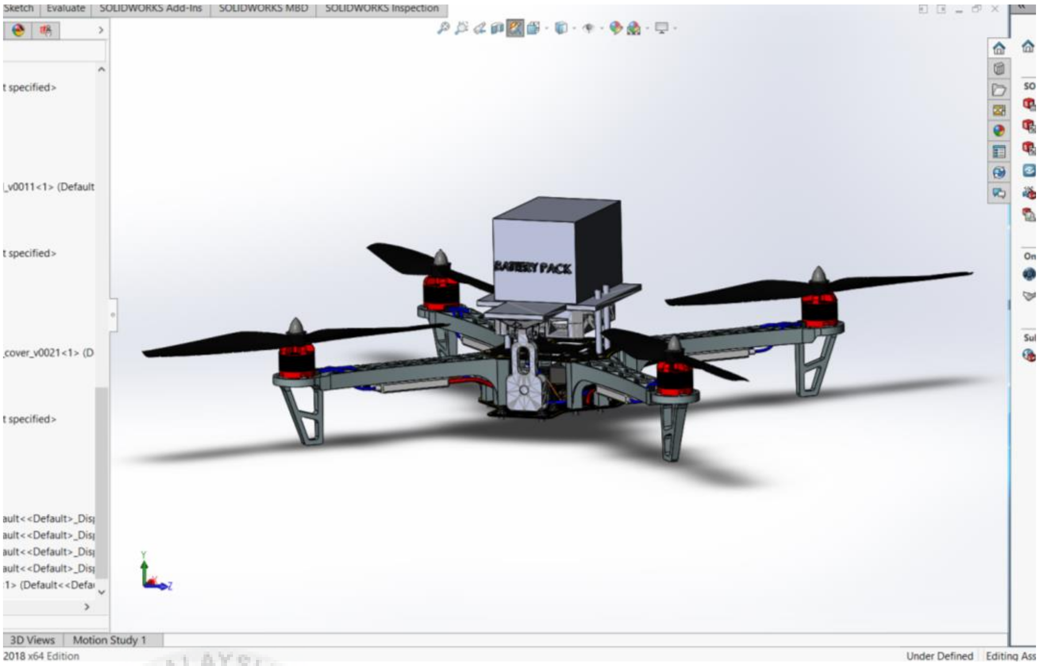


Figure 3.15: Drone with system (solidworks)

Figure 3.16: 3D printed parts

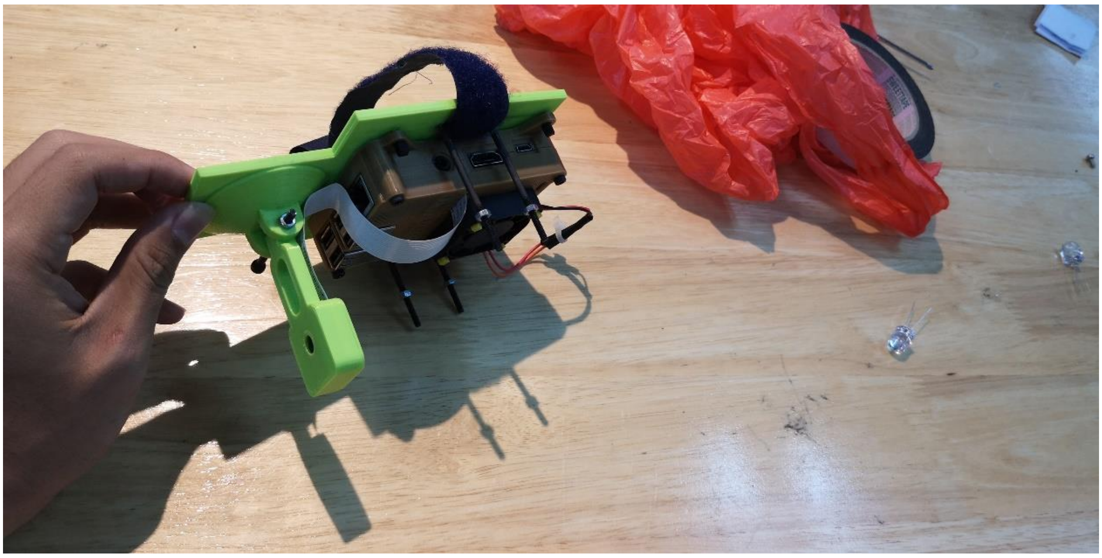


Figure 3.17: Assembled system

Figure 3.18: Fully assembled drone

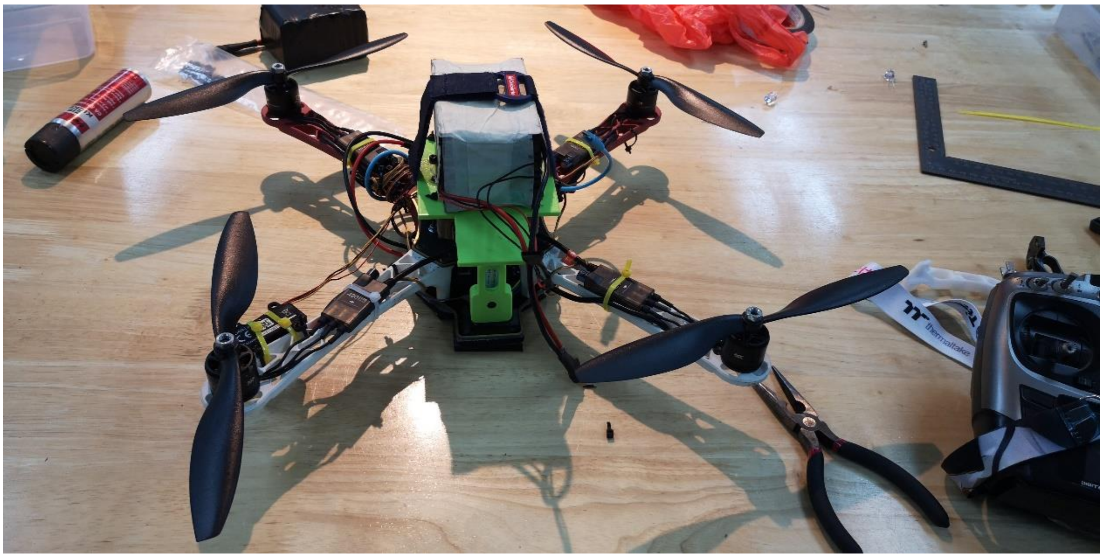


Figure 3.19: Drone with system on

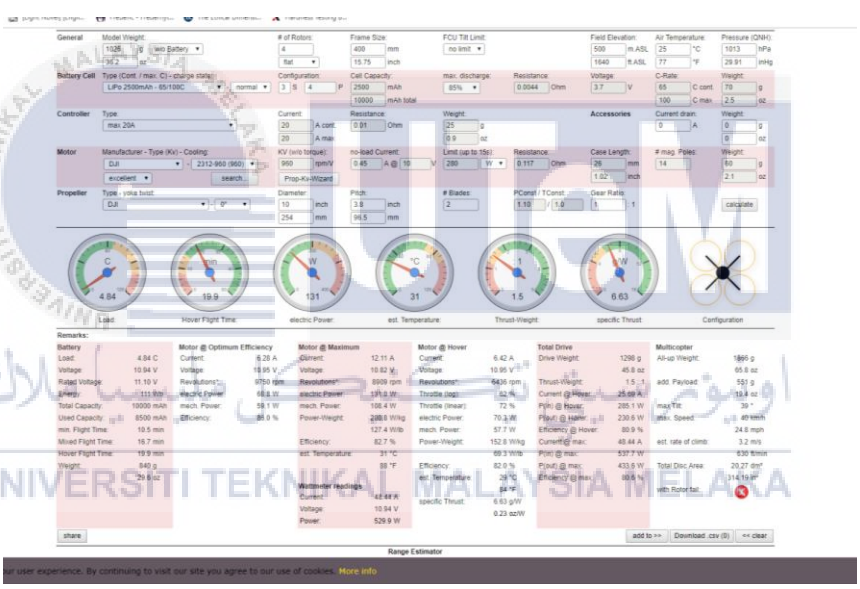


Figure 3.20: Calculation for thrust to weight ratio and theoretical flight time

Figure 3.20 shows the calculation for theoretical flight time and thrust to weight ratio for the assembled drone. From the calculation it shows that this drone will have a 20 minutes flight time and a thrust to weight ratio for 1.5 which fulfilled the requirements for this design.

