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MULTY-SENSORY CONTROL SYSTEM FOR REMOTELY CONTROL SURFACE VESSEL

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Bachelor of Mechatronics Engineering

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"I hereby declare that I have read through this report multy-sensory control system for remotely control surface vessel and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic)"

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A report submitted in partial fulfillment of the requirements for the degree of Mechatronic Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

"I declare that this report entitle this report multy-sensory control system for remotely control surface vessel is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

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ABSTRACT

Surface vessel with wireless control provides an alternative ways to deploy ROV. The additional on multi-sensory control system makes the surface vessel more reliable for transporting ROV into the specific point before release it down into the water. This system enables the surface vessel to avoid the obstacle in front of it while waiting the operator to turn out direction of the surface vessel in case the operator can't see the obstacle in front of the surface vessel because of the distance between them are far. The first objective is for this project is to develop surface vessel enable to deploy the ROV. The second objective is to develop wireless control with suitable sensor use for navigation system. For this objective, it will be carry out by undergo the experiment which is comparison between the two types of sensor which are ultrasonic sensor and IR sensor. The third objective is about the performance of the surface vessel. There are two experiments carried out for the third objective of this project which are the different weight of the ROV or load can affect the time taken to it drops down into the water and the size of propeller is affect the speed of surface vessel.

ABSTRAK

Kapal permukaan dengan kawalan tanpa wayar memberikan suatu jalan lain untuk menggerakkan ROV. Sebagai tambahan pada kawalan sistem pelbagai pengesan ia membuatkan kapal permukaan menjadi lebih dipercayai untuk membawa ROV ke suatu titik tertentu sebelum melepaskan ia ke dalam air. Sistem ini membolehkan kapal permukaan untuk menggelak halangan yang berada dihadapannya sementara menunggu operator untuk menukar arah kapal permukaan apabila berlaku kes operator tidak perasan terdapat halangan yang berada di kapal permukaan kerana jaraknya antara mereka sudah jauh. Objektif pertama projek ini ialah untuk membina sebuah kapal permukaan yang boleh membawa ROV. objektif kedua ialah membina kawalan tanpa wayar dengan pengesan yang bersesuaian untuk digunakan pada navigasi system. Bagi objektif ini satu eksperimen dijalankan bagi membandingkan pengesan diantara pengesan Ultrasonik dan pengesan IR. Objektif ketiga mengenai prestasi kapal permukaan. Terdapat dua eksperimen dijalankan pada objektif ketiga ini iaitu perbezaan berat atau beban memberi kesan kepada masa diambil untuk ROV turun sepenuhnya kedalam air dan size kipas mempengaruhi kelajuan kapal permukaan.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The ROV moves underwater for monitoring the underwater view. Before it goes down to the underwater, it needs a vessel to carry it to specific point before release it. Surface vessel is created for deploying the ROV. Surface vessel will moves on the water to specific point then discharge the ROV into the water. The communication used for the surface vessel is wireless communication.

The method for the surface vessel to drop the ROV is linear drop by cylinder rod. This surface did not use tugs method like a crane to drops the ROV on the water. The navigation of surface vessel not limited onto the operator control the surface vessel but the sensors that implement on the surface vessel will help the surface vessel to avoid the obstacle. Therefore, the design of surface vessel with wireless communication is meant to make works simple.

1.2 Motivation

The underwater vehicle that is used to monitoring the undersea view requires a complicated operation before it goes down to the sea. The ROV needs some medium or transportation to transport it into the water. It will be simply the work if the ROV can be carried into the destination whereby it can be discharged by operate it with wireless control. Thus, the multi sensory surface vessel with wireless control are require to help in deploying the ROV into the sea.

1.3 Problem statement

The problems of the surface vessel nowadays is requires expensive big ship to deploy the ROV. The uses of big ship need more manpower for the beginning operation which is to moves the big ship into the water from shore. Therefore, the desire to launch the surface vessel together with ROV from shore must be considered to reduce the manpower for the beginning operation.

Surface vessel with cable wire control has limit control area. The surface vessel that use the cable wire must depends on how long the cable wire is. The long wire is easily knotted. Mostly surface vessel used is not always wireless control. It's an option that we want to take to develop the wireless surface vessel. Surface vessel needs another device for navigation if the remote control operated by human did not notice there is an obstacle in front of surface vessel.

1.4 Objectives

The objectives of this project are:

1. To develop surface vessel enable to deploy the ROV.
2. To develop the wireless remote control with suitable sensor use for navigation steering system.
3. To evaluate the performance of surface vessel on the water in terms of the time taken for the ROV slot base to move down completely by using different weight and the speed of surface vessel with different size of propeller.

1.5 Scopes and limitation

The scope of this project consists of:

1. The design of surface vessel is meant for on the water only. It moves on the water with ROV attach on it.
2. Surface vessel must carry the ROV without drops it at the wrong point.
3. The suitable sensor to use at the surface vessel for detecting obstacle in certain range.
4. The performance of surface vessel in terms of weight of ROV and the speed of motor by using difference size of propeller.

The limitation for this project is the size of surface vessel is not necessary bigger as it must follow the ROV size to attach on it. The ROV used in this project is not in the actual size. This project model the size of ROV.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Surface Vessel (SV) is designed for deploying the ROV. The communication used on the SV is wireless communication with several implanted sensors that helps it on the navigation system. This section reviews the important elements of surface vessel. The first element is the study of discharging ROV from SV, which explains the deployment configuration mounts the ROV above the SV. The second element is the detection of obstacle by sensor. The sensors use to detect object in front of it and have its detection range. Different type of sensor has different detection range. The last element is the component selection of actuator used for discharging ROV. In this element, the comparison between three types of actuator will be explained later.

2.2 THE DISCHARGING ROV METHOD BY SURFACE VESSEL

Accurate predictions of the hydrodynamic loads are important at the design stage as well as in operation, particularly during the launch and recovery phases when snatching of the tether may occur [1]. This paper introduce about the linear dropping load by moving the shaft downward. The shaft holds the load cover slot and moves downward to the sea water. Figure below is the experiment setup by this paper. It illustrates on how the dropping load works.

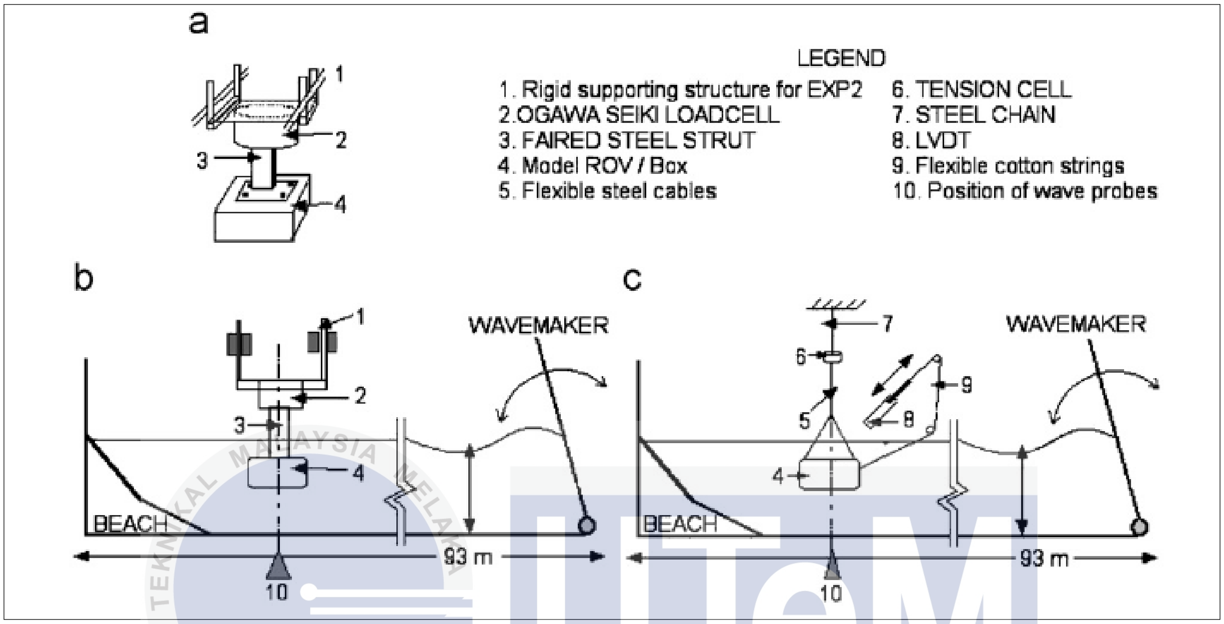

Figure 2.1 Experiment setup and the legend for discharging load [1].

The other method to discharging the ROV is with using crane. Two main types of vessel regularly used are the anchor handling or support tug, and the offshore (preferably stern) trawler [2]. In this method, the uses of hydraulics are the main part because it carries the heavy load such as ROV. Figure 2.2 shows about the crane discharging ROV.

