UNIVERSITI TEKNOLOGI MALAYSIA

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : NUR FADZLIE BIN RAHMAT

Date of birth : 9 SEPTEMBER 1990

Title : CAMERA MOUNTED ROBOT (CAMBOT)

Academic Session: 2012/2013-2

I declare that this thesis is classified as:

☐	**CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)*
☐	**RESTRICTED**	(Contains restricted information as specified by the organisation where research was done)*
☑	**OPEN ACCESS**	I agree that my thesis to be published as online open access (full text)

I acknowledged that Universiti Teknologi Malaysia reserves the right as follows:

1. The thesis is the property of Universiti Teknologi Malaysia.
2. The Library of Universiti Teknologi Malaysia has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

SIGNATURE | **SIGNATURE OF SUPERVISOR**

900906-04-5461
(NEW IC NO. /PASSPORT NO.)

PROF. DR. SHAMSUDIN BIN HJ. MOHD AMIN
NAME OF SUPERVISOR

Date: 20 JUNE 2013

Date: 20 JUNE 2013

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Engineering (Electrical - Mechatronics)".

Signature : ....

Supervisor : PROF. DR. SHAMSUDIN BIN HJ. MOHD AMIN

Date : 20 JUN 2013

CAMERA MOUNTED ROBOT (CAMBOT)

NUR FADZLIE BIN RAHMAT

A report submitted in partial fulfillment of the
requirement for the award of the degree of
Bachelor of Engineering (Electrical - Mechatronics)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2013

"I declare that this thesis entitled "Camera Mounted Robot (CAMBOT)" 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	:	NUR FADZLIE BIN RAHMAT
Date	:	10 JUN 2013

This thesis is dedicated to my family and friends.

To my loving parents, Rahmat Bin Ali and Siti Mariyam Binti Samsuri,

Thank you both for giving me strength to reach for the stars and chase my dreams.

To my supervisor, Prof. Dr. Shamsudin Bin Hj. Mohd Amin,

Your guidance and kinds were so valuable.

To all my beloved friends,

Our moments never been forgotten in my heart.

ACKNOWLEDGEMENT

The Final Year Project is long and arduous, yet valuable journey, as I have gained a lot of knowledge in my field of interest. It requires a lot of patience and dedication in completion of this project but I could not have done it without the support from people around me. First of all, I would like to express my deepest gratitude to my project supervisor, Prof. Dr. Shamsudin bin Hj. Mohd Amin for the guidance and enthusiasm given throughout the progress of this project. My outmost thanks to my family who have given me support all these years. Their love and endless motivation have certainly spurred me to scale to greater level of achievements. I would like to express my gratitude to my friends whom involve directly or indirectly with this project, especially to all my course mates and seniors who had given me help technically and mentally during the journey to accomplish this project. Last but not least, to Fatin Damia for being my personal guide, translator, and motivator. I would never have made it without you. Thank you all for giving me technical advice, moral support and idea to enhance my project. Thank you so much.

ABSTRACT

Camera mounted robot (CAMBOT) is developed for monitoring purposes especially for natural disaster. The main objective of this project is to build a low-cost rescue robot that have highly potential and demand in the present and future market and to design a robot to search for the survivor in the disaster area and assist the rescue worker in the rescue mission. The user can control the CAMBOT through the PS2 wireless controller. The PS2 wireless controller is connected to the CAMBOT wirelessly by a SKPS. The program is designed in such a way it enable the user to control the robot movement by manually clicking the direction buttons on the PS2 wireless controller. The main program is developed using Arduino 1.5.2. This is developing to control 6 robot movements. The data and instruction will be sending from the PS2 wireless controller to the CAMBOT via a transmitter and receiver interface circuit.

ABSTRAK

Camera Mounted Robot (CAMBOT) dihasilkan untuk kegunaan pemerhatian terutamanya untuk bencana semula jadi. Objektif utama untuk projek ini adalah untuk membina robot penyelamat yang berkos rendah yang mempunyai keupayaan yang tinggi dan permintaan dalam market sekarang dan akan datang dan untuk menghasilkan robot untuk mencari mangsa dalam kawasan bencana dan membantu pekerja penyelamat dalam misi menyelamat. Pengguna mampu mengawal CAMBOT melalui pengawal tanpa wayar PS2. Pengawal tanpa wayar PS2 disambungkan ke CAMBOT secara tanpa wayar melalui SKPS. Program dihasilkan untuk membolehkan pengguna untuk mengawal pergerakan robot secara manual menekan butang arah pada pengawal tanpa wayar PS2. Program utama dihasilkan menggunakan arduino 1.5.2. Penghasilan ini untuk mengawal 6 pergerakan robot. Data dan arahan akan dihantar dari pengawal tanpa wayar PS2 ke CAMBOT melalui litar perantara penghantar dan penerima.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

USB	-	Universal serial bus
V	-	Voltage
DC	-	Direct current
I/O	-	Input/Output
PWM	-	Pulse-width modulation
AC	-	Alternating current
PID	-	Proportional Integral Derivative
PS2	-	PlayStation 2
IP	-	Internet protocol
PIC	-	Peripheral Interface Controller
UART	-	Universal Asynchronous Receiver/Transmitter
IC	-	Integrated Circuit

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background Study

Defining a robot can be tough. Basically a robot is a programmable, self-controlled device that is consists of electronic, electrical or mechanical units. It is literally a machine that put in function as a living agent. A robot they never get tired and best used to replace human, because they can endure physical conditions that are dangerous for human. For example, they assist human to operate in airless condition, and the big difference between a robot and a human is that, it never get bored by repetition. Moreover, their work can be done up to 100% flawless due to they are unable to be distracted from the task at hand.

A robot seems to be a perfect choice to be used in industry production and domestic application due to their several advantages. One of the living example of domestic robot is the V-Bot Robotic Vacuum Cleaner (RV-8) in which, it has smart cleaning program, such as four cleaning movements and sensors such as Cliffavoidance sensor to prevents V-Bot from falling down staircases. To make life easier, a robot has been used in many circumstances such as to position the car frames, bolt pieces together, welding, priming and etc.

A robot are truly reliable as it is much useful and helpful to the human. Helping human do their daily chores is one point, but the save our lives is another. When Japan, China and Philippines have been hit by natural disaster, a rescue robot has been developed. This development is essential as we may save life in the event of a disaster. Even though some research shows that Malaysia may face natural disaster in the future, but our technology is still far behind to develop this rescue robot.

1.2 Problem Statement

The statistics from Centre for Research on the Epidemiology of Disasters (CRED) shows natural disaster keep increasing from year to year. Figure 1.1 shows the graph of natural phenomenon that occurs around the world since 1900-2000.