3.6 System calibration

The program is written and then is calibrated by obtaining the data from real data. A simple setup is made and the calibrated data is then inserted into the program to calculate. The setup of the calibration is shown in the figures below.

Figure 3.21: Calibration setup

Figure 3.22: Calibration setup (far, person A)

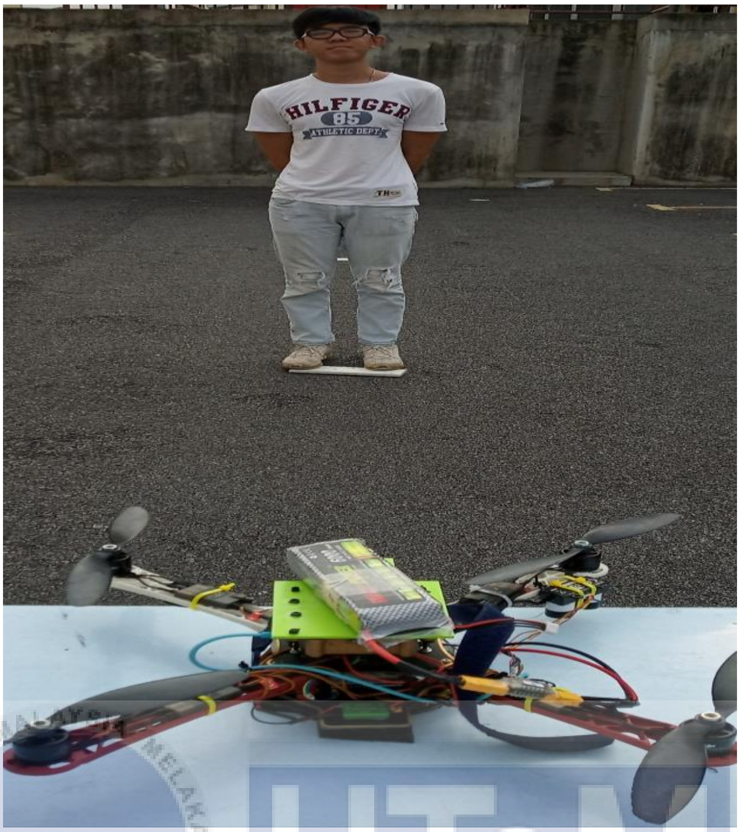


Figure 3.23: Calibration setup (near, person A)

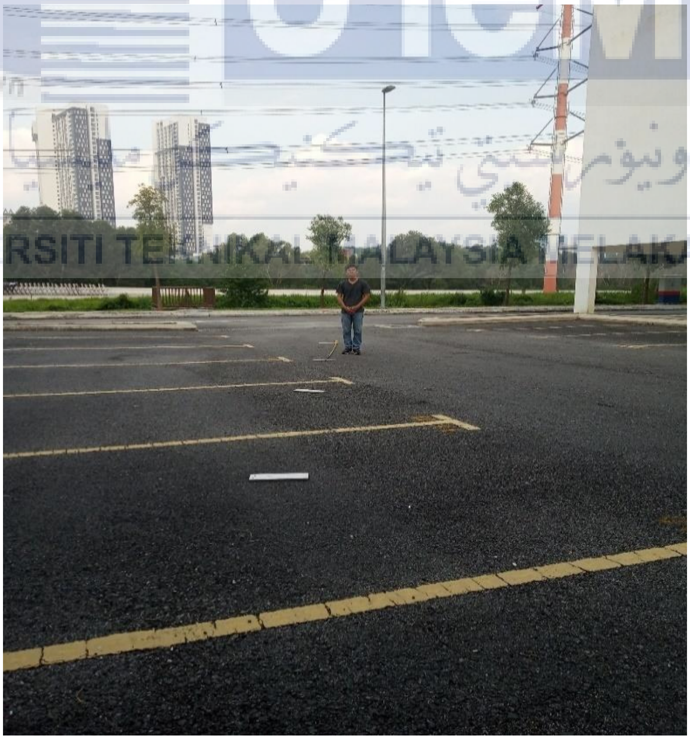


Figure 3.24: Calibration setup (far, perosn B)

Figure 3.25: Calibration setup (near, perosn B)

The person A and person B is to stand in front of the system at increasing distance from 3 meters from the drone until 12 meters from the drone. The program then calculates the total y pixels that the person occupied in the frame. The data obtained is then recorded, tabulated, plotted and then analysed.

Meters	Total of y pixels occupied (test A (184cm))	Total of y pixels occupied (test B (168cm))
3	173	143
4	129	124
5	105	95
6	85	72.5
7	72.5	69
8	63	58
9	58	57
10	53	46
11	48	45
12	46	40

Table 3.2: Calibration data

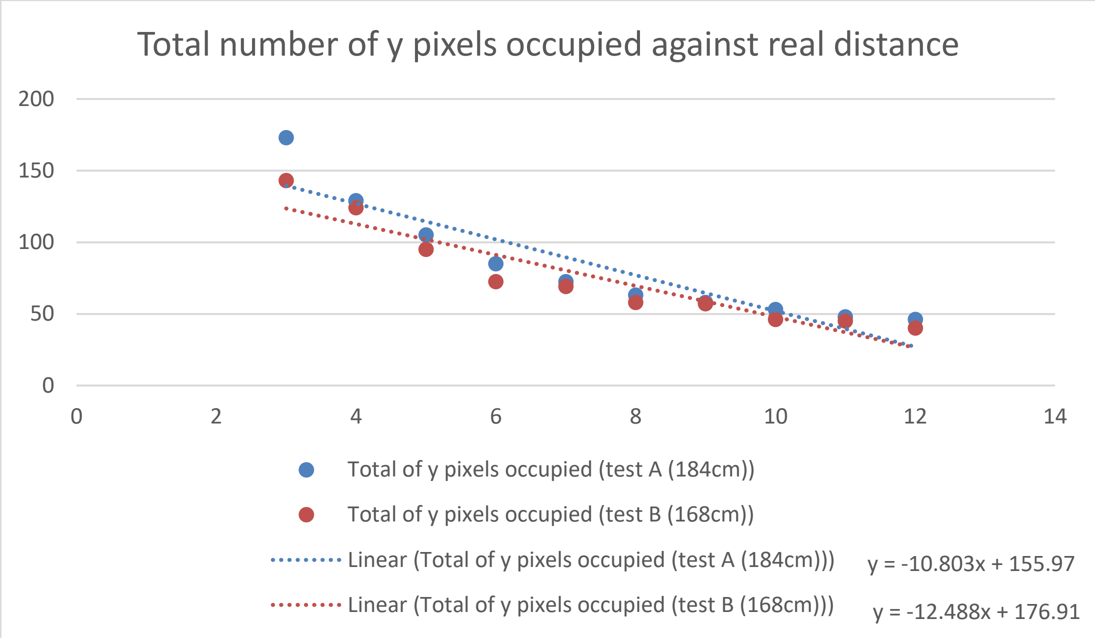


Figure 3.26: Graph plotted from the data obtained

With the data obtained, a graph is plotted and the equation for the best fit line is obtained. With these equations the average is then calculated, then the final equation y = -11.6455+166.44 is inserted into the program so the data will directly display in real time.

3.7 Experiments setup

For experiment setup, the materials and measuring apparatus used are listed out:

1. Raspberry pi
2. Pi camera
3. Drone (assembled with the system)
4. Computer (as ground system)
5. Remote controller
6. Measuring tape
7. Marker (to mark the distance)

There are 5 experiments designed to test the capabilities and limitation of the system.

1. Payload test (include the system)
2. Measure the error between real distance and the calculated distance when it is stationary
3. Measure the error between real distance and calculated distance during flight

4. Measure the miss rate of the system
5. Measure the effectiveness of the system in different lighting condition

All the setup and procedure for the experiments in mention below.