Figure 2.2 The Stem Mounted Crane

2.3 OBSTACLE DETECTION BY SENSOR

When SV moves on the water, any obstacle lying in the path of the vehicle can give potential to damage threat. The obstacles can be avoided by the navigation plan that use the valuable information obtained to the SV. This information was provided from the inclusion data of a forward looking. Based on the paper (Martin, An, Nelson, & Smith, n.d.), sonar sensor transmits a single beam. The beam itself is deflected using phased array technique to sweep along a vertical plane [3]. The sonar sensor has following specification [4]:

Operating frequency	: 650 kHz – 950 kHz
Bandwidth, Vertical	: 40° at 650 kHz, 35° at 800 kHz, 30° at 950 kHz
Bandwidth, Horizontal	: 3.0° at 650 kHz, 2.5° at 800 kHz, 2.0 at 950 kHz
Range setting	: From 5m to 100m

Figure below explains the range of sonar sensor and its bandwidth by AUV.

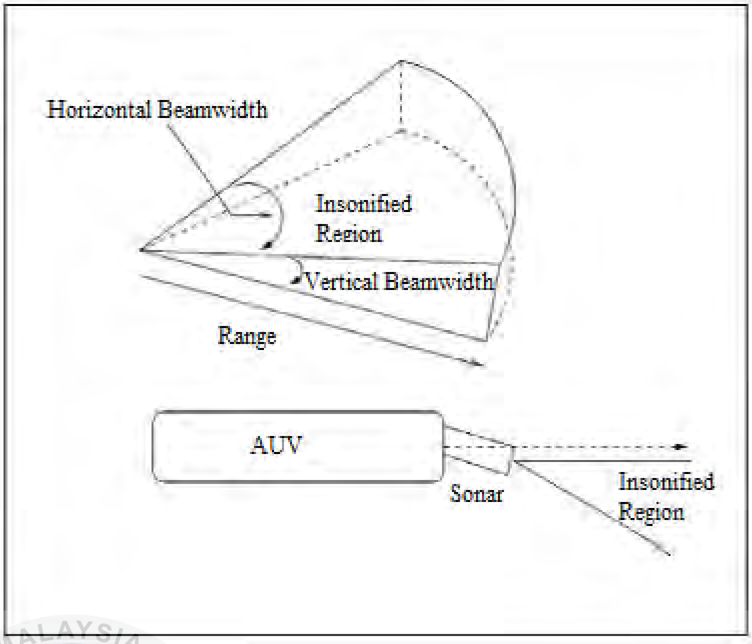

Figure 2.3 AUV with Sonar sensor and its bandwidths [6]

Another sensor that can detect the obstacle is Infrared sensor (IR). The Infrared sensor consists of one infrared LED and a pair of silicon phototransistors [5]. The phototransistor is used to detect the energy reflected by an obstacle from LED [5]. The signal returned from the sensor is dependent on the energy emitted from LED and the detectable range of the photo-transistors. The distance for the infrared sensor to detect the obstacle is less than 45 cm [5]. The infrared sensor can't detect object above than 45 cm is because were indistinguishable due to the lack of energy detected by the phototransistors. Paper (Wu, Chen, Jiang, Yu, & Yu, 2010) states that the Infrared sensor can be classified into two categories which are:

1. Un-cooled thermal infrared sensor
2. Photon infrared sensor

The un-cooled thermal infrared sensor can be function at room temperature without any expensive cryogenic cooler, which makes it suitable for many cost sensitive applications compared to the photon infrared sensor [6].

The Ultrasonic sensor (US) widely used to measure the distance because of its wide beam – width, sensitivity to specula surfaces. The Ultrasonic sensor can generate frequency sound waves of 310 kHz by range from 50 mm to 400 mm [5]. This sensor can calculate the time interval between sending and receiving the echo to determine the distance to an object [5]. Ultrasonic sensor produce mostly accurate representation of the object distance with various distance but it's difficult to face the object with round shaped. They are useful under conditions of poor lightning and transparent objects. Figure below describe the area of detection object between 2 types of sensor.

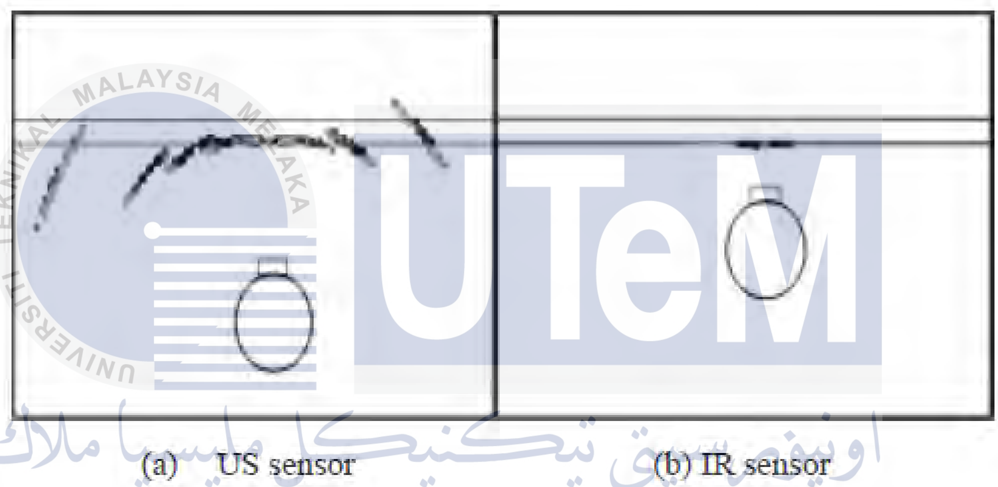

Figure 2.4 Distance data from the flat surface [5]

Ultrasonic sensor is high resolution compare to the infrared sensor [4]. This paper states that accuracy percentage for ultrasonic sensor is higher than infrared sensor which are about 90% to 97% compare to the infrared sensor which is 92% to 95% accuracy percent. This paper also state that the standard error for ultrasonic sensor is lower range than the standard error for infrared sensor.

2.4 ACTUATORS FOR DISCHARGING ROV

2.4.1 TYPES OF ACTUATORS

Pneumatic cylinder has several advantages which are easy maintenance, convenient assemblage, clean operating condition, higher reliability and lower cost [7]. In addition, pneumatic cylinders are light weight and can be readily installed using common compressed air supplies [8]. The pneumatic cylinder also has the limitations which are:

1. Relatively low accuracy

   – As pneumatic systems are powered by the force provided by compressed air, their operation is subject to the volume of the compressed air. As the volume of air may change when compressed or heated, the supply of air to the system may not be accurate, causing a decrease in the overall accuracy of the system.

2. Low loading

   – The cylinders of pneumatic components are not very large. Therefore, a pneumatic system cannot drive loads that are too heavy.

3. Processing required before use

   – Compressed air must be processed before use to ensure the absence of water vapor or dust. Otherwise, the moving parts of the pneumatic components may wear out quickly due to friction.

4. Inconsistent moving speed

   – The air can easily be compressed which resulted the moving speeds of the pistons are relatively inconsistent.

5. Noise

   – Noise will be produced when compressed air is released from the pneumatic components.

The hydraulic cylinders use an incompressible fluid so the force applied at one point is transferred to another point. Based on paper (Huang & Cao, 2011), hydraulic cylinders have following superiority [9]:

- Realizing step less speed regulating in large field.
- Each component of fluid drive can be arranged conveniently and neatly in requirement.
- Easy operating, convenient controlling and easy to realize automation and remote control.
- Working substance generally uses mineral oil, and can self-lubricating compared with motion surface.

Meanwhile the disadvantages of hydraulic cylinder are stated from paper (Zhao, Chen, & Chen, 2009) are [10]:

1. Unstable hydraulic oil behavior

   – The compressibility of the hydraulic fluid and the working temperature change lead to oil density variation, which is an important inaccuracy sources.

2. Hydraulic system leakage

   – In the high pressure, all hydraulic system exist certain leakage. This can cause the position keeping capacity of cylinder to lose, and other serious consequences.

3. Working loads variation

   – Due to many random effects, the working loads may not always keep consistent.

Electrical actuated systems is easy to interface with control system in which the electrical actuated uses electricity and it is easy available unlike fluid power which require pumps and compressor. The advantages of electric actuator systems are it offers lighter weight, increased reliability, maintainability and operability and improved safety through the elimination of high pressure and hazardous fluids. Besides that, electric actuators have an intrinsic simplicity and low cost that makes it suited to many applications [11].

2.4.2 ACTUATOR SELECTION

The selection of the actuator for discharging ROV is between electric actuator, pneumatic actuator and hydraulic actuator. Table 2.1 below shows the comparison between 3 types of actuators.

Table 2.1 The comparison between 3 types of actuator [12]

	Electrical Actuators	Hydraulic Cylinders	Pneumatic Cylinders
Installation	All electric operation requires simple wiring.	Requires expensive plumbing, filtering, pumps	Requires expensive plumbing, filtering, pumps
Accuracy	Very repeatable (to ± 0,013 mm) and rigid, multi-stop capabilities.	Requires expensive position sensing and precise electro-hydraulic valving to	Difficult to achieve. Requires expensive position sensing and precise valving to

		implement, has tendency to creep.	implement, has tendency to creep.
Speed	Smooth, variable speed with from 0 to 2 m/s with controlled acceleration.	Difficult to control accurately. Varies with temperature and wear. Stick slip can be a problem.	More susceptible to stick slip and varying load. Well-suited for light high speed applications.
Reliability	Repeatable, reproducible performance during the entire product life. Very little maintenance required.	Very contamination sensitive. Require regular maintenance. Seals are prone to leak. Reliable with diligent maintenance.	Very contamination sensitive. Air sources require proper filtration. Good reliability, but usually many system components are involved.
Power	Up to 40 000 N	Virtually unlimited force. Most powerful.	Up to 25 000 N. Typically used below 6000 N.
Cost	Moderate initial cost, very low operating cost.	Hydraulic power unit cost is high.	Components often cost less, but installation and maintenance are increased.