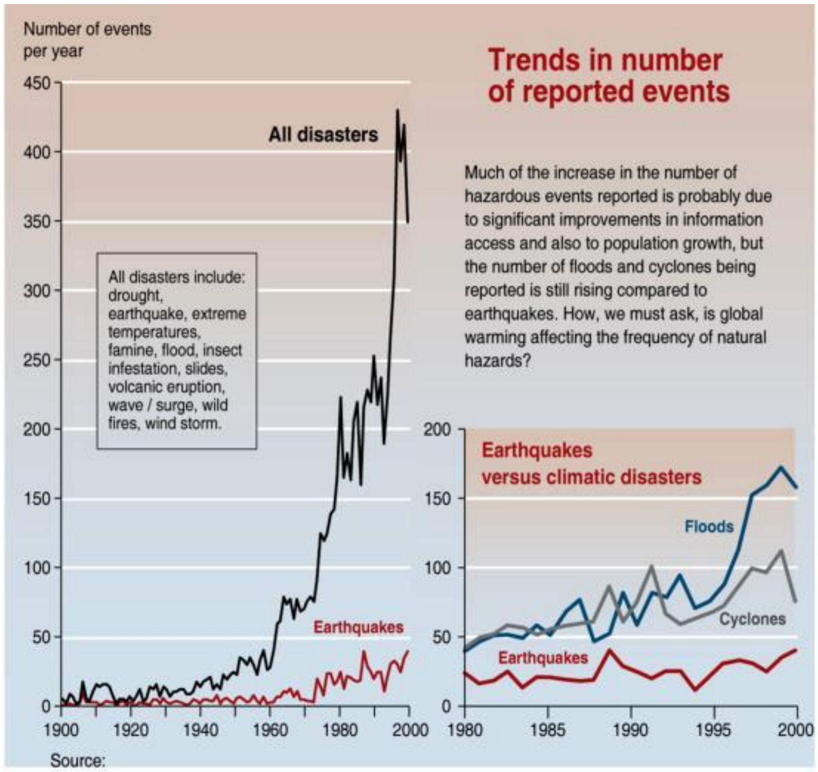


Figure 1.1: Natural disaster statistics from (1990 - 2000)

Recently, at epicenter in Manjung, Perak on 29 April 2009, an earthquakes do occurred,eventhough Malaysia are supposedly blessed with natural disaster free area.

As a matter of fact, there are number of serial event that link Malaysia to an earthquakes. Take the region around Sabah for an example, the area around Ranau, Kudat and Lahad Datu, has been hit by earthquakes over the years, and seismological also predict that these area in Sabah can be hit by earthquakes two or three times per year.

The Research Group (E-Seer) from Engineering Seismology and Engineering Earthquake, Universiti Teknologi Malaysia, has foreseen that a larger earthquake might occur in Malaysia. This is due to the earthquakes in Indonesia triggered the fault lines that has been inactive up until recently in peninsular Malaysia.

One of the E-Seer R&D, Dr Norhisham Bakhary, says that most buildings in Malaysia would collapse if the event of an earthquakes occurred. This is due to the,with the exception of the Penang Bridge and KLCC, Malaysian buildings are not build to take the hit from the force of an earthquake.

He also add that buildings in Malaysia are designated for a normal load. But, in the event of an earthquakes, lateral load are enforced. He said the cost for buildings that can withstand earthquakes are higher, as it need bigger structural members, and a high quality materials.

"Nobody wants to spend that much because they think it will never happen. I have spoken to building owners but no one really seems to care," says Dr Norhisham. "The firemen cant check the connections which are covered. Do we have to wait until something happens before we take any preventive action?"he adds.

Visual inspection are needed as a post-earthquake assessment, to ensure the buildings are still safe. The structural members also should be test to identify unseen damage. The rehabilitation process can proceed if the test results are positive.

1.3 Objective

The objectives of this project are:

1. To build a low-cost rescue robot that can help to reduce the government fund when search and rescue process are required.

2. To develop a rescue robot that will help the survival of a disaster victim, and help the workers to reach the area the unable to reach themselves.

1.4 Scope of Project

The scopes of study of this project are as followed:

1. In the robot structure design, the wheel used are the conventional wheels. This is to enable a smooth ride on a flat surface for the robot. In addition, two servomotor are attached to the robot in order to record all possible view.

2. In order to allow the user from harmful environment or harmful device, a wireless control system and wireless monitoring system was used in this project. This is important to avoid a wire or cable interruption.

3. A wireless control system, wireless PS2 controller, and Cytron PS2 Starter Kits are used. They are essential to control the motion of the robot. A Iteaduino Leonardo microcontroller interface act as the main processing unit and C language are the programming language.

4. A wireless IP camera has been installed as monitoring system. The video can be viewed by using computer, laptop or smart phone.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A review about previous paper works, researches, books article and journals related to this title are shown in this chapter. The theoretical and methodological recommendations from these academic materials have been studied so that the advantages could be applied to this project.

2.2 Methodology

2.2.1 Darmstadt Rescue Robot

Figure 2.1 Darmstadt Rescue Robot

A PhD program Cooperative, Adaptive, and Responsive Monitoring in Mixed Mode Environments, funded by the German Research Foundation lead by the team of Hector Darmstadt at the Technische Universitat Darmstadt. They covered their research mostly on the areas of navigation and coordination of multiple autonomous vehicles. They also do their fundamental research in monitoring n mixed mode environments that are characterized by the heterogeneity resources, capabilities and connectivity.

A RoboCup soccer has already experienced in hardware and software of autonomous robots, and there have been studies in simulation on cooperative control. A development of numerous numbers of different algorithms from computer vision that can detect people faces and recognise objects which are suitable to use as a filing device. It is said that an unmanned aerial and ground vehicles surveillance and environmental monitoring systems has been finally found by the team members from mechanical engineering. The team’s name was recently changes from Darmstadt Recue Robot Team, to Hector Darmstadt, which stands for, Heterogeneous Cooperating Teams of Robot.

2.2.2 Sandia Gemini-Scout Mine Robot

Figure 2.2: Sandia Gemini-Scout Mine Robot

A proud product of Sandia Labs, in which this Gemini Scout Robot, can withstand explosions, crawl over builders, go through an 18 inches of water, and navigate through rubble piles.

The Gemini-Scout Mine Rescue Robot size is less than 61cm (4 feet) long and 30.5 cm (2 feet) tall, and it is small enough to go around tight corners and get in safety. To get new operators to learn the system quickly, the Sandia engineers had to build something intuitive, in which they used an Xbox 360 game controller to direct the robot.

As the Gemini-Scout's controls and equipment needs to be waterproof as to ensure its functionality in watery area. It can navigate through 45cm (18 inches) of water, crawl over boulders, and rubble piles, and it can be used to evaluate potentially dangerous environments.

2.2.3 ROBHAZ-DT3

A Korean troops in Iraq has created a robot for hazardous application, ROBHAZ-DT3. Yujin Robot and the state-run Korea Institute of Science and Technology are the team responsible developing the this ROBHAZ-DT3 robot. It is equipped with portable remote controlled station and wireless communication of image and data.

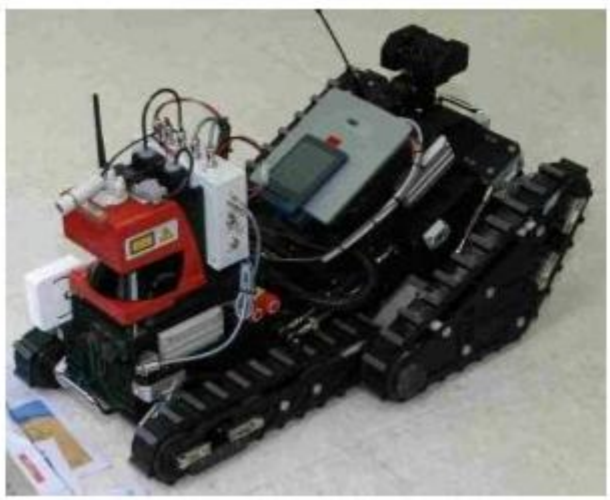


Figure 2.3: ROBHAZ-DT3

As it is fully equipped with laser sensors that enables the remotely-operated bot to create a map of the place where an event has taken its place. Moving object are detected by infrared cameras. This robot also has foldable arms, temperature sensors, and four sets of camera. It is uniquely installed with a set of tank treads that make it easily run through an uneven terrain. This is are truly remarkable as it allows waterproof, great flexibility, and able to climb stairs.