3.7.1 Payload test (include the system)

Figure 3.27: Items and equipment for payload test

The batteries for the drone are charged to full capacity before proceeding to the experiment. The drone is then set up and a timer is prepared beside the pilot so that the pilot can know when he reached the designated flight time. For this experiment the ground station is not set up. When the drone reached the flight time, the pilot will then land the drone and check the voltage dropped by the prepared multi-meter. The procedure is then repeated 3 times with the timer set at 10, 20 and 30 minutes. The voltage obtained from the multi-meter after the flight is recorded and the data is then subtracted from the original voltage to obtain the voltage dropped. The obtained data is then recorded in the table 3.3.

Voltage dropped, v = voltage before flight – voltage after flight

Table 3.3: Flight time against voltage dropped (with system on it)

Weight of the system / grams	Flight time/ minutes					
	Trial 1 / min	Voltage dropped / v	Trial 2 / min	Voltage dropped /v	Trial 3 / min	Voltage dropped / v
175						

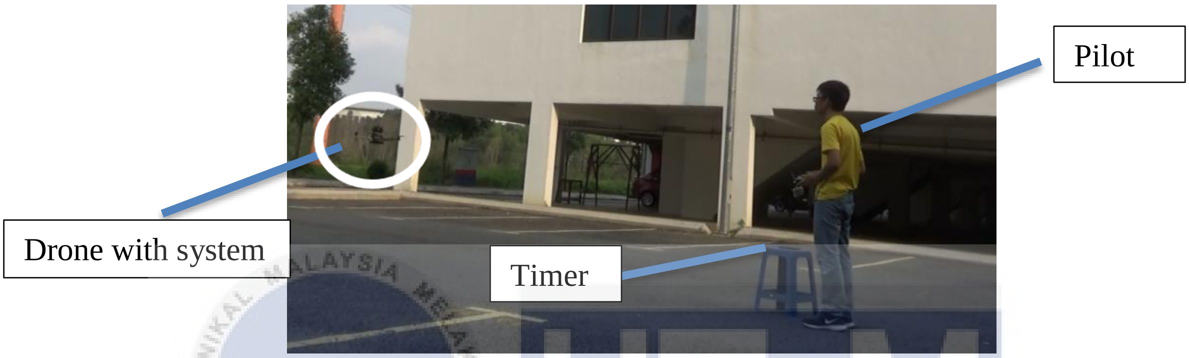


Figure 3.28: Payload test

3.7.2 Measure the error between real distance and the calculated distance when it is stationary

The system is prepared and the local area hotspot is setup (phone hotspot). After this the system and the drone is then turned on. The raspberry pi has an auto connected wi-fi and auto start scrip so as soon as the system is powered up it will automatically stream its camera to the local area network (192.168.43.18:8000/index.html). The ground station is also connected to the same network so that it can stream the video. Next the ground station is set up by opening a web browser to view the live streaming from the raspberry pi camera. Then start the terminal for ubuntu and find the prewritten program and run it. The sequence is shown in the figures.