The selection of the actuator is based on easy installation, good in accuracy and low cost. Among these selection criteria, electrical actuator meets the requirement. Electrical actuator requires simple wiring and no need expensive plumbing, filtering and pumps. Besides that, electrical actuator is very repeatable and rigid in accuracy. It doesn’t need expensive position sensing and valve components to implement. Lastly, electric actuator is low operating cost. Although it is moderate initial cost compare to the pneumatic actuator, but when it comes for the installation and maintenance, the pneumatic actuators are costly.

2.5 LITERATURE CONCLUSION

In conclusion, the method for discharging the ROV by SV used is linear drop by shaft method instead of using crane. It is most suitable because it is more stable when discharging ROV onto the water. ROV will not swag when dropping it to the water because on that time, the ROV also is completely in static. The sensor use is Ultrasonic sensor. This sensor can detect object with higher resolution than Infrared sensor and low cost compare to the Sonar sensor. The actuator used for discharging ROV is electrical actuator. Although the method of discharging ROV is linear drop downward by shaft is describe on paper using a hydraulic actuator, the actuator can be replace by the electrical actuator. In this case I choose the same method meanwhile the discharging ROV actuator used is electrical actuator. The actuator uses is depending on what load it holds. For this project, the ROV is a modeling not following the actual size and the less weight. Hydraulic cylinder is suitable for weight load.

CHAPTER 3

METHODOLOGY

3.1 Design Process

3.1.1 Project flow chart

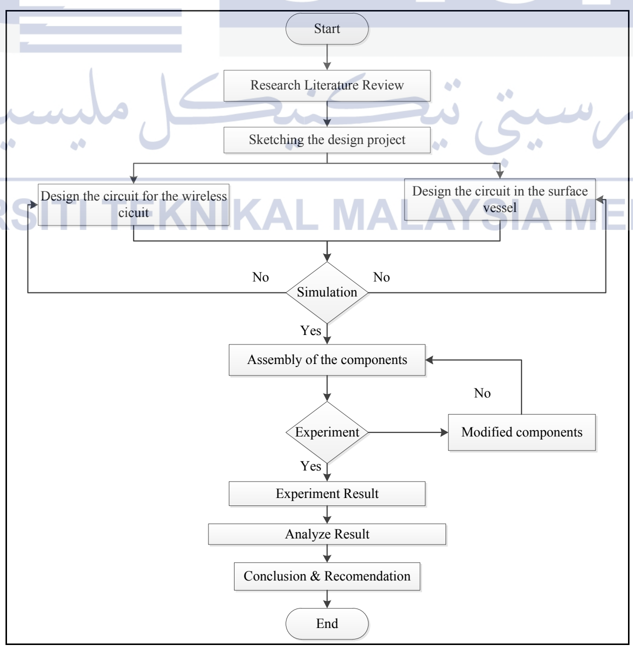

Figure 3.1 Project flow chat

The project is conducted for one year. The first half year project or PSM 1 is about proposing the project then the other half year or PSM 2 is about hardware assembly the components of project. The project flow chart is starting from research the literature review that relates to the project. The components selection is done in literature review. Literature review is the very important part for designing the project. After meets the selected components, the next process is to design the sketching project. The sketching design project can be done by using solid work software. The next process is designing the circuit inside the surface vessel. The circuit inside of the surface vessel was designed by using the Fritzing and Arduino software. The fritzing software design the electronic components connection while the Arduino software is for the programing part. The circuit was simulated after the design process was done. If the simulation is success, then continue to the next stage which is assembly the components. In this part, all the components have been gathered and assembling them was taken a few weeks to complete it. The assembly process consists of the surface vessel development and the wireless remote control for controlling the surface vessel. The next process is to test the assembled project with the experiment that has been prepared from the PSM 1. This experiment is required to achieve the objective project. If the experiment conducted seems not give what the result we expected, the components need to be adjusted. Otherwise, if the experiment is successfully give the good result, and then analyze the results. Then continue to the last process which is makes the conclusion and the recommendation for the project.

3.1.2 Operation flow chart

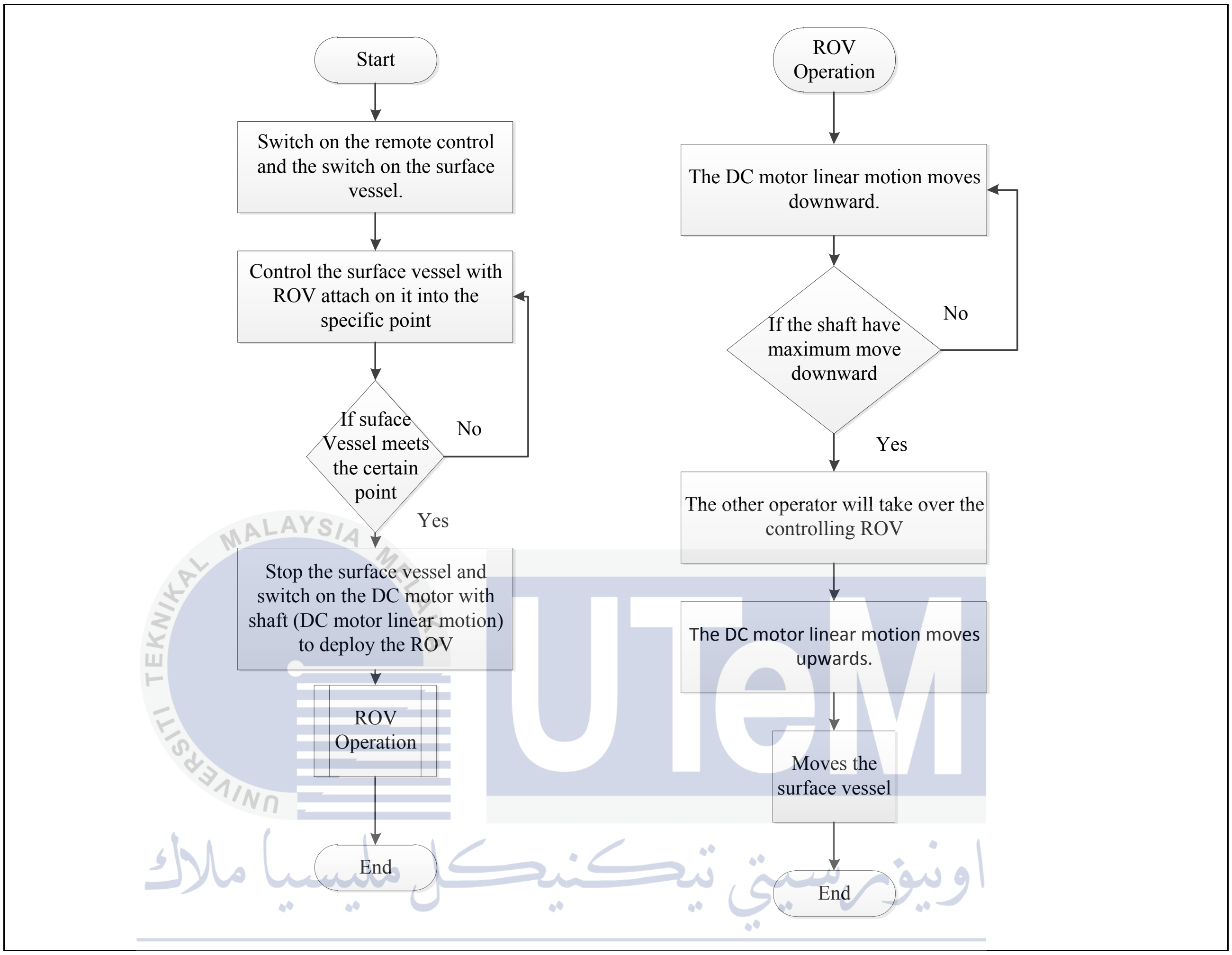

Figure 3.2 Operation flow chart

The operation flow chart is describing about the surface vessel operation flow process. The process is beginning with the switch on the remote control and switch at the surface vessel is turned on. The surface vessel can be controlled by using remote control to drive it to the specific point. The surface vessel moves with the ROV attach on it. If the surface vessel meets the points where it deploys the ROV, the surface vessel stops and the switch button for the DC motor linear motion turned on. The DC motor linear motion moves the cylinder rod downward onto the water. The end of the cylinder rod holds the ROV slot base. The rod is continuously moves downward until it reaches the maximum length. The cylinder rod stops and after that the operator of ROV will take controls the ROV to the desired point. After the ROV has discharge from the ROV slot base, the cylinder rod moves upward back to the original position. At this point, the DC motor linear motion will be controlled by switched it off from the wireless remote control. After the cylinder rod completely moves upward, the surface vessel continue to move.

3.2 Design Project

3.2.1 Hardware

<u>7007 RC Boat Body</u>

The material used for the body of boat is plastic. This material is mostly available anywhere for an RC boat. Plastic material is a lightweight material. The reason I choose this material is because the cost is inexpensive. The 1001 RC boat will be use 2 body to form the surface vessel.