2.2.4 Hibiscus

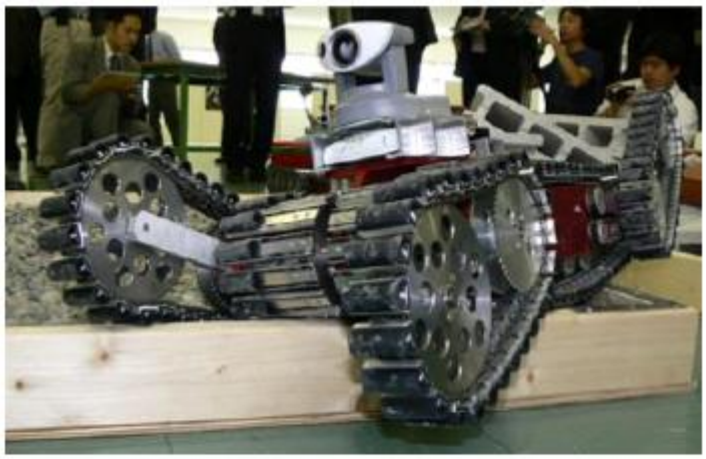


Figure 2.4: Hibiscus

A rescue robot named Hibiscus was developed by Chiba Institute of Technology and its main purpose is to look for survivors in case of earthquakes in Japan. It can detect heat signature of a trapped survivors with its infrared thermal camera. This robot are able to communicate to operator via WiFi 802.11g and is using a SH-4 processor, with its maximum speed of 1.1 meters per second. The dimensions are 370 mm x 650 mm x 180 mm and weighs is 22.5 kg. A 3700 mAh Lithium Polymer battery which lasts for 60 minutes are used to powered the robot. To move obstacles easily, the Hibiscus robot are design with six independent crawlers and has two flipper arms.

2.3 Summary

Rescue robot had been made in different shape and each of them designed to follow characteristic. Robot vision had been research in developing rescue robot.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The development process of the CAMBOT are shown in this chapter. It includes the body mechanism, the structure, the circuit and also its software.

3.2 Mechanical Design of Robot Structure

The robot structure and its modification are discussed thoroughly in this section. original component.

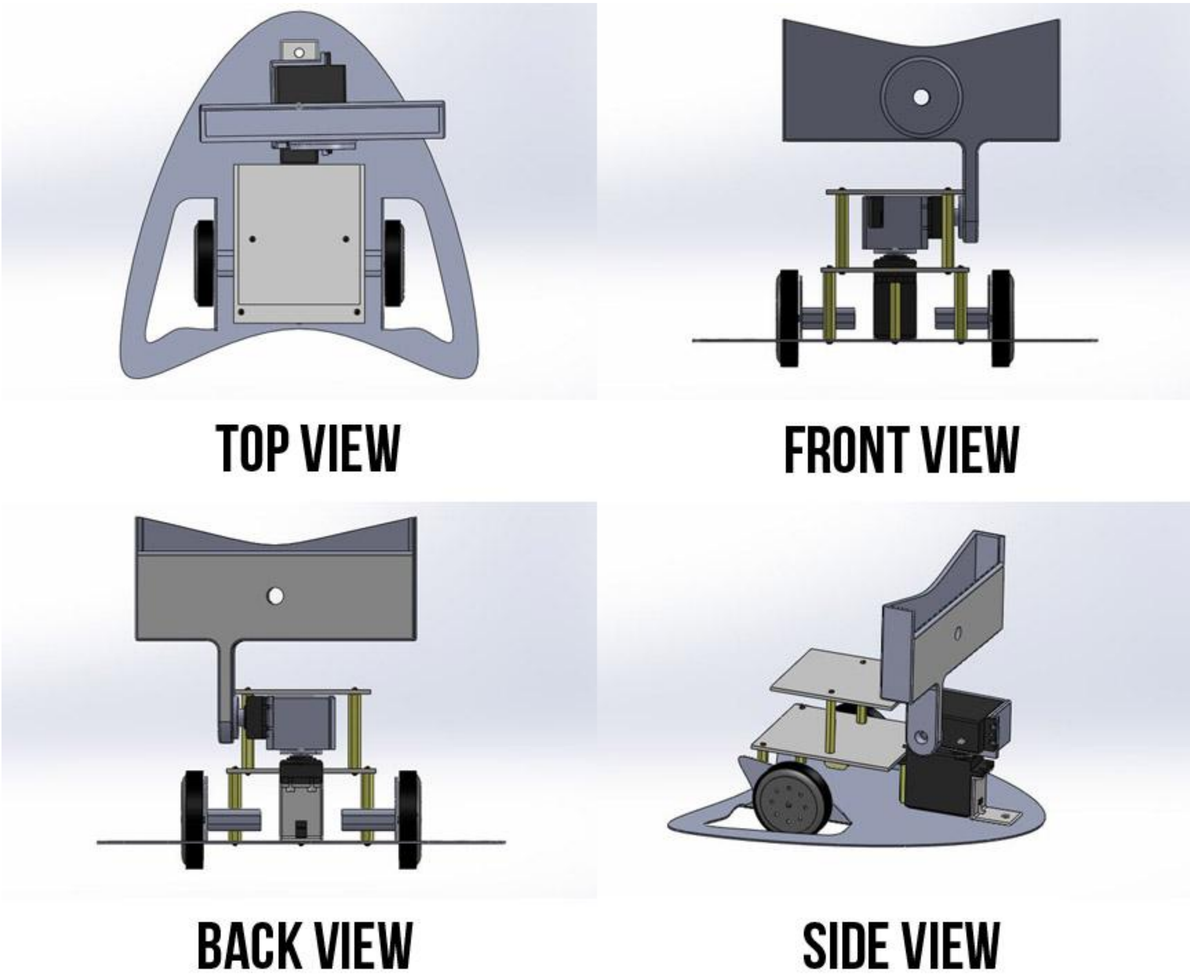


Figure 3.1: Three Dimensions Drawing of The Rescue Robot

3.2.1 Main Robot Structure

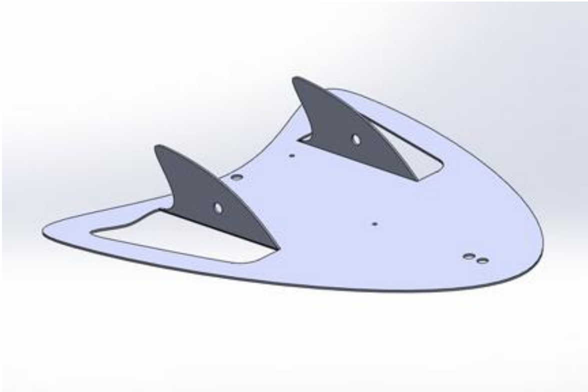


Figure 3.2: Main Robot Structure

To travel on a flat surfaces, the rescue robot need to be stable. That is why conventional wheel is use. Several conventional wheels have been studied in order to choose the most suitable conventional wheel for this project. The design, shape, price, function, limitation of each conventional wheel have been considered. The conventional wheels was used in this project is Cytron Set.

Cytron Set was chosen because there are several advantages of it. The base is wide and low this makes CAMBOT more stable. The material also strong made from iron can maintain the body shape. Besides, it also has a lot of hole for flexible used.

Moreover, Cytron Set consists of two micro metal gear motor used to control the robot motion. This micro metal gear motor has enough torque to move the CAMBOT and the micro size give advantages to CAMBOT by reduced the spaces.