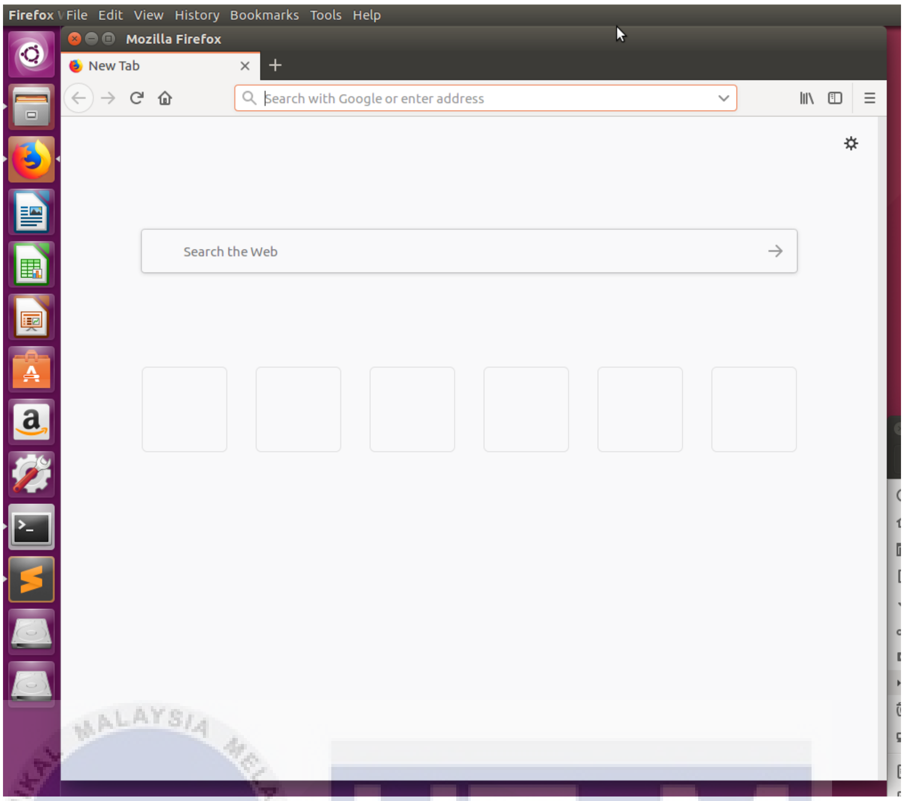


Figure 3.29: Start with opening a web browser

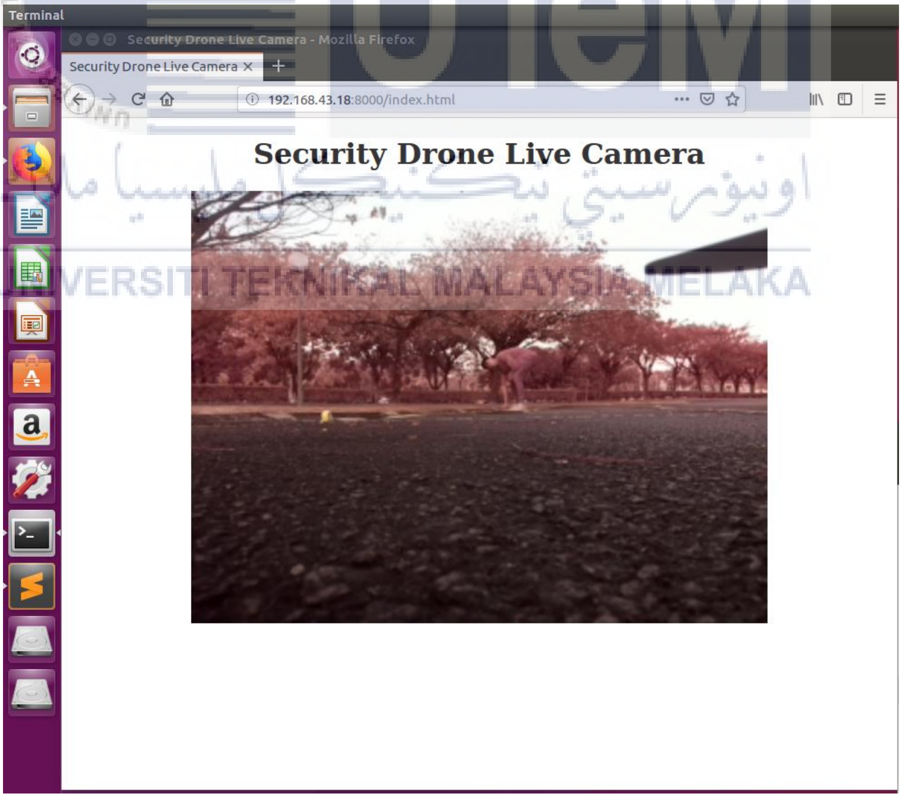


Figure 3.30: Search for 192.168.43.18:8000/index.html

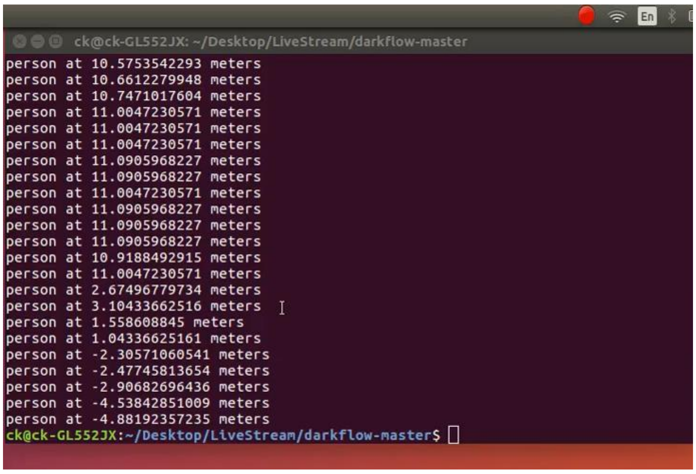


Figure 3.31: Go to the folder that contain the program code

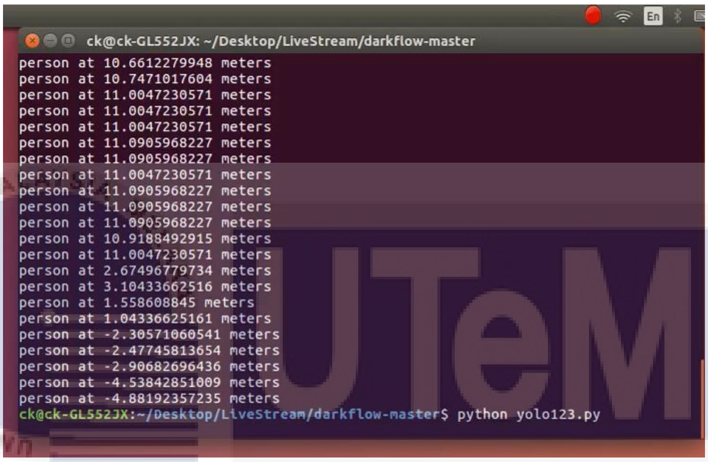


Figure 3.32: Run the python code

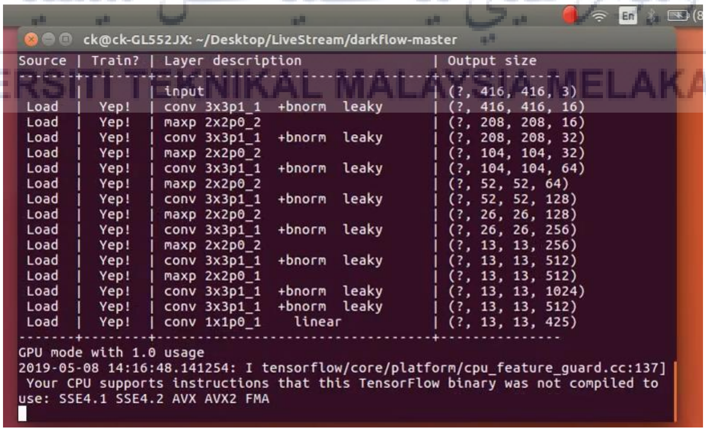


Figure 3.33: Wait for the program to finish running

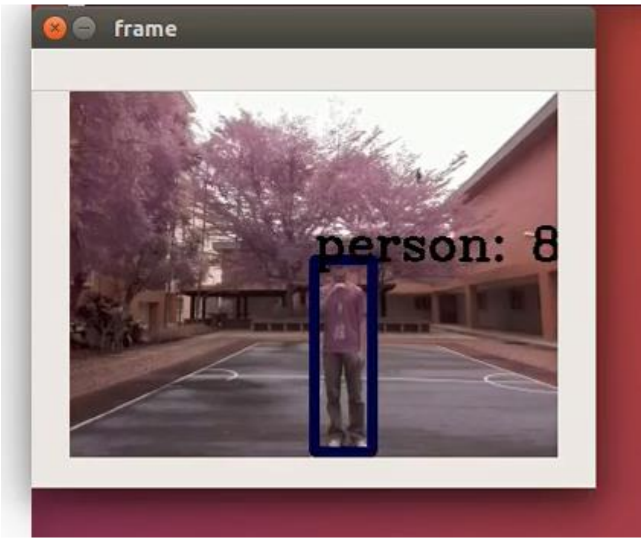


Figure 3.34: Wait for a frame that will show the processed images

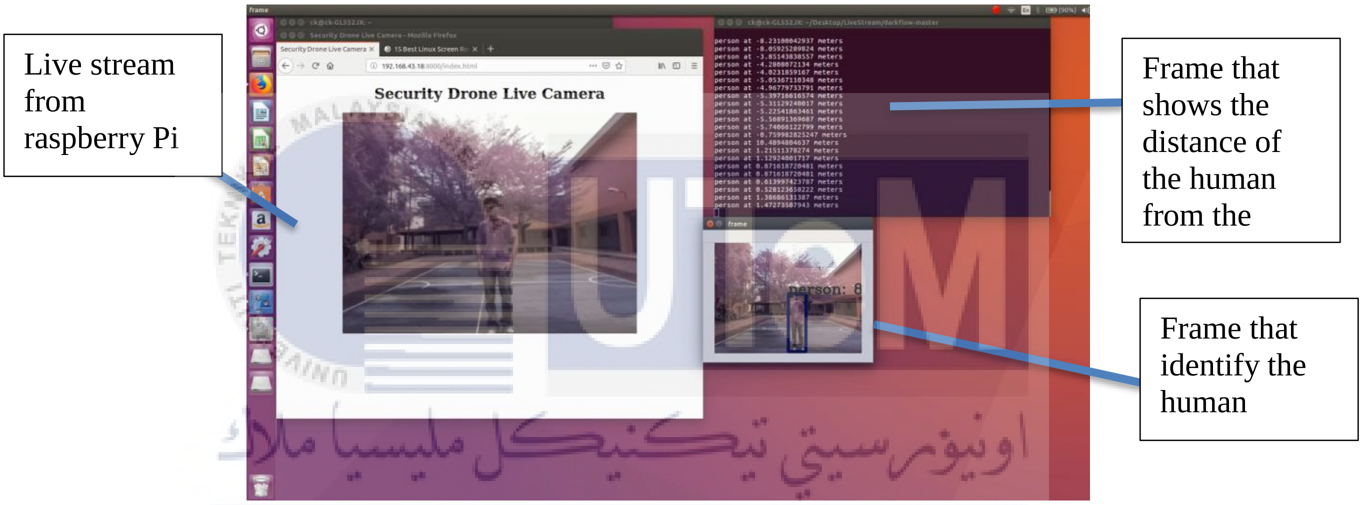


Figure 3.35: The screen after setting up everything

After setting up everything the ground system and the drone a person take the drone up to the chest level and a tester will start standing in front and away from the drone at 3 meters and the ground station will calculated the distance using the program. The obtained data is then tabulated into table 3.4. This procedure is then repeated for 4, 5, 6, 7, 8, 9, 10, 11, 12 meters. The layout of the experiment is shown in the figure 3.34.

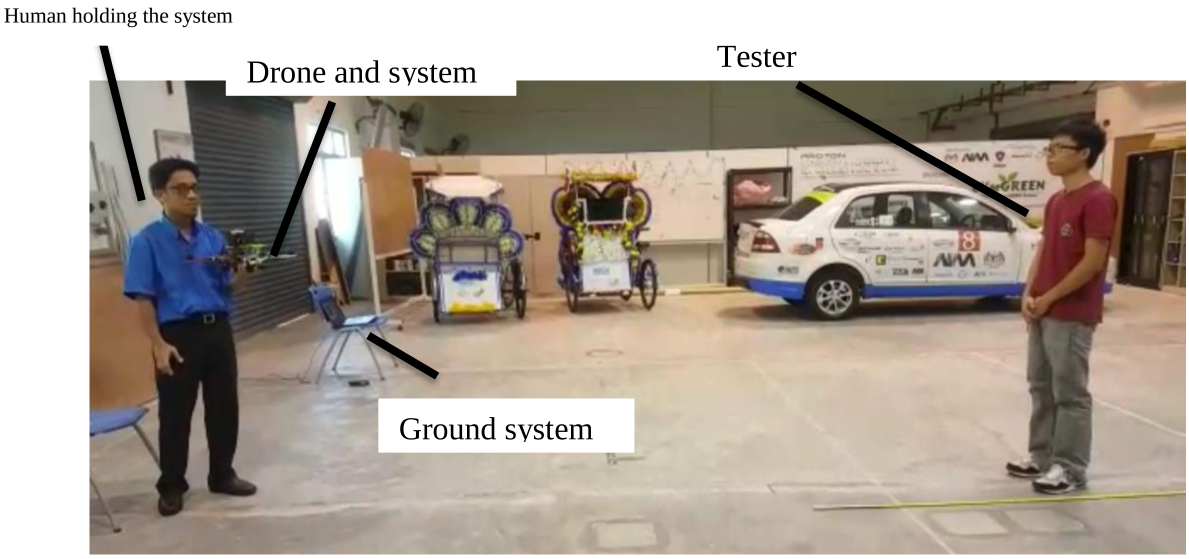


Figure 3.36: Setup for measure the error between real distance and the calculated distance when it is stationary

Table 3.4: Error between real distance and the calculated distance when it is stationary

Real Distance	Distance calculated by the system (Stationary)			Average	Error %
	Trial 1	Trial 2	Trial 3		
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

Table 3.4: Error between real distance and the calculated distance when it is stationary

The percentage relative error is calculated by using the formula below.