Figure 3.3 The body part of surface vessel

Iron plat

The iron plate is used at the center of the surface vessel body to store the circuit casing box. The casting box is made of plastic and it store all the circuit that control the surface vessel. This material was selected because it has strong properties of material. The iron plat also is used to mount the DC motor linear motion and as the ROV slot base.

Figure 3.4 The iron plate

Aluminium

The small size of aluminium is used to join the two RC boats. While the large size of aluminium is used as the ROV slot frame. This material is lightweight material and it is easy to make a hole by drilling it with drilling tool. The drilling hole purpose is to insert the screw so the two materials will combine together.

Figure 3.5 The Aluminium

CL-SK024R

CL-SK024R is the RC Boat circuit that used for receiving and transmitting the signal or the wireless control. This wireless control circuit also controls the DC motor.

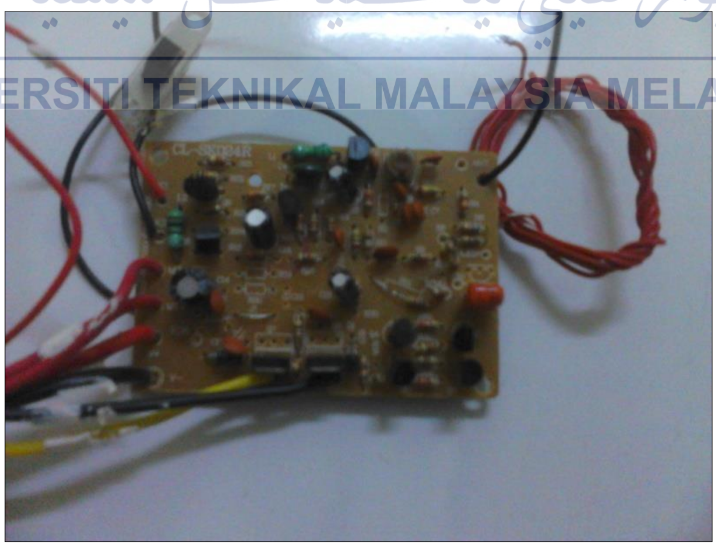

Figure 3.6 The CL-SK024R RC boat circuit

MX-JM05V 4 Channel Wireless Control

MX-JM05V is another wireless device that is used to control DC motor linear motion. It have 4 channel wireless communication but for this project it only use 2 channel in which it control the direction of DC motor forward and backward by switching the buttons.

Figure 3.7 The 4 channel wireless control

Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins. 6 pins of it can be used as PWM outputs. It have 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino Uno in surface vessel works to controls the motor when the sensor detects the obstacles.

Figure 3.8 The Arduino Uno

L298 Motor Driver

The motor driver L298 is an integrated monolithic circuit in a 15 lead Multiwatt and PowerSO20 packages. It is a high voltage that can receives 12V and high current dual full bridge driver. The motor driver is very important part when connecting Arduino Uno with DC motor because the Arduino Uno cannot receive more than 5V and the DC motor needs more than 5v to operates efficiently. Therefore, the L298 motor driver acts as the medium between the motor and the Arduino Uno. Besides that, it also can control the direction of the DC motor.

Figure 3.9 The motor driver L298

HC-SR04 Ultrasonic Sensor

The ultrasonic sensor is used to detect the obstacle. It is a vision sensor that detect any obstacles infront of it. It have 4 pins which are Vcc, Trig, Echo and Ground. The ultrasonic sensor Operates on 40kHz ultrasonic frequency range. The operating voltage is about 4.8 V to 5.5 V.

Figure 3.10 The Ultrasonic sensor

Limit Switch

Limit switch also act as a sensor to detect the obstacle. it is a switch that operated by the motion of a machine part or presence of an object. The different between the limit switch and ultrasonic sensor is limit switch is a touch sensor type.

Figure 3.11 The limit switch

DC Motor and DC Motor Linear Motion

DC motor is used to move the surface vessel. While the linear DC motor is used for discharging the ROV. It moves downward and upward. The location of the linear DC motor is at the behind of the control box (at the center of the surface vessel). The other two DC motors used to connect to the propeller.

Figure 3.12 DC motor and linear DC motor

Propeller

Propeller is the combination of blades that form exactly like a fan which is connected to the DC motor. It is very important part for moving the surface vessel.

Difference number of blades gives the difference speed of motor when moving on the water.

Figure 3.13 The propellers

7.2V battery

The battery is used as the voltage supply to the RC circuit and to supply the voltage for activating L298 Motor driver when using Arduino Uno.

Figure 3.14 The 7.2V battery

3.2.2 Software

The softwares used for designing the Surface Vessel are Arduino, Solid Work and Fritzing. The Arduino software is for the programming. The Solid Work software is for drawing the design. lastly, the fritzing software is used for designing the circuit. Instead of using Arduino as the the hardware part, it also has a software that can be use for the coding.

Arduino Software

The step for using this software is:

1. Open Arduino program application.
2. An empty worksheet will be displayed.
3. Start writing the program step by step.
4. After finish writing the codes, save the file and click the Right Icon to compile the program.
5. The compiler will check for errors and display the result message.
6. After the compiler shows no error, click the Right Arrow Icon to upload the coding to the Arduino Uno.