3.2.2 Iphone 4 Holder

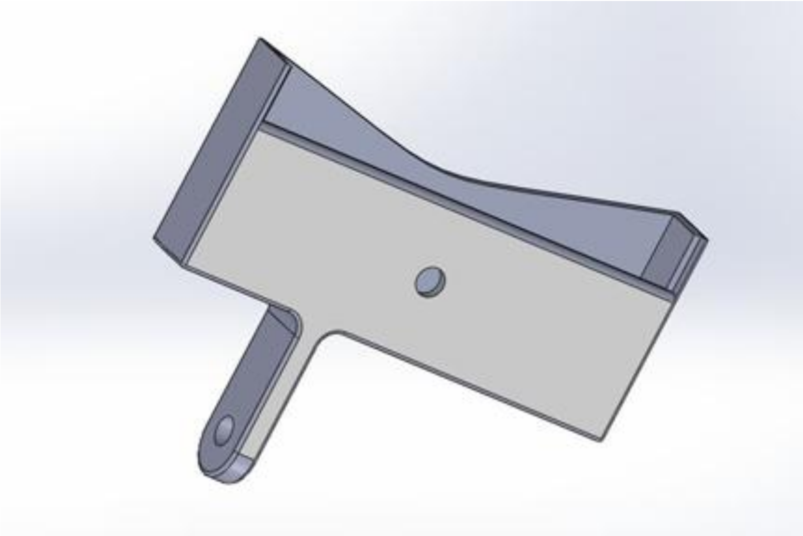


Figure 3.3: iPhone 4 Holder

The applications of the rescue motor are the real situation may face a lot of obstacles and limited spaces. In order to overcome this recording the robot structure was modified by adding two servomotors with holder at the front of the CAMBOT. The holder made using 3D printing and it function as iPhone 4 holders. This holder is navigating by two servomotors. One servomotor for left and right movement another one servomotor for upward and backward movement.

3.3.3 Bracket

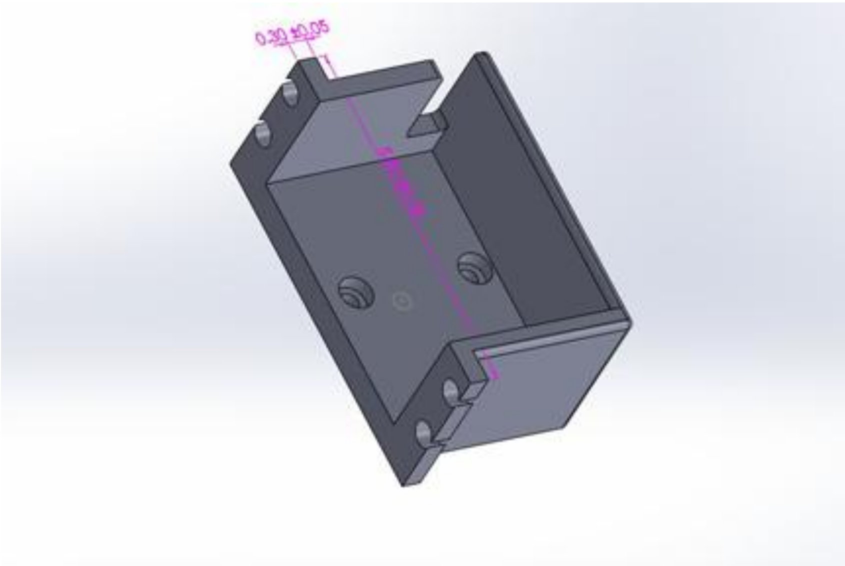


Figure 3.4: Bracket for Servomotor

In the original design, servomotor is attached by others servomotor but they is problem when we attached both together which is too loose. Due to this problem a bracket is designed accordingly to make sure the attachment stronger.

This bracket is designed using solidwork 2012 and made by using 3D printing.

3.3 Components and Electrical Circuitry

This section discusses the electrical circuitry design and components used. The full circuit connection is show in Appendix B. Table shows the major components used in this project.

NO.	Components	Quantity
1	Iteaduino Leonardo	1
2	L298	1
3	PS2 Starter Kit	1
4	PS2 wireless Controller	1
5	Apexis Wireless IP Camera	1
6	Servomotor	2
7	Micro metal gearmotor	2

Table 3.1: Major Components Used In This Project

3.3.1 Iteaduino Leonardo

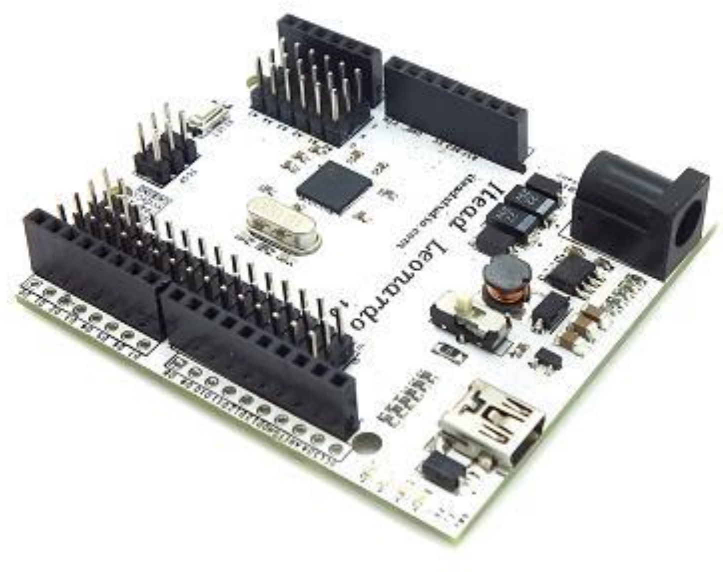


Figure 3.5: Iteaduino Leonardo

Microprocessor	ATmega32U4
PCB size	68.58mm X 58.42mm X 1.6mm
Indicators	Power,TX,RX,L
Power supply(recommended)	7-23V DC
Power supply(limits)	23 VDC (max)
Communication Protocol	UART,SPI,IIC
Clock Speed	16MHz
RoHS	Yes

Table 3.2: Specifications of Iteaduino Leonardo

Specification	Min	Type	Max	Unit
Input voltage	7	-	23	VDC
Operating Voltage	-	3.3/5	-	VDC
DC Current per I/O Pin	-	40	-	mA

Table 3.3: Electrical Characteristics of Iteaduino Leonardo

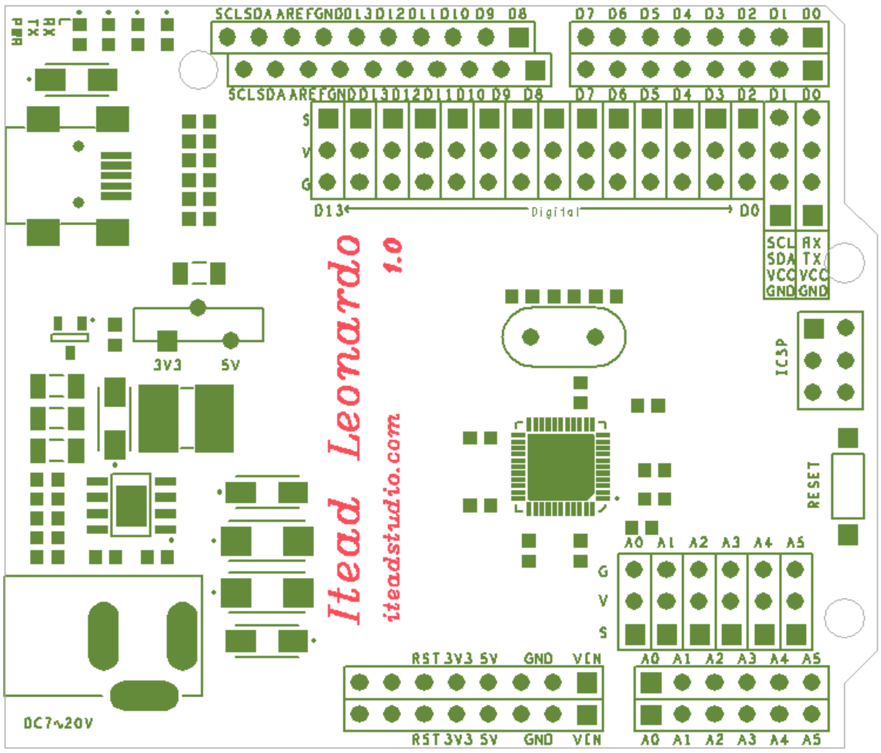


Figure 3.6: Pin Diagram of Iteaduino Leonardo

Index	Name of Arduino	Alternate Function	Pin of Atmega32u4
1	D0	UART DIN	PD2
2	D1	UART DOUT	PD3
3	D2	IIC_SDA	PD1
4	D3	IIC_SCL/PWM	PD0
5	D4	External Interrupt 0/A6	PD4
6	D5	External Interrupt 1/PWM	PC5
7	D6	PWM	PD7
8	D7	A7	PE6
9	D8	A8	PB4
10	D9	PWM/A9	PB5
11	D10	PWM/A10	PB6
12	D11	PWM	PB7
13	D12	A11	PD6
14	D13	PWM	PC7
15	A0		PF7
16	A1		PF6
17	A2		PF5
18	A3		PF4
19	A4		PF1
20	A5		PF0