Percentage Relative Error (%) = (measured value – true value) / true value x 100%

3.7.3 Measure the error between real distance and calculated distance during flight

The setup is the same with the previous experiment but how instead of a human holding the drone the drone is flown by a pilot and the tester was moving away from the drone. The obtained data is then tabulated into table 3.5. This procedure is then repeated for 4, 5, 6, 7, 8, 9, 10, 11, 12 meters. The layout of the experiment is shown in the figure 3.34.

Figure 3.37: Setup for measure the error between real distance and calculated distance during flight

Table 3.5: Error between real distance and calculated distance during flight

Real Distance	Distance calculated by the system (Flight)			Average	Error %
	Trial 1	Trial 2	Trial 3		
3					
4					
5					
6					
7					
8					
9					
10					

11					
12					

3.7.4 Measure the miss rate of the system

The setup for this experiment is the same as the experiment before this. But instead of focusing on the distance sensing, the main focus of this experiment is on the miss rate of the system against different posture of human. The tester is to stand away from the drone and the system constantly at 5 meters away. Then the tester is to have different posture and the ground station will show whether it is a person or not. The posture includes facing the camera standing, ducking yaw with different degree to the camera, lying flat on the ground, moving in different speed. The data is then recorded and tabulated into the table 3.6.

Table 3.6: Miss rate against different human posture

Human posture	True positive Trial 1	True negative Trial 2	False positive Trial 1	False negative Trial 2
Facing camera standing				
Ducking				
Yaw with different degree to the camera				
0				
30				
60				
120				
180				

Lying flat on the ground				
Moving in different speed				
Slow (walk slowly)				
Moderate (walk)				
Fast (run)				

3.7.5 Measure the effectiveness of the system in different lighting condition

The setup for this experiment is the same with previous experiment but will focus on lighting condition of the experiment area. The system is tested in outdoor during a sunny and cloudy day and indoor with light on and lights off. The system should show whether it detects a person or not. The results is then recorded in the table 3.7.

Table 3.7: Miss rate against different lighting conditions

Lighting conditions	True positive Trial 1	True negative Trial 2	False positive Trial 1	False negative Trial 2
Outdoor				
Day (sunny)				
Day (cloudy)				
Indoor				
Day (without light)				
Day (with light)				

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Payload test (include the system)

An experiment on the payload that the system can carry to achieve optimum flight time is designed. The objective of this experiment is to test the ability of the quadcopter to fly for a certain amount of time. This is because the quadcopter must achieve a certain amount of flight time while carrying the system to be practicable.

Table 4.1: Flight time against voltage dropped (with system on it)

Weight of the system / grams	Flight time/ minutes					
	Trial 1 / min	Voltage dropped / v	Trial 2 / min	Voltage dropped /v	Trial 3 / min	Voltage dropped / v
175	10	0.93	10	0.89	10	0.95
	20	1.89	20	1.82	20	1.86
	30	2.77	30	2.87	30	2.85

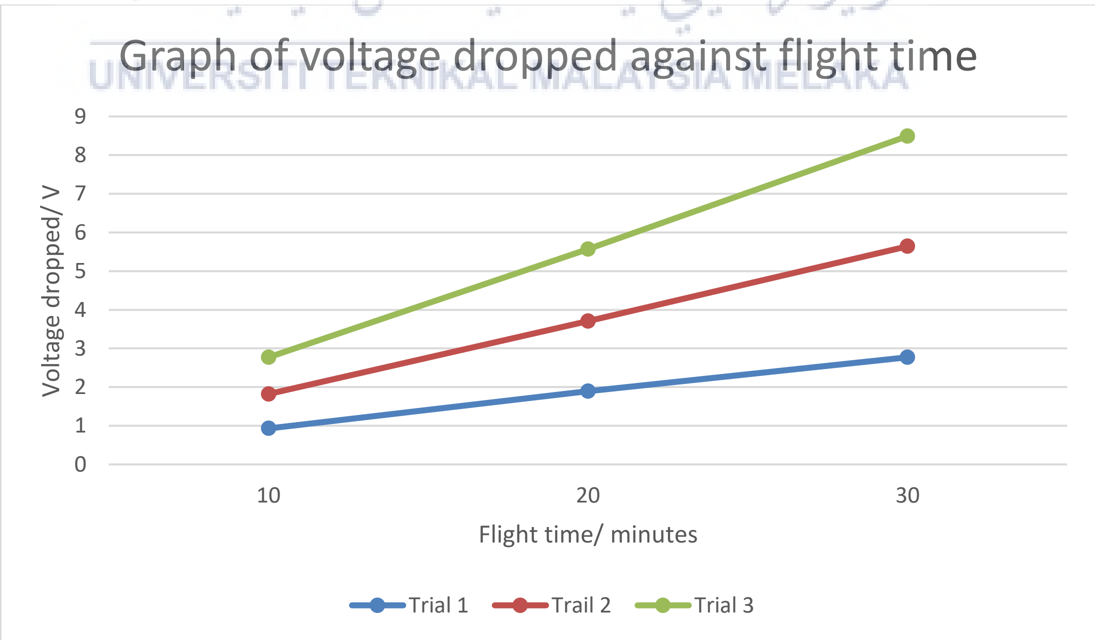


Figure 4.1: Graph of voltage dropped against flight time

The table 4.1 shows the voltage dropped for every 10 minutes through out all the trial runs the voltage have a consistent drop of around 0.9 volt per 10 minutes. For a 3S battery (12.6 volt) it is recommended to be used until the voltage drop to 9 volt which is a 3 volt drop to ensure the battery can be recharged and still be healthy after use. The table shows that even with the weight of the system on the drone it can still have a flight time of 30 minutes this is a good flight time consider the commercial drone nowadays can only fly for 15 to 20 minutes.

4.2 Measure the error between real distance and the calculated distance when it is stationary

Percentage Relative Error (%) = (measured value – true value) / true value x 100%

This experiment will test the accuracy of the system by testing system from 3 meters to 12 meters when the system is stationary. Using the above equation we can find the percentage error from the real distance.

Table 4.2: Error between real and calculated distance when it is stationary

Real Distance	Distance calculated by the system (Stationary)			Average	Error %
	Trial 1	Trial 2	Trial 3		
3	1.12	1.52	1.67	1.43	52.33
4	2.53	3.12	3.00	2.88	28.00
5	5.16	5.25	5.08	5.16	3.20
6	6.36	6.02	6.53	6.03	0.50
7	7.31	7.22	7.14	7.22	3.14
8	7.98	7.82	7.91	8.45	5.63
9	8.68	8.52	8.17	8.46	6.00
10	8.77	8.68	8.85	8.77	12.30
11	9.71	9.02	10.06	9.60	12.73
12	8.77	9.63	8.60	9.00	25.00