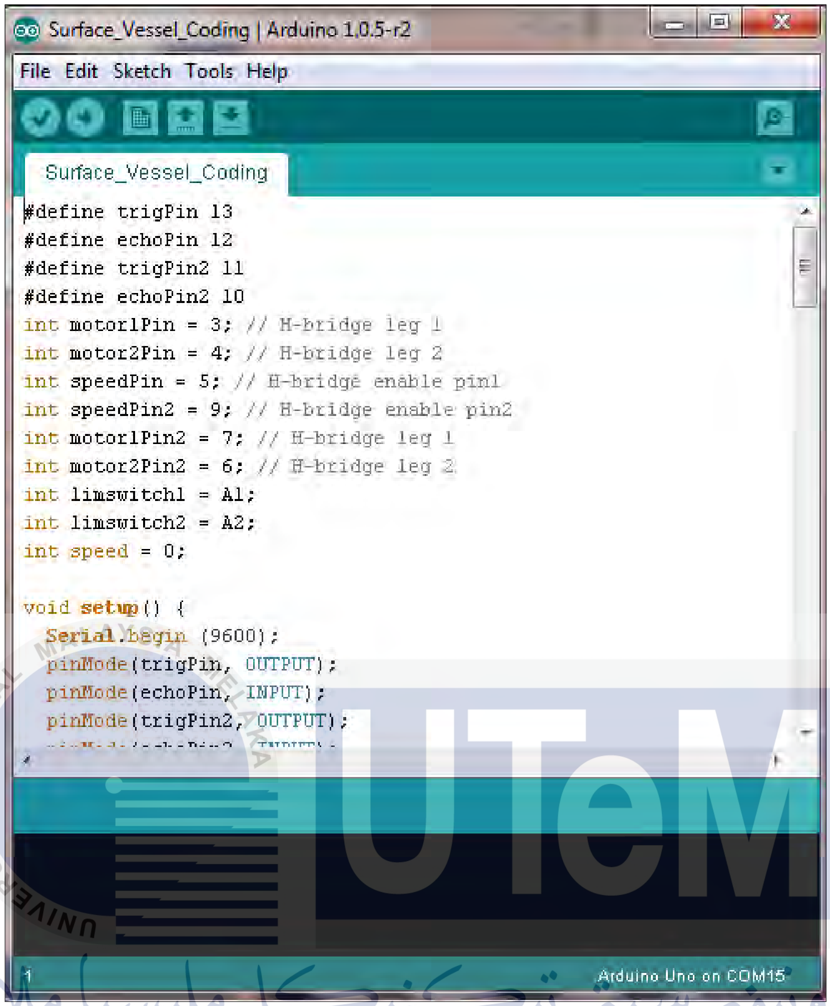

Figure 3.15 The coding of surface vessel from Arduino Uno

Solid Work

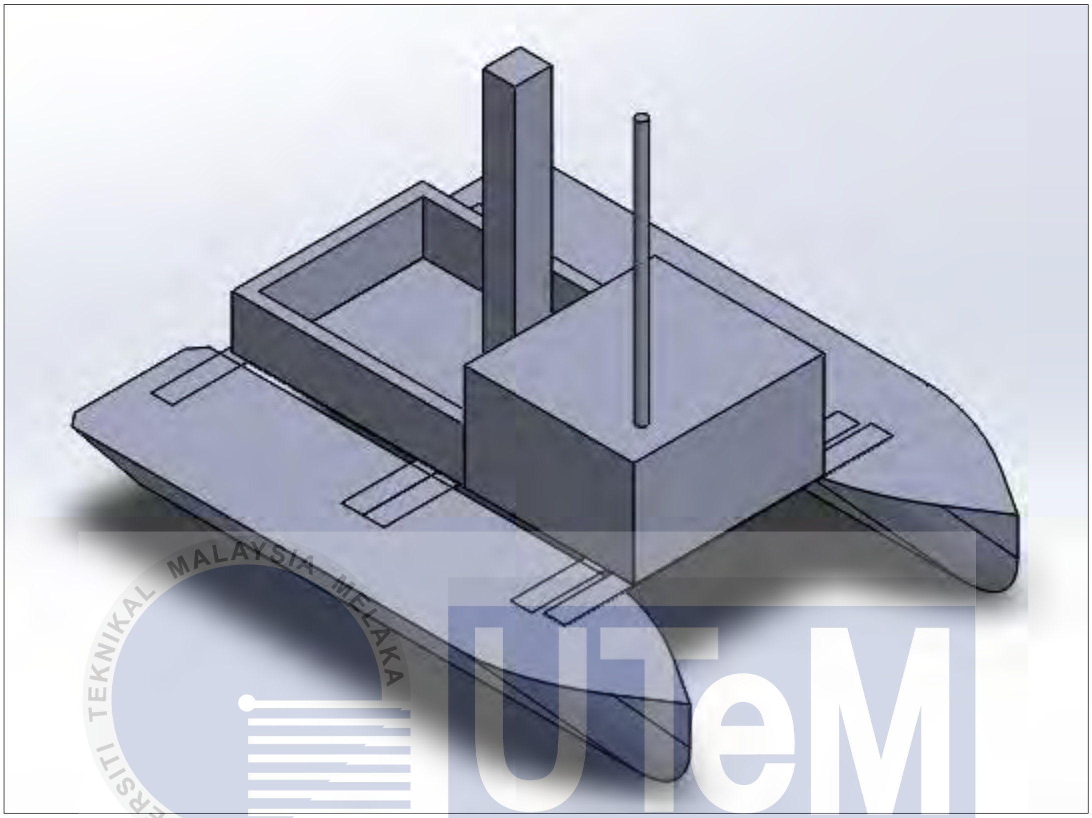

Figure 3.16 Surface vessel designs from Solid Work software

Fritzing

1. Open up the Fritzing application.

2. Click on the search part to place the component that we want to use in this project. Repeat this step until all of components are shown.

3. Create the circuit either on the proto board or outside of it and make sure all of components are connected correctly.

4. The components in schematic diagram were automatically created when designing the circuit on the circuit diagram at bread board.

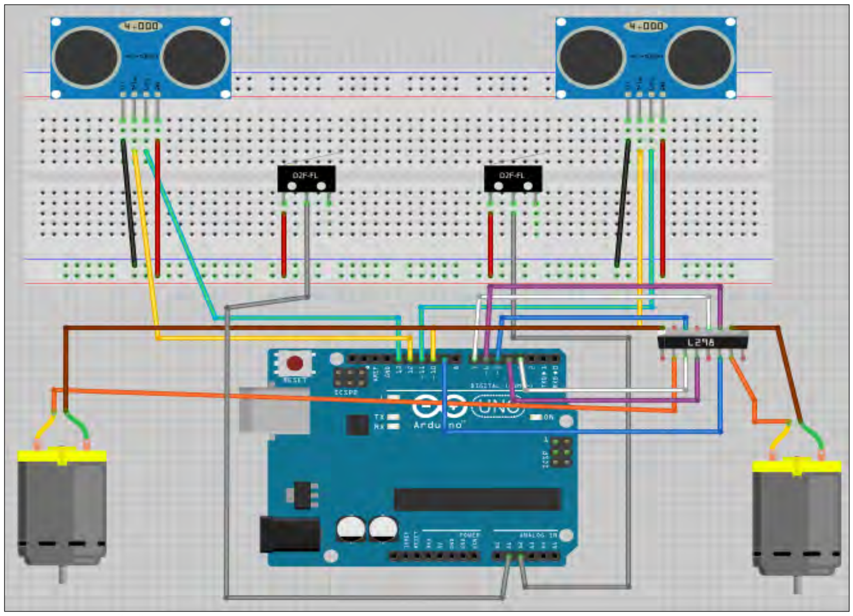

Figure 3.17 The breadboard circuit diagram

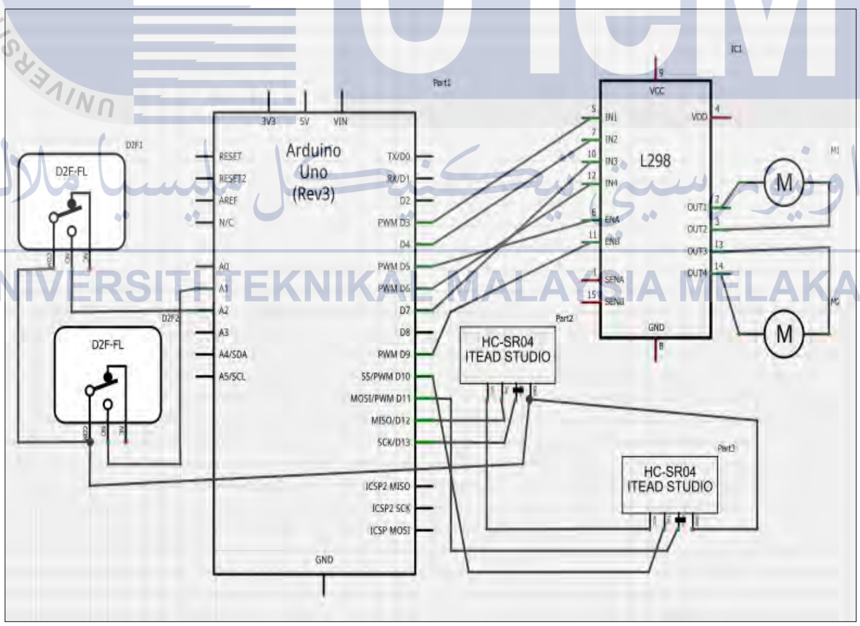

Figure 3.18 The schematic circuit diagram

3.3 Experiment Design

3.3.1 Experiment 1: The Accuracy of detection sensors

Objective: To evaluate the accuracy of detection obstacle between Infrared sensor and Ultrasonic sensor.

Apparatus:

1. Proto board
2. Resistor 220 ohm
3. Wire
4. Ultrasonic sensor
5. Infrared Sensor
6. LED
7. Arduino Uno
8. Mahjong paper
9. tape measure

Procedure:

1. The mahjong paper was setup by marking the distances of 10cm, 20cm, 30cm, 40cm, 50cm and 60cm.
2. The Resistor and LED were connected to the Arduino Uno together with proto board.
3. The Ultrasonic Sensor was connected to the circuit.
4. The detection obstacle of ultrasonic sensor was adjusted by the coding as shown in Apendix B with distance of 10cm, 20cm, 30cm, 40cm, 50cm and 60cm.
5. The detection distances were measure by referring the activation output (LED) for each distance.

6. Step 3, 4 and 5 were repeated by using IR sensor and using the coding as shown in Apendix C
7. The collected data were tabulated.

3.3.2 Experiment 2: Payload test

Objective: To analyze the time taken for the shaft connected from DC motor to completely moves downwards for discharging ROV with difference type of load.

Apparatus:

1. Linear DC motor.

2. ROV slot base.

3. Stop watch

4. Load from 1kg to 5kg

5. Surface vessel with wireless control including Linear DC motor.

Procedure

1. The place to carry out the experiment was setup at the lake.
2. The Surface vessel was putted on the lake and maintains it in static state.
3. The linear DC motor was controlled by using wireless remote control to moves downward the cylinder rod to the water with no load.
4. The time taken for the cylinder rod to move downward completely was recorded three times.
5. Step 3 until 4 were repeated with difference load 1kg to 5kg
6. The recorded data were tabulated..

3.3.3 Experiment 3: Surface vessel speed with difference propellers.

Objective: To determine the speed of surface vessel by using difference size of propellers.

Apparatus:

1. Surface vessel with wireless control including DC motors.
2. Three difference size of diameter propellers which are 4cm, 7.8cm and 10.7cm.

3.19 The different size of propeller

3. Stop watch

Procedure:

1. The 8m of distance the track water was set up by marking the starting point and the end point.
2. The time taken for surface vessel to reach the end point from the starting point using propellers with 4cm diameter was taken.
3. Step 2 were repeated for five times.
4. Step 2 and 3 were repeated by using 7.8cm and 10.7cm propeller size of diameter.

5. The recorded data were tabulated.

3.4 Summary of the methodology

This section describes the process of the surface vessel development and the experiment design for achieving the project objective. The design project consists of the hardware part and the software part. The hardware part explains about the materials for developing surface vessel. For the software part, it designs the drawing project, programming project and simulation project. The experiment design is made up for achieving the second and third objective.

CHAPTER 4

DISCUSSION AND RESULT ANALYSIS

4.1 The Complete Assembled Surface Vessel

The surface vessel needs to be sealed the entire hole so the water will not entering into the boat that can cause the circuits and the electronic components to be damaged and disfunctioning. The figures below show the complete surface vessel.

Figure 4.1 The surface vessel with wireless remote control

Figure 4.2 Top View of the surface vessel

Figure 4.3 Side view of the surface vessel

Figure 4.4 Front view of the surface vessel

4.2. The Experiment Result

4.2.1 Experiment 1: The accuracy of detection sensors

Table 4.1 The distance detection obstacle between Ultrasonic sensor and Infrared sensor.