Table 3.4: Pin Map of Iteaduino Leonardo

Figure 3.6 shows the pin diagram of Iteaduino Leonardo and Figure 3.7 shows the pin map of Iteaduino Leonardo. Iteaduino Leonardo have 20 digital input/output pins which 7 used as PWM and 12 as analog inputs, a micro USB connection, a 16MHz crystal oscillator, a reset button, and an ICSP header, and a reset button. This microcontroller contains everything needed to support. Connect USB cable to a computer or power it with an battery or AC-to-DC adapter to get started. The Iteaduino Leonardo differs from others and has built-in USB communication to eliminating secondary processor needed. This allows the Iteaduino Leonardo to connected computer as a keyboard and mouse, moreover to a virtual (CDC) serial/COM port. The Iteaduino Leonardo also has other implications for the behavior of the board. The Iteaduino Leonardo is chosen to be used as the main processing unit for the CAMBOT because it has high enough performance and cheaper price, which is only cost about RM45. Moreover, this Iteaduino Leonardo have 7 PWM modules with 10 bits resolutions.

PS2 Starter Kit communicated by using the receiver pin (RX) and transmitter pin (TX). Direction of the two motors is control by four pins of the Iteaduino Leonardo. While the speed of motors is control by two pins RC1 and RC2.

3.3.2 Motor Driver L298

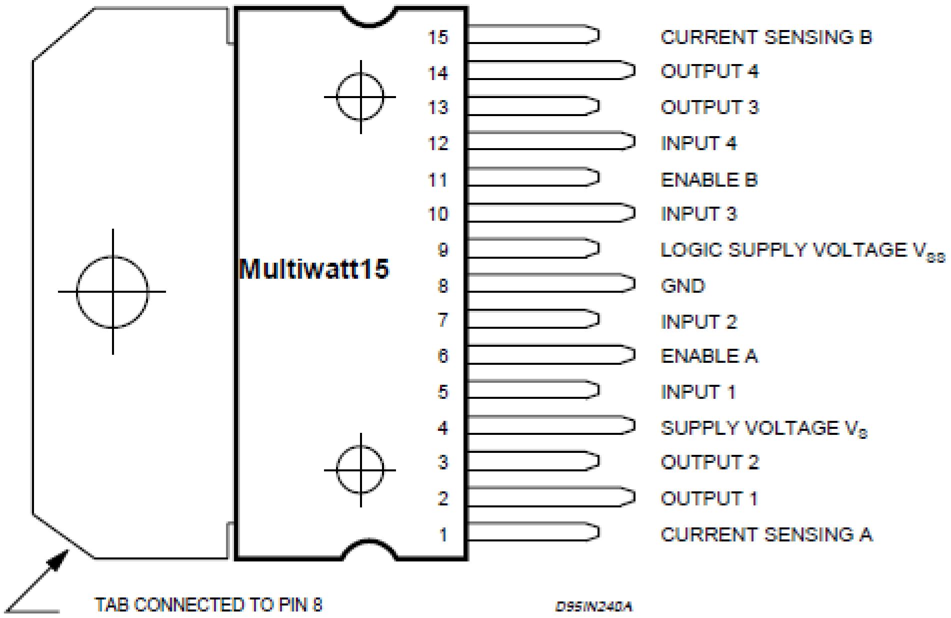


Figure 3.7: Motor Driver L298

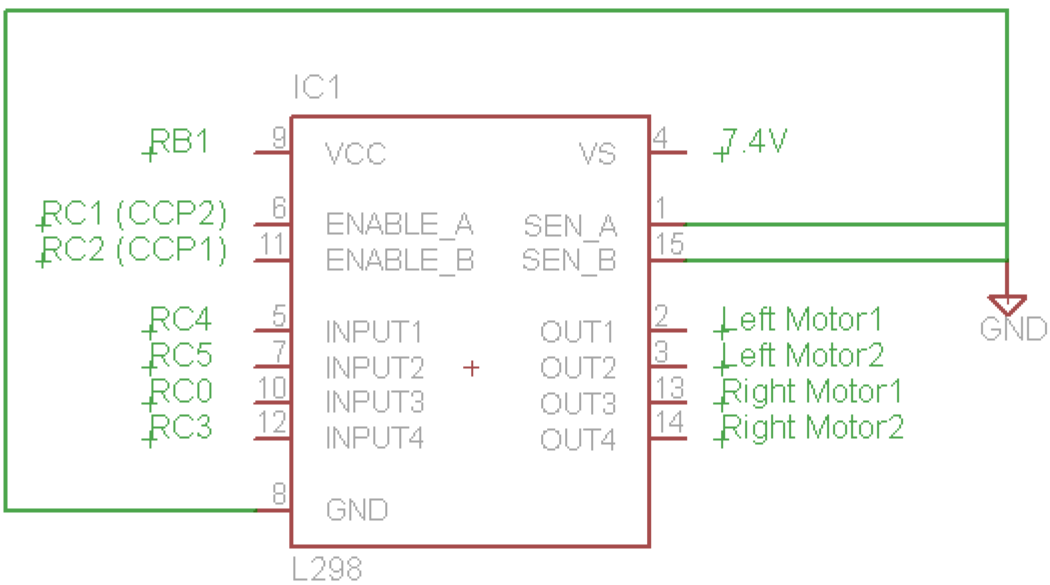


Figure 3.8: Conventional Wheel Motor Driver Circuit Connection

Figure 3.10 shows the architecture of Motor Driver IC L298 and Figure 3.11 and Figure 3.11 shows the circuit connection. The L298, in which contains a high current four channels, was chosen because it is suitable to use for controlling the two Dc motors per motor driver bidirectional. Hence, made it capable of delivering a 2.5A current output per channel.

This motor driver consists of four inputs and four outputs. The four inputs of the driver are connected to the microcontroller and the other four outputs are connected to the four terminals of two motors. 5V of power supply are given the logic for Motor Driver IC L298. On the other hand the motor power supply in this project is 7.4V and it is connected to pin 4 of the IC. Two enable pin of L298 are connected to the PWM signal, in which there are pin 6 and pin 11. These are used to control the speed of the motor. A PWM signal use an 8 bits, thus the range of the PWM signal used are 0 to 255, with 255 as the maximum speed.

3.3.3 PS2 Starter Kit and PS2 Wireless Controller

A PS2 controller is embedded in the robot design as the situation around the rescue robot is unsafe and unpredictable. Hence, made it easier for the user to navigate the robot whenever he wants it to go.