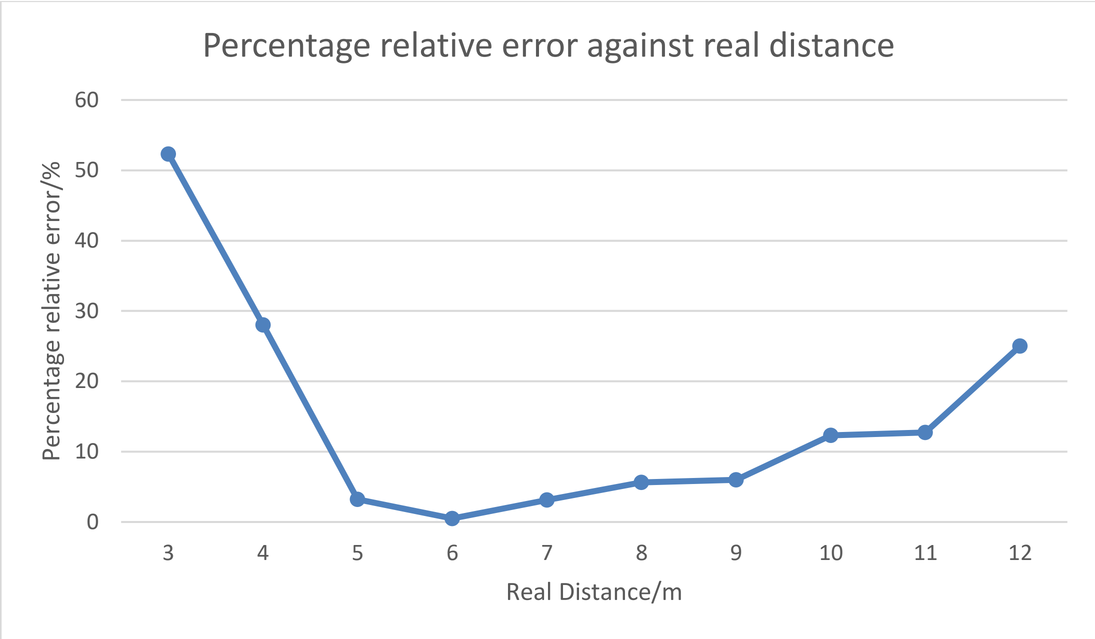


Figure 4.2: Percentage relative error against real distance

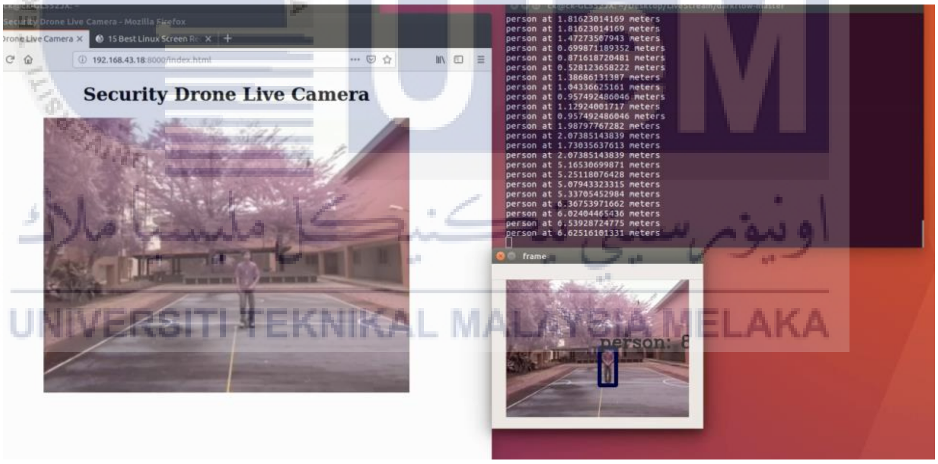


Figure 4.3: Results for distance calculated from the program when the drone is stationary

The results from the table shows that the error starting at 3 meters is very high then it becomes lower and lower as the tester is further and further away from the system until the tester is 7 meters then the error will start to increase again. This is because as the tester move further and further away from the system the changes in y axis pixel is decreasing until it is so small that the system cannot differentiate it. The accuracy from 5 to 7 meters is very high and is the desirable results. One of the factors affecting the accuracy is because of the processing power of the raspberry pi and the ground station. For this setup the raspberry pi can only stream video of 320x240 pixels to the ground station and the ground station is only capable of processing the video at 8 frames per seconds. If the video resolution is increased the ground station will not be able to process it at a reasonable speed. If the processing power of the ground station is increased the system can have a higher resolution and thus a more accurate data can be obtained.

4.3 Measure the error between real distance and the calculated distance during flight

Percentage Relative Error (%) = (measured value – true value) / true value x 100%

This experiment will test the accuracy of the system by testing from 3 meters to 12 meters when the system is hovering in the air. Using the equation from the previous experiment the percentage error is to be calculate.

Table 4.3: Error between real and calculated distance during flight

Real Distance	Distance calculated by the system (Flight)			Average	Error %
	Trial 1	Trial 2	Trial 3		
3	0.89	1.02	1.67	1.19	60.33
4	1.57	2.0	1.67	1.75	56.25
5	3.89	4.02	3.07	3.66	26.80
6	5.50	6.09	4.50	5.36	10.83
7	6.67	7.10	5.89	6.55	6.43
8	7.75	6.50	8.92	7.72	3.50
9	8.77	7.60	8.99	8.45	6.11
10	8.53	8.85	8.79	8.72	12.80
11	9.01	8.78	7.06	8.12	26.18
12	7.98	10.01	8.97	8.96	25.33

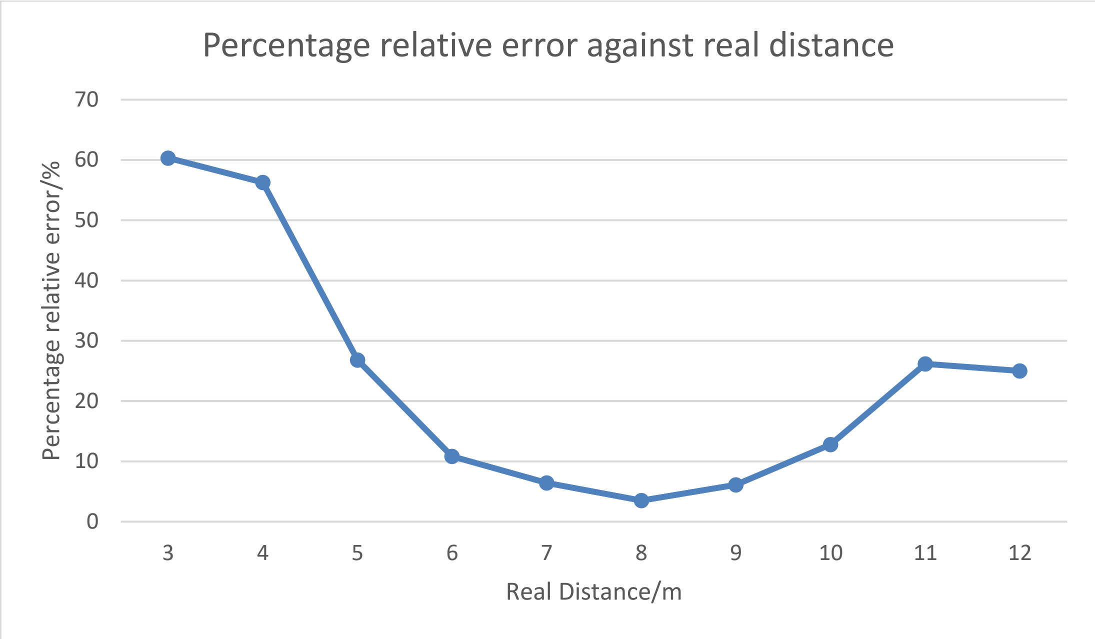


Figure 4.4 Percentage relative error against real distance

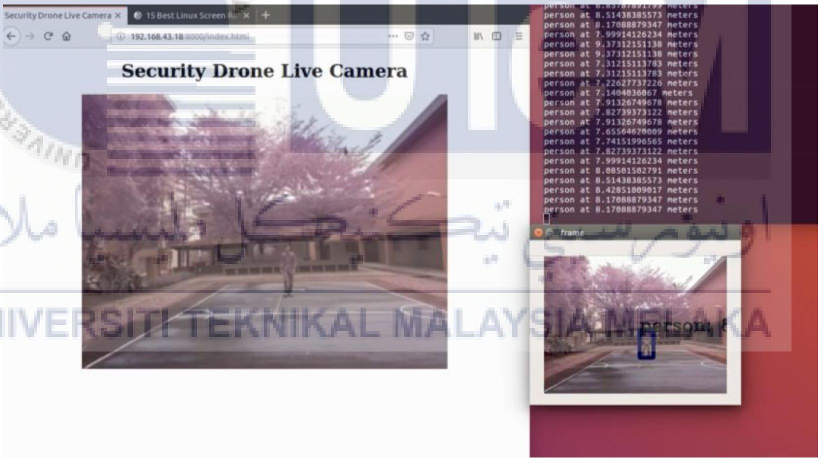


Figure 4.5: Results for distance calculated from the program of the drone during flight

From the table 4.3 we can see a similar trend as the experiment when it is stationary. The error will decrease until a certain point and then increase again when the tester is too far away. This is due to the same reasons mention in the previous discussion. But for this experiment it is noted that the relative error is higher than the previous experiment. This is because this drone does not have an onboard GPS. The onboard GPS can allow it to fly in loiter mode. This mode allows the drones to hover in place without the control of the pilot. Because this drone do not have a onboard GPS, it causes the drone to hover and move around and the pilot have to constantly fly it back to the original place. The increase in error is due to the fact that the drone is moving.