Actual distance, cm	Distance detection, mm	
	Ultrasonic sensor	Infrared Sensor
10	9.9	11.1
20	20.1	20.9
30	29.8	30.7
40	40.4	40.6
50	50.8	50.6
60	61.4	60.7

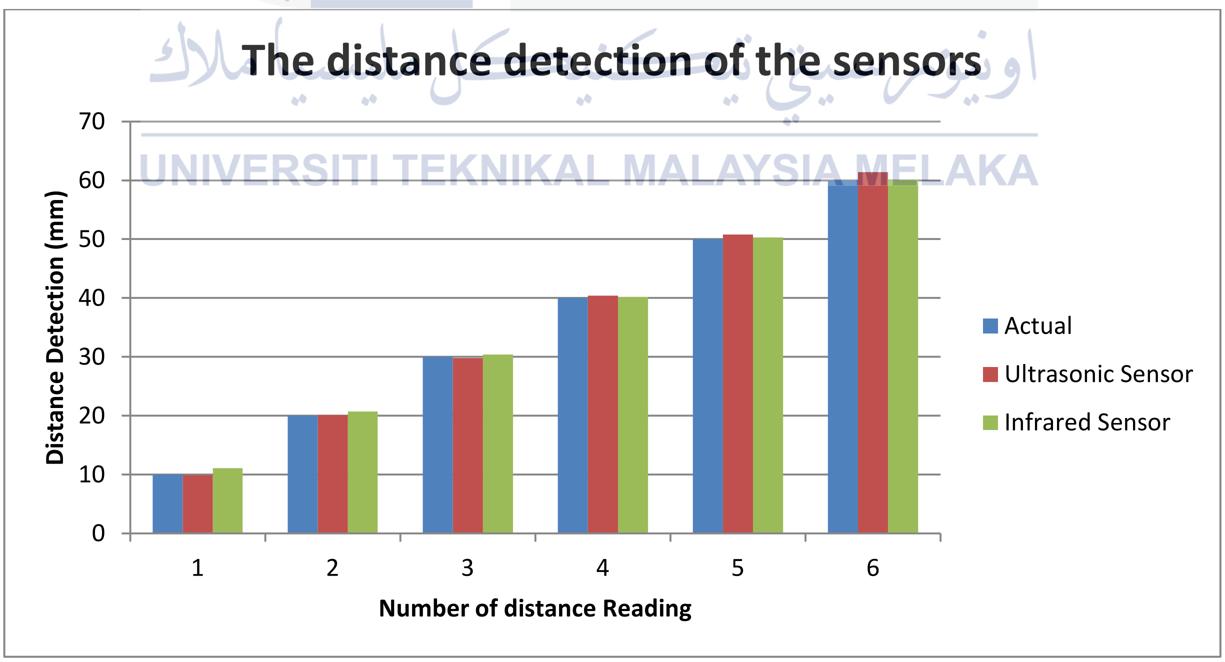

Figure 4.5 Result of the distance detection sensor comparing to the actual distance.

Based on the figure 4.5, it shows that the measurement data from ultrasonic sensor is mostly accurate than infrared sensor. We can say that the closer the sensor readings to the actual reading, the more the accuracy of the sensor detection objects by given specific distance. The standard error is inversely proportional to the accuracy. The lower the standard error, the higher the accuracy of the sensor to detect objects. Thus, the standard error for ultrasonic sensor is lower and the accuracy percentage is higher than infrared sensors. From the figure 4.5 also we can state that the ultrasonic sensor better in accuracy for small range otherwise, the IR sensor is better for long range.

Overall percentage accuracy in this experiment for the Ultrasonic sensor is around 97.7% to 99.5%. For the IR sensor is about 89% to 98.8%. The Ultrasonic sensor shows most accurate value which is near to 100%. Although the accuracy for Ultrasonic sensor is most accurate compare to IR sensor, but it show an increasing error when the distance detection is increase. On the contrary for IR sensor, it begins to detect more accurate when the distance is increasing. In this experiment, IR sensor didn't reach 99% accuracy but it is possible to reach if the distance detection is increasing.

$$\text{Standard Error}, \quad e = |\text{Experiment Value} - \text{Actual Value}|$$

$$\%\ \text{Error} = \left|\frac{e}{\text{Actual Value}}\right| \times 100 \tag{4.1}$$

For the accuracy, if experiment value < actual value:

$$\%\ \text{Accuracy} = \frac{\text{Experiment Value}}{\text{Actual Value}} \times 100 \tag{4.2}$$

If experiment value is > actual value:

$$\%\ \text{Accuracy} = (1 - e\ ) \times 100 \tag{4.3}$$

From this experiment, the better detection is the good resolution. The detection more sharp and accurate if the resolution is higher. For the conclusion of this experiment, the ultrasonic has better resolution than IR sensor by giving the distance between 10cm to 6cm detection distance.

4.2.2 Experiment 2: Payload test

Table 4.2 Types of loads with difference time taken reading

Load, kg	Displacement, cm	Time Taken, s		
		1st Reading	2nd Reading	3rd Reading
0	17	21.62	21.60	21.59
1	17	20.98	21.08	20.97
2	17	21.17	21.17	21.26
3	17	21.61	21.52	21.42
4	17	21.23	21.37	21.33
5	17	21.54	21.44	21.44

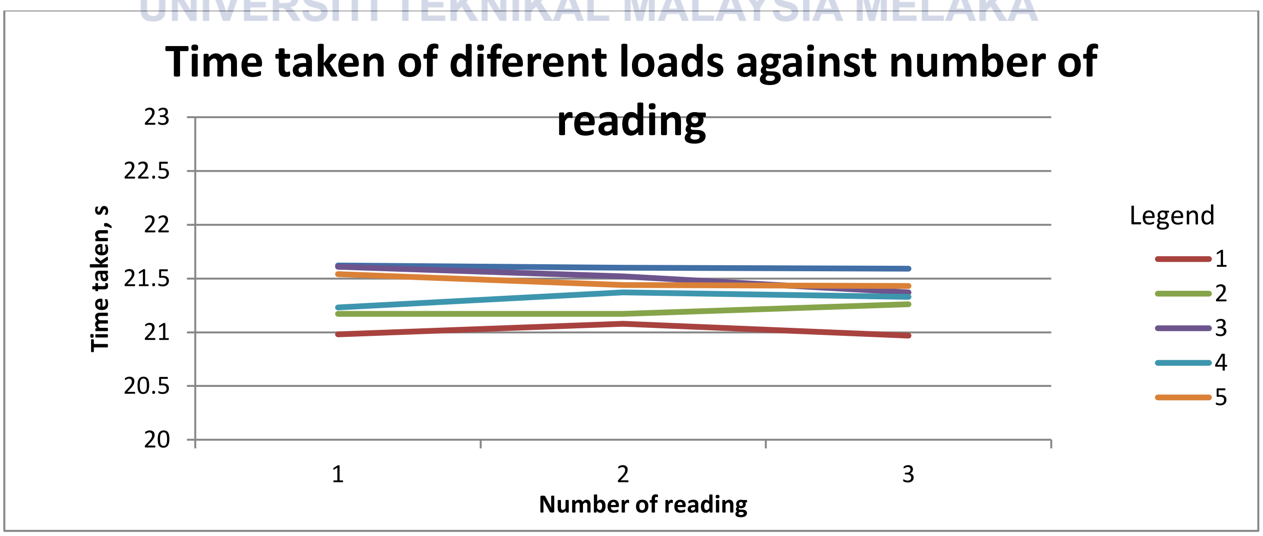

Figure 4.6 Experiment results of different loads in three readings.

Based on the figure 4.2, the time taken of cylinder rod to moves completely downwards has the reading around 20.98s to 21.62s with different loads. The cylinder length is fixed at 17cm. According to Newton's law of gravitation the speed of a falling object does not depends on the mass of an object. From the table 4.2, it shows that the time taken didn't give a huge different reading even though the loads are different. Means that Mass doesn't affect the speed. It determines how quickly an object change speed which is acceleration. Mass determines how strong a force has to be to accelerate an object at a given rate.

$$F = ma \tag{4.4}$$

$$\text{Speed} = \text{Distance} / \text{Time} \tag{4.5}$$

$$m = \text{Mass} \times 9.81 \tag{4.6}$$

Calculating the average of each load:

Average Time taken of load 0kg,s $= \frac{21.62+21.60+21.59}{3}$

$= 21.60s$

Average Time taken of load 1kg, s $= \frac{20.98+21.08+20.97}{3}$

$= 21.01s$

Average Time taken of load 2kg, s $= \frac{21.17+21.17+21.26}{3}$

$= 21.20s$

Average Time taken of load 3kg, s $= \frac{21.61+21.52+21.42}{3}$

$=21.52s$

Average Time taken of load 4kg, s $= \frac{21.23+21.37+21.33}{3}$

$= 21.31s$

Average Time taken of load 5kg, s $= \frac{21.54+21.44+21.44}{3}$

$= 21.47s$

By applying the equation (4.4), (4.5) and (4.6)

Kg convert to Newton by multiply by 10

Load 0kg

F_0 = 0N since there is no load.