Figure 3.9: Wireless PS2 Controller

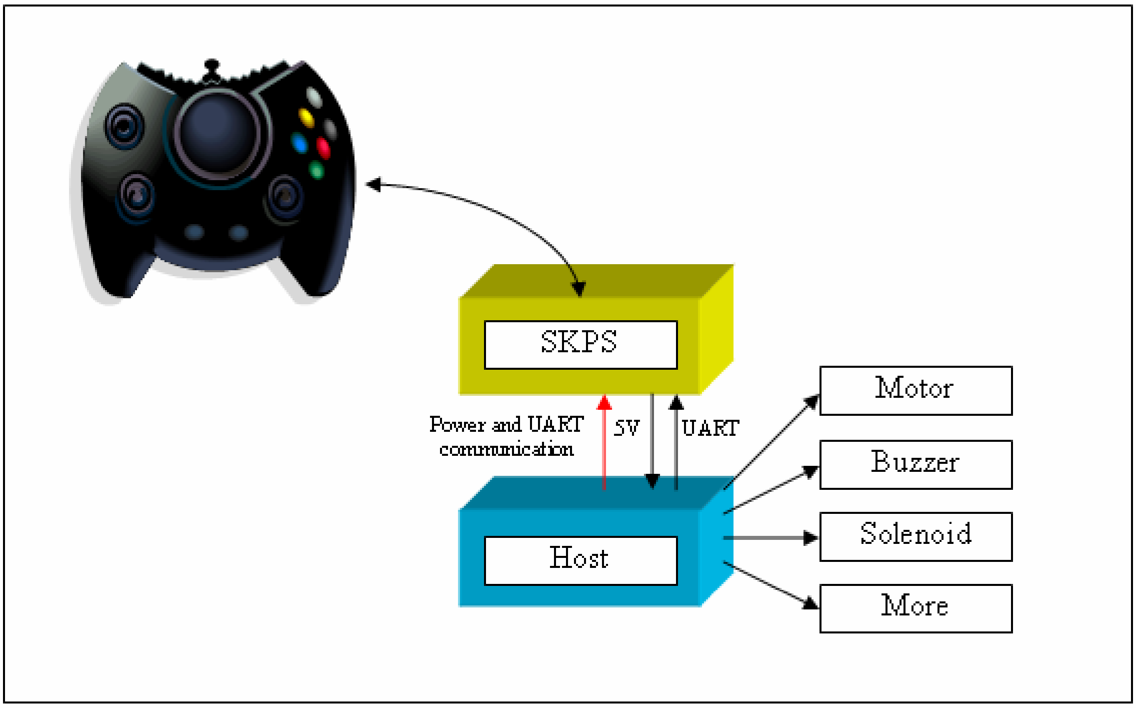


Figure 3.10: System overview

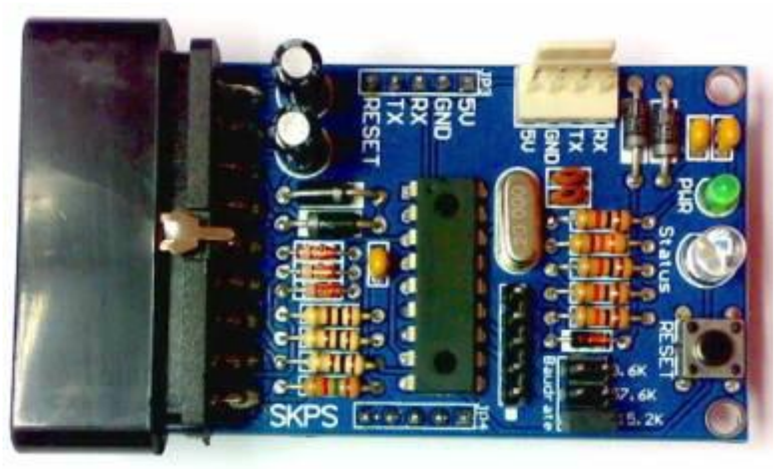


Figure 3.11: Board layout of SKPS

Label Function

A – Connector for PS2 controller

B – 5 ways header pin for external power supply and UART interface.

C – Alternative 4 ways 2510 header pin for external power supply and UART.

D – On board power indicator LED. It should be ON if SKPS is powered by stable 5V.

E – On board indicator LED, it indicators the connection status between SKPS and PS2 controller.

No controller connected : Blink

Controller connected : On with 50% brightness

Controller connected (button pressed): On with 100% brightness

F – Reset button for SKPS board.

G – Baud rate selector. User may either choose 9600, 57600 or 115200 baud rate. Place the jumper to select the baud rate.

Label	Definition	Function
5V	Power Input for SKPS	External power source for SKPS, the typical voltage is 5V. Please ensure this 5V source is a stable supply. Please do not use normal AC-DC adaptor to power it. It is recommended to use linear regulator (7805) to provide

		5V supply.
GND	Ground or negative	Ground of power and signal.
RX	SKPS UART Receive signal	This is SKPS's receiver pin, it should be interfaced to 5V logic UART, no divider is necessary. This is an input pin to SKPS. It should be connected to microcontroller's transmitter pin.
TX	SKPS UART Transmit signal	This is SKPS's transmitter pin; it should be interfaced to 5V logic UART. This is an output pin from SKPS. It should be connected to microcontroller's receiver pin.
RESET	SKPS Reset pin	Reset pin of SKPS. It should be connected to a push button to Gnd, or NPN transistor.

Table 3.5: Product Specifications and Limitations

5V	Power source for SKPS	4.5	5.5	V
GND	Operating voltage ground	0	0	V
RX	Receiver pin of SKPS	0	5.5	V
TX	Transmitter pin of SKPS	0	5.5	V
RESET	Reset pin of SKPS	0	5.5	V

Table 3.6: Absalute Maximum Rating

Figure 3.14 shows a Wireless PS2 Controller. PS2 is abbreviation for Playstation 2. PS2 wireless controller 2.4GHz and Cytron PS2 Controller Starter Kit were utilized to control the robot remotely. PS2 controller is chosen because it is easily obtainable from any local game store, and offered control system that are easy to use by a human.

The problem with the usage of PS2 is its socket and the protocol to communicate with the robot body. The PS2 socket is different and not easy to find. Furthermore, each button and analog stick has its own digital signature, in which its protocol is uneasy to locate.

To solve this problem, the Cytron PS2 Starter Kit is used. In this case, reading the Joystick buttons will be easier. Besides, it also comes with a standard connector for Sony PS2 controller to plug-in.

In an essence, the Cytron PS2 Starter Kit is using serial communication over UART and only requires four simple connections on it. There are a transmitter (TX), receiver (RX), voltage supply 5V and Ground. Indeed the TX and RX are cross connected to TX (pin 25) and RX (pin 26) on Iteaduino Leonardo. Cross connection means the transmitter (TX) of PS2 Starter Kit is connected to the receiver (RX) of Iteaduino Leonardo while the receiver (RX) of PS2 Starter Kit is connected to the transmitter (TX) of Iteaduino Leonardo. The connection enables the two devices to communicate and transfer data with each other.

The other values were assigned to other movements of the robot to solve the scrambled Rubik's Cube. The Table 3.25 shows the movements of the robot with the corresponding notations and values.

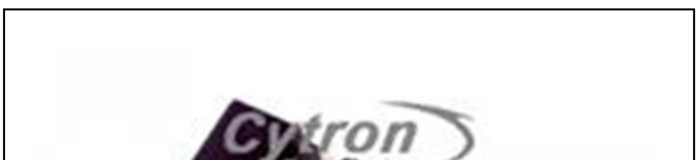


Figure 3.12: PS2 Controller Starter Kit

3.3.4 Apexis Wireless IP Camera

Figure 3.13: Apexis Wireless IP Camera

Figure 3.16 show Apexis Wireless IP Camera. As mention before the situation around the rescue robot is unsafe and unpredictable, Apexis wireless IP camera was used to monitor and send the captured image to the robot operator.