4.4 Measure the miss rate of the system

This experiment will test how accurate the system is able to detect human being in different posture and position. The subject is to do all kinds of posture and the system is to detect their presence during flight.

Table 4.5: Miss rate against different human posture

Human posture	True positive	True negative	False positive	False negative
Facing camera standing	✓			
Ducking	✓			
Yaw with different degree to the camera				
0	✓			
30	✓			
60	✓			
120	✓			
180	✓			
Lying flat on the ground				✓
Moving in different speed				
Slow (walk slowly)	✓			
Moderate (walk)	✓			
Fast (run)				✓

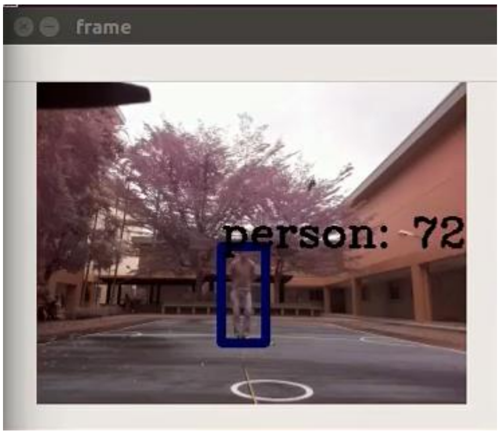


Figure 4.6: Facing the camera standing

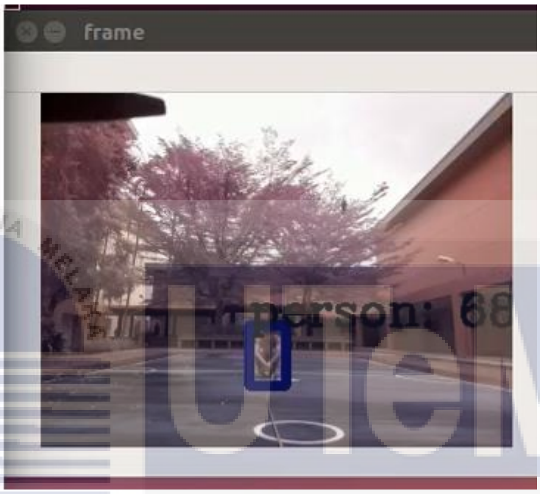


Figure 4.7 Ducking

Figure 4.8: Yaw in different degree to the camera

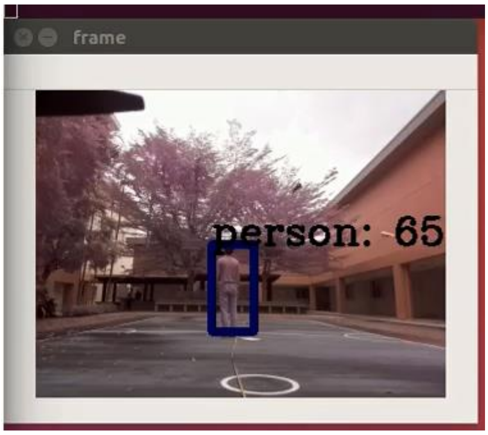


Figure 4.9: Yaw in different degree to the camera

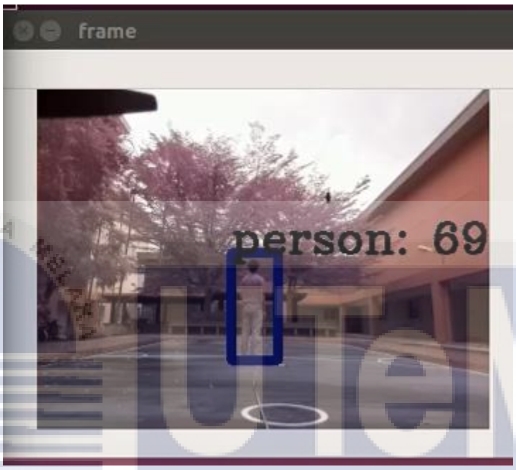


Figure 4.10: Yaw in different degree to the camera

Figure 4.11: Walking slowly

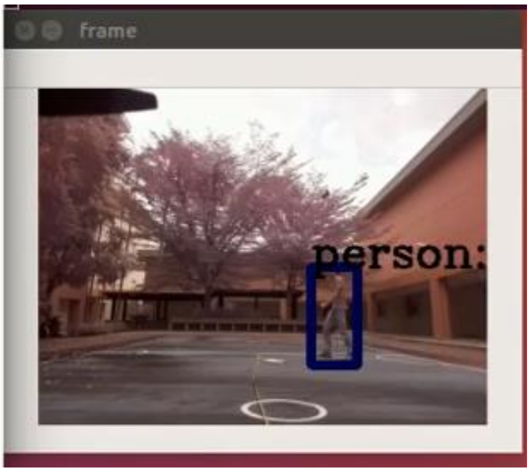


Figure 4.12: Walking at normal speed

Figure 4.13: Lying on the ground

From the table above we can see that the system is able to recognize the tester as a person for most of the posture. The system is unable to detect the tester when the tester run across the drone. This is because the processing power of the ground station is only 8 frames per second, and it cannot process the tester as it is too fast for the system to detect it. Another posture that the system triggered a false negative is the lying on the ground posture. The figure 4.10 shows that the system recognise this as a car instead of a person. This is because the “weight” used in the program does not train the image of a person lying flat on the ground. If we need the system to be able to detect it then we will need to retrain the “weights” for the system.

4.5 Measure the effectiveness of the system in different lighting condition

This experiment is to test the accuracy of the system in different lighting conditions. The result during the day is expected to be greatly higher than the results during the night.

Table 4.5: Miss rate against different lighting conditions

Lighting conditions	True positive	True negative	False positive	False negative
Outdoor				
Day (sunny)	✓			
Day (cloudy)	✓			
Indoor				
Day (without light)	✓			
Day (with light)	✓			

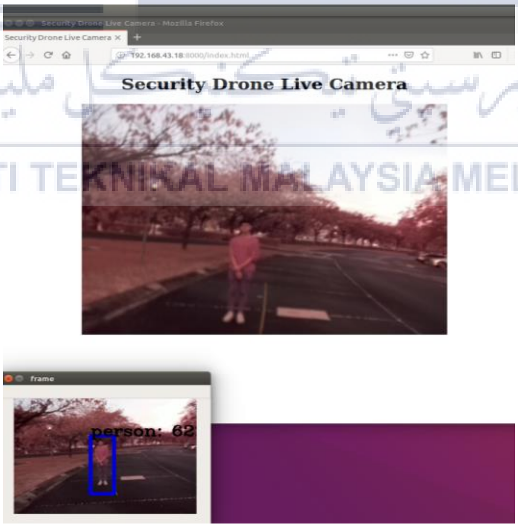


Figure 4.14: Outdoor Day (sunny)