$a_0 = \frac{V_0}{t_0}$

$= \frac{\frac{17\times10^{-2}}{21.60}}{21.60}$

$= 0.364 \times 10^{-3} m/s^2$

Load 1kg:

$F_1 = 100 \times 9.81 \times a_1$

$= 100 \times 9.81 \times \frac{V1}{t_1}$

$$= 981 \times \frac{\frac{17\times10^{-2}}{21.01}}{21.01}$$

$$= 0.0378\text{N}$$

$$a_1 = \frac{\text{F}_1}{m}$$

$$= \frac{0.0378}{981}$$

$$= 0.385 \times 10^{-3}\text{m/ s}^2$$

Load 2kg:

$$\text{F}_2 = 200 \times 9.81 \times a_2$$

$$= 200 \times 9.81 \ \frac{V2}{t_2}$$

$$= 1962 \times \frac{\frac{17\times10^{-2}}{21.20}}{21.20}$$

$$= 0.742\text{N}$$

$$a_2 = \frac{\text{F}_2}{m_2}$$

$$= \frac{0.742}{1962}$$

$$= 0.378 \times 10^{-3}\text{m/ s}^2$$

Load 3kg:

$$\text{F}_3 = 300 \times 9.81 \times a_3$$

$= 300 \times 9.81 \times \frac{V3}{t_3}$

$= 2943 \times \frac{\frac{17\times10^{-2}}{21.52}}{21.52}$

$= 1.080\text{N}$

$a_3 = \frac{\text{F}_3}{m_3}$

$= \frac{1.080}{2943}$

$= 0.367 \times 10^{-3} \text{m/ s}^2$

Load 4kg:

$\text{F}_4 = 400 \times 9.81 \times a_4$

$= 400 \times 9.81 \times \frac{V4}{t_4}$

$=3924 \times \frac{\frac{17\times10^{-2}}{21.31}}{21.31}$

$= 1.469\text{N}$

$a_4 = \frac{\text{F}_4}{m_4}$

$= \frac{0.150}{3924}$

$= 0.374 \times 10^{-3} \text{m/ s}^2$

Load 5kg:

$\text{F}_5 = 500 \times 9.81 \times a_5$

$$= 500 \times 9.81 \times \frac{V5}{t_5}$$

$$= 4905 \times \frac{\frac{17\times10^{-2}}{21.47}}{21.47}$$

$$= 1.809\text{N}$$

$$a_5 = \frac{F_5}{m_5}$$

$$= \frac{1.809}{4905}$$

$$= 0.369 \times 10^{-3} \text{m/ s}^2$$

From the equation (4.5), the speed for each load didn't same to the others as Newton's law of gravitation mentioned about the mass didn't affect the speed. The speed for average load 0kg to 5kg are $7.87 \times 10^{-3}\text{m/s}$, $8.09 \times 10^{-3}\text{m/s}$, $7.90 \times 10^{-3}\text{m/s}$, $8.00 \times 10^{-3}\text{m/s}$ and $7.92 \times 10^{-3}\text{m/s}$. Although it has a little bit different value but it shows that mass gives an affect to speed from this experiment. The factor that can be considered for not equally to the theoretical is the inconsistency taken the time taken reading. This might be due to the human error which is too fast or slow start to record the time taken and can be also due to the battery voltage decreasing after using it too long. The force for the loads shows an increasing each time the load is increase. Therefore, it can be conclude that the higher the mass the higher the force.

4.3 Experiment 3: Surface vessel speed with difference propellers.

Table 4.3 Types of propeller with different time taken reading.

Types	Time taken. s					Speed, m/s				
	1st Trial	2nd Trial	3rd Trial	4th Trial	5th Trial	1st Trial	2nd Trial	3rd Trial	4th Trial	5th Trial
Small	5.52	6.20	5.98	6.32	6.37	1.449	1.290	1.338	1.266	1.256
Medium	9.32	9.27	8.93	9.16	9.21	0.858	0.863	0.896	0.873	0.868
Large	10.38	10.34	9.93	10.18	11.00	0.771	0.774	0.806	0.786	0.727

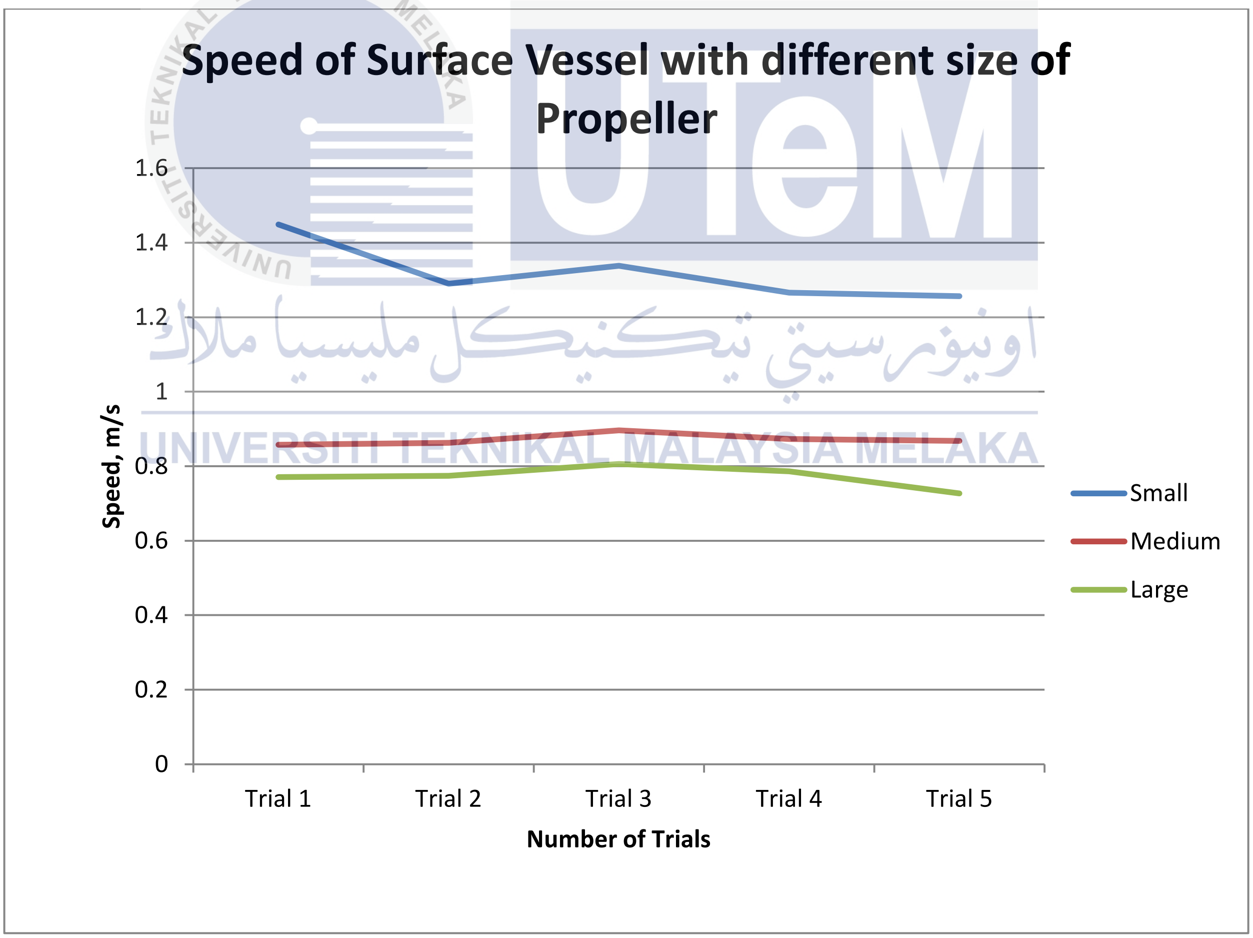

Figure 4.7 Results of different speed types of propellers.

This experiment is about to measure the speed of the surface vessel with different type of propeller connected to the DC motor. The type of propeller used at the motor gives difference time taken. The distance is fixed at 8 m while the time taken for each type propeller will takes 5 trials. The speed of the surface vessel then can be calculated by dividing the distance with the time taken from each of the trials.

From the previous equation:

$$\text{Speed} = \text{Distance} / \text{Time} \qquad (4.5)$$

Based on the equation (4.5), the overall speed of small propellers are about 1.266m/s to 1.449 m/s and its show the highest speed among of the other propeller size. The overall speed of speed of medium size propellers are about 0.858m/s to 0.896m/s. lastly, for the overall speed of large size propellers are about 0.727m/s to 0.806m/s. Therefore, from this experiment, the speed of motor is inversely proportional to the time taken as the increasing of time will lower the speed.

The size of propeller makes different speed on the surface vessel. This is because the bigger size of propeller will make heavier load on the motor. The DC motor used in this experiment didn’t have a high load capacity to hold the heavy load. The DC motor also is connected with long shaft that use to mount the propeller at the end of the shaft rod. The bigger the size of propeller, the harder of DC motor to make a rotation and it consume a high energy.

The other factor is the force or thrust in the water. The smaller the size of the propeller, the higher the force on the propeller to push the water. The high thrust or force gives the high speed of the surface vessel. While the larger size of propeller makes the force become lower thus the speed of the surface vessel will decrease. Apart of that, the pressure equation stated that force is directly proportional to the pressure and inversely proportional to the area.

$$P = \frac{F}{A} \qquad (4.7)$$

From this experiment, it can be conclude that the smaller size of propeller gives the higher speed of surface vessel compare to the larger size of propeller as the large size of propeller makes the heavier load to the DC motor when rotating it in the water and the small size of propeller gives the high pressure so it can easily push the water efficiently.