Apexis wireless IP camera was chosen because it has built in servo motor to rotate camera view. The camera has maximum pitch angle 2 and maximum yaw angle 2. Apexis Wireless IP Camera it has the moderate resolution and cheaper price compared to other wireless IP camera. The video provided by the camera is of a middle quality but good enough for this project.

The video can be viewed live by any device, such as from computer, or laptop, or even by using supported phones. These user friendly specs would make the handling job for the operator much easier. Furthermore, the three different ways to view the live camera can be used during the scarcity of electrical supply.

Apexis wireless IP camera create a wireless network connection around it automatically. Thus, any laptops, or smartphones that can detect WiFI can acces the live video. To make things easier, the Apexis wireless IP Camera does not require any software to view the live cam, it takes any ordinary web browser to operate.

3.3.5 Micro Metal Gearmotor

Micro Metal Gear motor as shown in Figure 4.21 was used as an actuator to move the forward, backward and driving the cleaning mechanism. For this robot, two type of gear ratio is needed. The first ratio is 289:1 Micro Metal Gear motor is used to move the robot. Second ratio is 150:1 Micro Metal Gear motor is used to drive the cleaning mechanism. To be able to move, the robot needs very high torque motor because of the weight of the robot. As for cleaning part, it need high speed motor to rotate and clean the mud. Table 4.1 shows the specification of the metal gear motors when running at 6V [14].

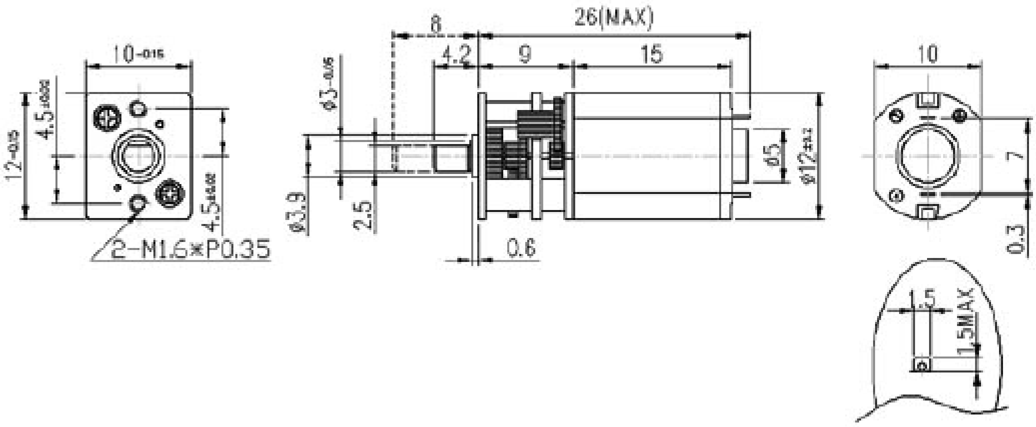


Figure 3.14 Micro Metal Gear motor with the dimension

Gearmotor	Gear Ratio	Free-run RPM	Free-run Current	Stall Current	Stall Torque (oz-in/kg-cm)	Weight (oz/g)
30:1 Micro	30:1	440	40 mA	360 mA	4/0.3	0.35/10
150:1 Micro	150:1	85	40 mA	360 mA	15/1.1	0.35/10
298:1 Micro	298:1	45	30 mA	360 mA	25/1.8	0.35/10

Table 3.7 The specification of the metal gear motors when running at 6V.

Since the motor control from the Iteaduino Leonardo is in open-loop control configuration, thus controlling motor becomes expensive when the noise is arising. Thus, it is difficult to compensate the desired point. For this project, the motor is fed with 9V.

3.3.6 RC Servomotor

The servomotor used to control the steering clockwise or counter clockwise. Servomotors generally have three wires, one for controlling the motor and the other two is the power supply. This servomotor powered directly from a battery or other DC supply, which is typically 3, 5, or 6 Volt. Figure 3.13 was the servo motor 9g Mini Servo. Following is the features for mini Servomotor. Servomotors receive an input signal in the form of a pulse width modulation (PWM) signal, and then turn their output shaft to the position indicated by the signal, 22 typically swinging in an arc of 90 or 180 degrees depending on the motor's specifications.

Figure 3.15: Servomotor

3.3.7 Lithium Polymer Battery

Lithium Polymer Battery, as shown in Figure 3.9 is the power supply for the robot. It is a rechargeable battery and it currently very popular in robotic sector due to its small size and lightweight. Followings are the features of the battery used in this project:

- Ordinary Voltage: 7.4V
- Fully-charge Voltage: 8.6V
- Capacity: 1300mAh
- Discharge rate: 15C

Figure 3.16: Lithium Polymer Battery

3.4 Programming and Software Design

This section discusses the software development process. Arduino 1.5.2 is used for writing program. C language is used to program the Iteaduino Leonardo. Simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Program flow chart is also included in the next section. Figure 3.17 shows the programming workplace of Arduino 1.5.2.