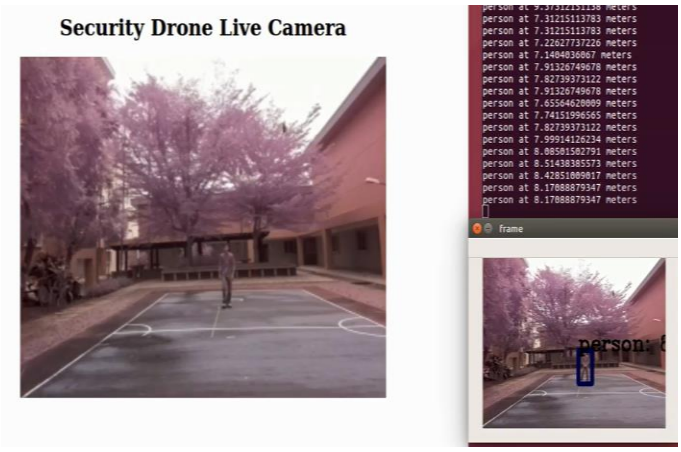


Figure 4.15: Outdoor Day (cloudy)

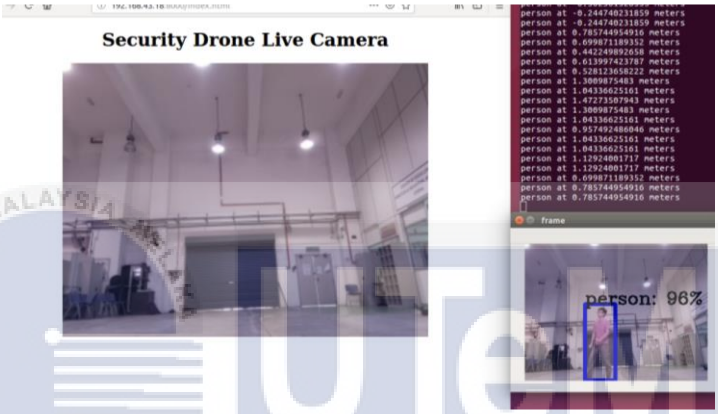


Figure 4.16: Indoor Day (with lighting)

Figure 4.17: Indoor Day (without lighting)

From the data obtained, we can see that the system is able to recognize the tester with a confidence level of more than 80 percent. It can recognize human in the day whether is sunny or cloudy for outdoor. It can even detect the tester in indoor condition with or without lighting. This is because the raspberry pi is equipped with the NOIR camera which can see with only some light. If during the night it will need an infrared blaster to enable it to see in the dark. With this accessory it can see in the night without any problem.

Chapter 5

Conclusion and recommendation

As a conclusion, all the objectives mentioned have been achieved and the scope of the project has been achieved as well. From this report we can conclude that estimation of distance of human from quadcopter using image processing method is a project full with a lot potential. This system can be used in a lot of different fields not just in surveillance. The accuracy of the system can reached up to 90 percent of the real distance but onl within a certain range of 5 to 9 meters. If there are more data sets and a better hardware better results can be achieved.

There are recommendation that can made to the system to further improve the system. First the ground station should have a better processing power and a dedicated graphic processing unit to enable the system to process the live stream in 60 frames per second. The raspberry pi can also be replaced by google coral or jetson nano for this kind of process. With this kind of small computers the system is able to process the image on board with around 25 frames per seconds and thus there will be no need of ground processing unit. The camera can also be replaced by a thermal imaging camera or a night vision camera to enable the system to see in the dark.

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APPENDIX A

Coding for human distance sensing and recognition

```
import cv2
from darkflow.net.build import TFNet
import time
import numpy as np

options = {
    'model': 'cfg/yolov2-tiny.cfg',
    'load': 'bin/yolov2-tiny.weights',
    'threshold': 0.6,
    'gpu': 1.0
}

tfnet = TFNet(options)
colors = [tuple(255 * np.random.rand(1)) for _ in range(1)]

url='http://192.168.43.18:8000/stream.mjpg'


capture = cv2.VideoCapture(url)

capture.set(cv2.CAP_PROP_FRAME_WIDTH, 320)
capture.set(cv2.CAP_PROP_FRAME_HEIGHT, 240)

#time.sleep(5)



while True:
    stime = time.time()
    ret, frame = capture.read()
    if ret:
```

```
        results = tfnet.return_predict(frame)
        for color, result in zip(colors, results):
            tl = (result['topleft']['x'], result['topleft']['y'])
            br = (result['bottomright']['x'], result['bottomright']['y'])
            label = result['label']
            difx = (result['bottomright']['x'] - result['topleft']['x'])
            dify = (result['bottomright']['y'] - result['topleft']['y'])
            area = (difx*dify)
            meters = ((dify-143.15)/-11.645)
            confidence = result['confidence']
            text = '{}: {:.0f}%'.format(label, confidence * 100)
            frame = cv2.rectangle(frame, tl, br, color, 5)
            frame = cv2.putText(frame, text, tl, cv2.FONT_HERSHEY_COMPLEX, 1, (0, 0,
0), 2)
            cv2.imshow('frame', frame)
            print (label),
            print ("at"),
            print (((dify-143.15)/-11.645)),
            print ("meters")
        #print('FPS {:.1f}'.format(1 / (time.time() - stime)))

        # print (label),
        # print ("at"),
        # print (((dify-143.15)/-11.645)),
        # print ("meters")

    if cv2.waitKey(99) & 0xFF == ord('q'):
        break

capture.release()
cv2.destroyAllWindows()
```

APPENDIX B

Coding for livestreaming from raspberry pi

```
#!/usr/bin/python3

# Web streaming example
# Source code from the official PiCamera package
# http://picamera.readthedocs.io/en/latest/recipes2.html#web-streaming

import io
import picamera
import logging
import socketserver
import socket
from threading import Condition
from http import server

PAGE="""\
<html>
<head>
<title>Security Drone System</title>
</head>
<body>
<center><h1>CK </h1></center>
<center><img src="stream.mjpg" width="640" height="480"></center>
</body>
</html>
"""

def get_ip_address():
   ip_address = '';
   s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
```

```
    s.connect(("8.8.8.8",80))
    ip_address = s.getsockname()[0]
    s.close()
    return ip_address


class StreamingOutput(object):
    def __init__(self):
        self.frame = None
        self.buffer = io.BytesIO()
        self.condition = Condition()

    def write(self, buf):
        if buf.startswith(b'\xff\xd8'):
            # New frame, copy the existing buffer's content and notify all
            # clients it's available
            self.buffer.truncate()
            with self.condition:
                self.frame = self.buffer.getvalue()
                self.condition.notify_all()
            self.buffer.seek(0)
        return self.buffer.write(buf)

class StreamingHandler(server.BaseHTTPRequestHandler):
    def do_GET(self):
        if self.path == '/':
            self.send_response(301)
            self.send_header('Location', '/index.html')
            self.end_headers()
        elif self.path == '/index.html':
            content = PAGE.encode('utf-8')
            self.send_response(200)
            self.send_header('Content-Type', 'text/html')
```

```
            self.send_header('Content-Length', len(content))
            self.end_headers()
            self.wfile.write(content)
        elif self.path == '/stream.mjpg':
            self.send_response(200)
            self.send_header('Age', 0)
            self.send_header('Cache-Control', 'no-cache, private')
            self.send_header('Pragma', 'no-cache')
            self.send_header('Content-Type', 'multipart/x-mixed-replace; boundary=FRAME')
            self.end_headers()
            try:
                while True:
                    with output.condition:
                        output.condition.wait()
                        frame = output.frame
                    self.wfile.write(b'--FRAME\r\n')
                    self.send_header('Content-Type', 'image/jpeg')
                    self.send_header('Content-Length', len(frame))
                    self.end_headers()
                    self.wfile.write(frame)
                    self.wfile.write(b'\r\n')
            except Exception as e:
                logging.warning(
                    'Removed streaming client %s: %s',
                    self.client_address, str(e))
        else:
            self.send_error(404)
            self.end_headers()

class StreamingServer(socketserver.ThreadingMixIn, server.HTTPServer):
    allow_reuse_address = True
    daemon_threads = True
```

```
with picamera.PiCamera(resolution='640x480', framerate=24) as camera:
    output = StreamingOutput()
    #Uncomment the next line to change your Pi's Camera rotation (in degrees)
    #camera.rotation = 90
    camera.start_recording(output, format='mjpeg')

    try:
        ip_address=get_ip_address()
        ip=(ip_address,5050)
        address = ip
        server = StreamingServer(address, StreamingHandler)
        server.serve_forever()
    finally:
        camera.stop_recording()
```