4.3 Summary of Result and Analysis

The design experiments in this section are based on the performance of the surface vessel. The first experiment is about the accuracy of distance detection obstacle by the sensors. The accuracy of distance detection is important for finding the suitable sensor to use at surface vessel. The sensitivity of sensor reacts with the certain distance is measured by comparing the actual distance. If the distance detection by the sensor is almost same to the actual distance, then it has high accuracy and suitable to use at surface. Second experiment is about the time taken for the shaft to completely move downward with different weight load. Time taken for the shaft moves downward is very short comparing the other when the load applied is larger. The third experiment is about the speed of surface vessel by using different size of the propeller. The size of the propeller is one of the factors need to be consider for measuring speed of boat RC.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the design project which is the surface vessel has been design by using Solid Work software and successfully developed for the hardware part. The beginning process for using this software must be select design part. The parts need to draw one by one and each of the finish design part needs to save before exit program so later on we can assembly all part from saving design part before. The design project from the solid work is a platform on how the hardware project looks like. The surface vessel was successfully developed for the hardware part. The design experiments were created in other to achieve the objective. The experiment 1 is about the comparison between ultrasonic sensor and IR sensor. The comparison is made based on the objective number 2 which are to develop the navigation system with suitable sensor. From this experiment, it shows that ultrasonic sensor is suitable sensor to use because it has better resolution. The experiment 2 and experiment 3 are about how to measure the performance of the surface vessel. The experiment 2 is about the payload test. In this experiment, the time taken for each of the load is a bit different. The different the reading of time taken gives the different speed. The experiment 3 is about the speed of the surface vessel by using different size of propeller. In this experiment, the smallest size of propeller gives the highest speed of surface vessel. It is because the smaller size of propeller didn't make heavier to the DC motor. It also has high force in the water when the DC motor starts to rotate because of its small size area of propeller. Therefore, all the objectives in this project were achieved.

5.2 Recommendation

The selection material for the body of surface vessel in this project use is plastic due to the inexpensive cost. The firmness of surface vessel body can be improved by using fiberglass material. This material is sturdy and lightweight. It is suitable for measuring the speed of the surface vessel when its body is light.

REFERENCES

[1] P. Sayer, "Hydrodynamic loads during the deployment of ROVs," Ocean Eng., vol. 35, no. 1, pp. 41–46, Jan. 2008.

[2] A. N. Moore, B. M. Norman, and R. V. Stephens, "The use of deep water moorings in commercial oceanography," *Proc. IEEE Sixth Work. Conf. Curr. Meas. (Cat. No.99CH36331)*, pp. 160–165, 1999.

[3] A. Martin, E. An, K. Nelson, and S. Smith, "Obstacle detection by a forward looking sonar integrated in an autonomous underwater vehicle," *Ocean. 2000 MTS/IEEE Conf. Exhib. Conf. Proc. (Cat. No.00CH37158),* vol. 1, pp. 337–341.

[4] A. Ghatak, D. K. Pratihar, and C. S. Kumar, "Online Measurement of Obstacles' Distances Using Forward Looking Sonar Sensor Mounted on an Experimental AUV," *2006 IEEE Int. Conf. Ind. Technol.*, pp. 983–988, 2006.

[5] T. Mohammad, "Using Ultrasonic and Infrared Sensors for Distance Measurement," pp. 293–298, 2009.

[6] Y. Wu, R. Chen, W. Jiang, T. Yu, and F. Yu, "A Novel Infrared Sensor Structure Compatible to Standard CMOS Process," *2010 Second Int. Conf. Model. Simul. Vis. Methods*, no. 1, pp. 254–257, May 2010.

[7] C. Tinghai, G. Han, B. Gang, and G. Xiangdong, "Influence of ultrasonic oscillations on static friction characteristics of pneumatic cylinder," *Proc. 2011 Int. Conf. Fluid Power Mechatronics*, pp. 160–163, Aug. 2011.

[8] D. C. Gross, "A Feedforward Mnn Controller for Pneumatic Cylinder Trajectory Tracking Control - Neural Networks,1997., *International Conference on*," pp. 1–6, 1997.

[9] D. Huang and L. Cao, "Study on hydraulic system design of mine bucket," *Proc. 2011 Int. Conf. Fluid Power Mechatronics*, pp. 1002–1005, Aug. 2011.

[10] Y.-X. Zhao, X.-D. Chen, and X. Chen, "Repeatability analysis of a vulcanizer hydraulic cylinder system using fuzzy arithmetic," *2009 IEEE Int. Conf. Comput. Intell. Meas. Syst. Appl*., pp. 204–207, May 2009.

[11] G. S. G. Song, H. S. H. Sun, and Y. Z. Y. Zheng, "Study of the control strategy for mechatronics system of electric actuator," *2007 Int. Conf. Electr. Mach. Syst*., no. 1, pp. 1584–1587, 2007.

[12] Inmoco, Electro-Mechanical vs. Hydraulic & Pneumatic Actuators, http://www.inmoco.co.uk/electro-mechanical_vs_pneumatic_actuators, [accessed 18 NOVEMBER 2013]

APPENDICES

APPENDIX A

Surface vessel coding

```
#define trigPin 13

#define echoPin 12

#define trigPin2 11

#define echoPin2 10

int motor1Pin = 3; // H-bridge leg 1

int motor2Pin = 4; // H-bridge leg 2

int speedPin = 5; // H-bridge enable pin1

int speedPin2 = 9; // H-bridge enable pin2

int motor1Pin2 = 7; // H-bridge leg 1

int motor2Pin2 = 6; // H-bridge leg 2

int limswitch1 = A1;

int limswitch2 = A2;

int speed = 0;


void setup() {

  Serial.begin (9600);
```

```
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  pinMode(motor1Pin, OUTPUT);
  pinMode(motor2Pin, OUTPUT);
  pinMode(speedPin, OUTPUT);
  pinMode(motor1Pin2, OUTPUT);
  pinMode(motor2Pin2, OUTPUT);
  pinMode(speedPin2, OUTPUT);
  pinMode(limswitch1,INPUT);
  pinMode(limswitch2,INPUT);
  digitalWrite(speedPin, HIGH);
  digitalWrite(speedPin2, HIGH);
}

void loop() {
  int switch1 = analogRead(limswitch1);
  int switch2 = analogRead(limswitch2);
  if (switch1 == HIGH)
  {
```

```
  {
 digitalWrite(motor1Pin, LOW);
 digitalWrite(motor2Pin, HIGH);
 analogWrite (speedPin, 255);
 digitalWrite(motor1Pin2, LOW);
 digitalWrite(motor2Pin2, LOW);
 analogWrite (speedPin2, 0);
 }
if(switch2 == HIGH)
{
  digitalWrite(motor1Pin, LOW);
 digitalWrite(motor2Pin, LOW);
 analogWrite (speedPin, 0);
 digitalWrite(motor1Pin2, LOW);
 digitalWrite(motor2Pin2, HIGH);
 analogWrite (speedPin2, 0);
 }
long duration, distance;
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
```

```
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = (duration/2) / 29.1;


long duration2, distance2;
digitalWrite(trigPin2, LOW);
delayMicroseconds(2);
digitalWrite(trigPin2, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin2, LOW);
duration2 = pulseIn(echoPin2, HIGH);
distance2 = (duration2/2) / 29.1;


if (distance < 10)
  {
  digitalWrite(motor1Pin, LOW);
  digitalWrite(motor2Pin, HIGH);
  analogWrite (speedPin, 255)
  }
else
```

```
{
  digitalWrite(motor1Pin, LOW);
  digitalWrite(motor2Pin, LOW);
  analogWrite (speedPin, 0);
}

if ( distance2 < 10)
  {
  digitalWrite(motor1Pin2, LOW);
  digitalWrite(motor2Pin2, HIGH);
  analogWrite (speedPin2, 255);
  }
else
  {
  digitalWrite(motor1Pin2, LOW);
  digitalWrite(motor2Pin2, LOW);
  analogWrite (speedPin2, 0);
  }

if (distance >= 200 || distance <= 0){
  Serial.println("Out of range");
```

```
  }
  else {
   Serial.print(distance);
   Serial.println(" cm");
  }
  delay(500);
  }
}
```

APPENDIX B

Ultrasonic sensor coding

```
#define trigPin 11

#define echoPin 12

#define led 13


void setup() {

  Serial.begin (9600);

  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

  pinMode(led, OUTPUT);

}


void loop() {

  long duration, distance;

  digitalWrite(trigPin, LOW);

  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);

  delayMicroseconds(10);
```

```
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration/2) / 29.1;
  if (distance == 10) {
    digitalWrite(led,HIGH);
}
  else {
    digitalWrite(led,LOW);
  }
  if (distance >= 200 || distance <= 0){
    Serial.println("Out of range");
  }
  else {
    Serial.print(distance);
    Serial.println(" cm");
  }
  delay(1000);
}
```

APPENDIX C

IR sensor coding

```
#include <DistanceGP2Y0A21YK.h>
#define led 13

DistanceGP2Y0A21YK Dist;
int distance;

void setup()
{
  Serial.begin(9600);
  Dist.begin(A0);
  pinMode(led,OUTPUT);
}

void loop()
{
  distance = Dist.getDistanceCentimeter();
  Serial.print("\nDistance in centimers: ");
```

```
 Serial.print(distance);
 delay(700); //make it readable


 if (distance <10)
 {
  digitalWrite(led,HIGH);
 }
 else
 {
  digitalWrite(led,LOW);
 }
}
```

APPENDIX D

Gantt chart of the project