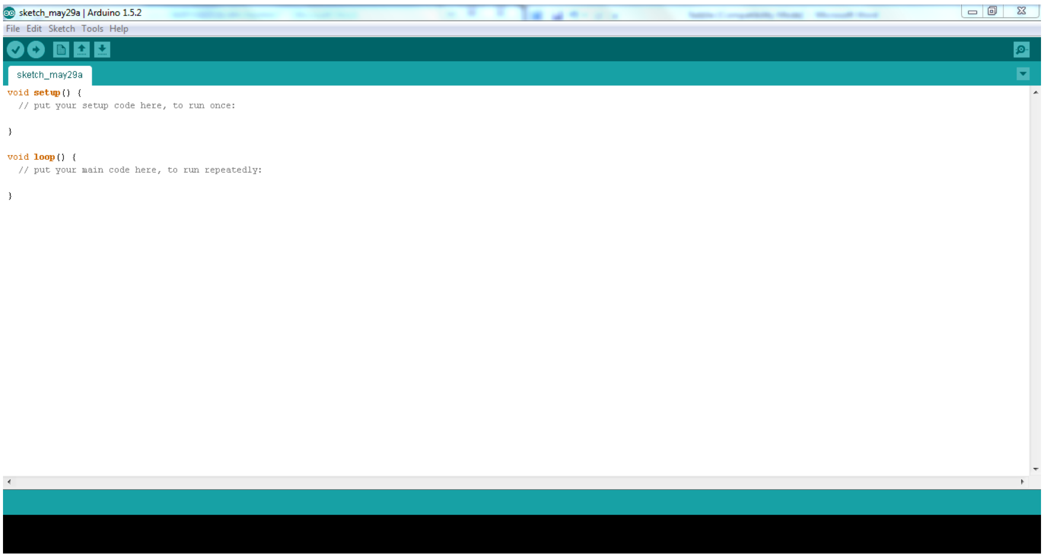
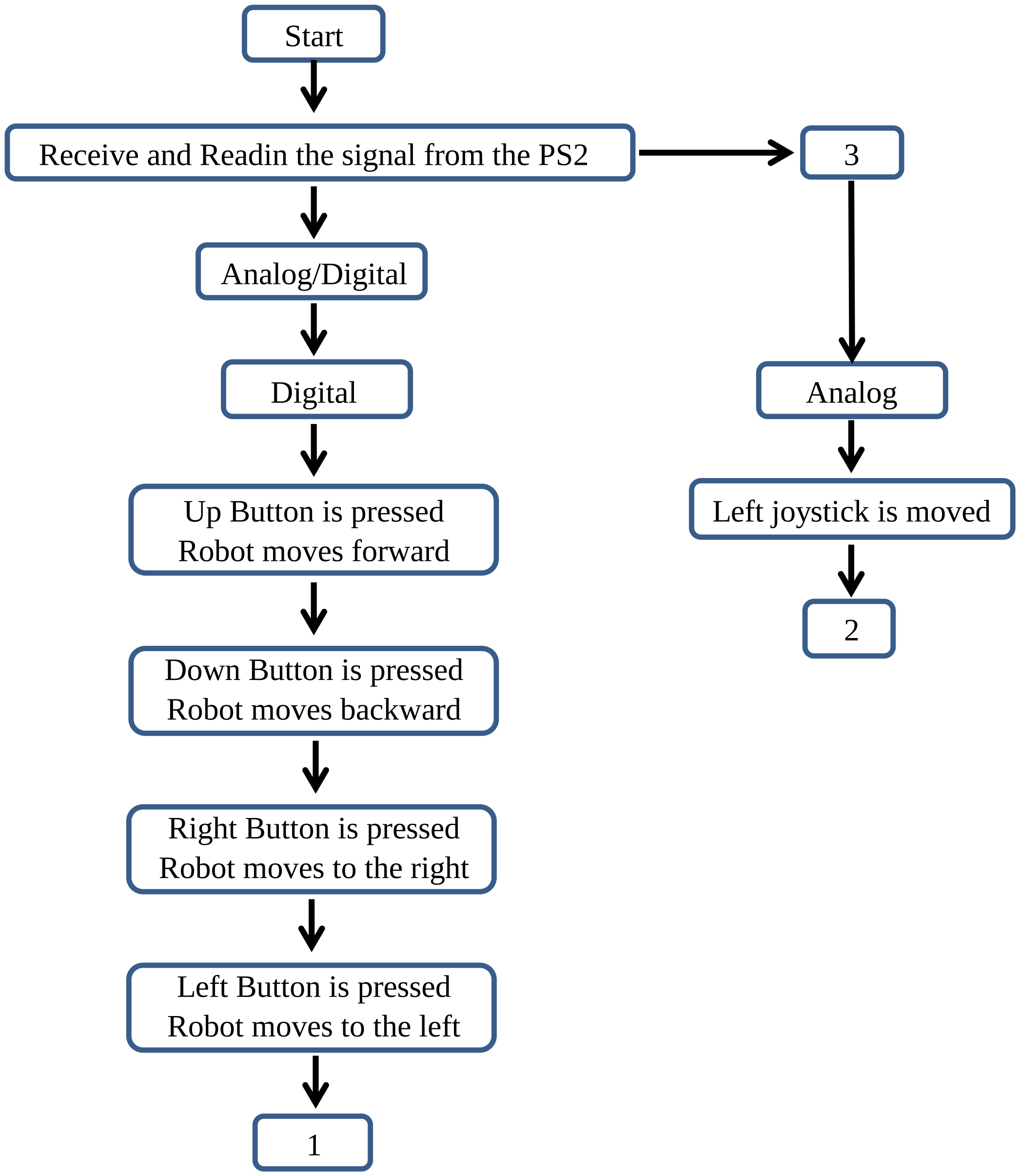
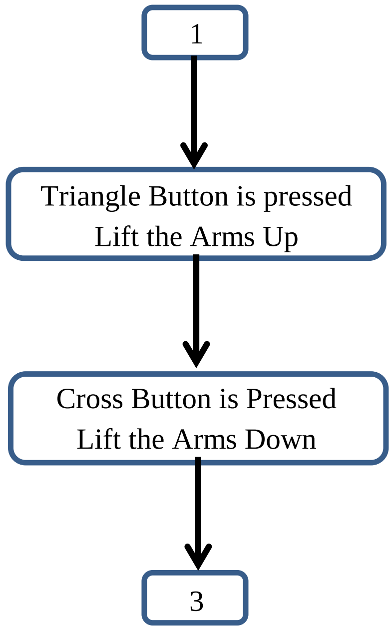


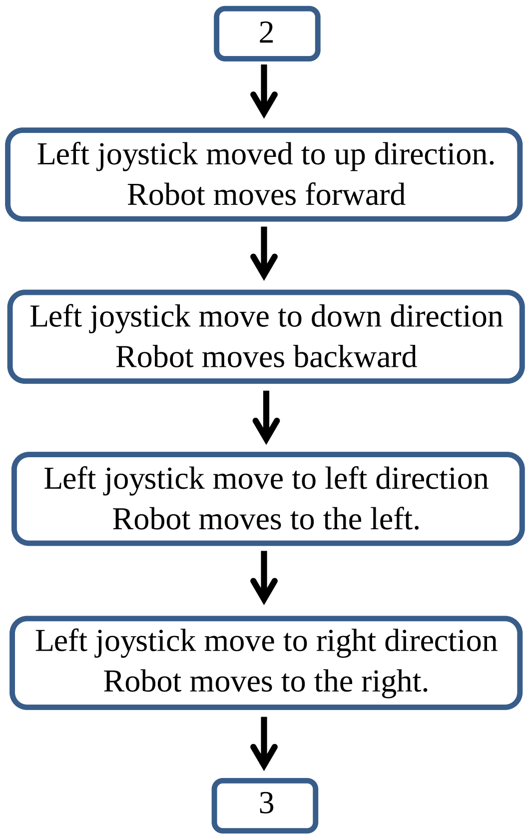
Figure 3.17: Arduino 1.5.2

3.4.1 Flow Chart

The rescue robot function mainly base on the signal received from the PS2 controller. The program flow chart is showed as below.




1
Triangle Button is pressed
Lift the Arms Up
Cross Button is Pressed
Lift the Arms Down
3


2
Left joystick moved to up direction.
Robot moves forward
Left joystick move to down direction
Robot moves backward
Left joystick move to left direction
Robot moves to the left.
Left joystick move to right direction
Robot moves to the right.
3

3.4.2 PS2 Starter Kit Protocol

PS2 wireless controller consist 30 buttons on it. In order to differentiate which button is pressed, PS2 starter Kit uses a unique protocol by defining each button with a particular number. The PS2 Starter Kit Protocol is showed as Figure 3.18.

#define p_select	0
#define p_joyl	1
#define p_joyr	2
#define p_start	3
#define p_up	4
#define p_right	5
#define p_down	6
#define p_left	7
#define p_l2	8
#define p_r2	9
#define p_1l	10
#define p_r1	11
#define p_triangle	12
#define p_circle	13
#define p_cross	14
#define p_square	15
#define p_joy_lx	16
#define p_joy_ly	17
#define p_joy_rx	18
#define p_joy_ry	19
#define p_joy_lu	20
#define p_joy_ld	21
#define p_joy_ll	22
#define p_joy_lr	23
#define p_joy_ru	24
#define p_joy_rd	25
#define p_joy_rl	26
#define p_joy_rr	27
#define p_con_status	28
#define p_motor1	29
#define p_motor2	30

Figure 3.18: PS2 Starter Kit Protocol

3.4.3 PS2 Starter Kit Signal Processing

This part discussed the signal process of the of the PS2 Starter Kit. The initial logic of all buttons is 1. The button will be automatically set to 0, when it has been pressed.

3.4.3.1 Button Control (Digital Control)

Digital Logic is used to control the button of the PS2. Whenever the button is pressed, the logic state of the up button is eventually turning to 0. Then, the ‘if’ loop condition become true, the ‘if’ loop will be executed. The syntax for the PS2 controller up button signal processing is shown in Figure 3.20.

```
if(skps(p_up)==0)
{
  digitalWrite(left1, LOW);
   digitalWrite(left2, HIGH);
   analogWrite(pwmLeft,  150);
   digitalWrite(right1, LOW);
   digitalWrite(right2, HIGH);
   analogWrite(pwmRight, 150);
}
```

Figure 3.19: Syntax of PS2 Starter Kit (Digital Control)

3.4.3.2 Joystick Control (Analog Control)

To control the joystick of the PS2, the joystick angle (analog) is used. The syntax to demonstrate this begin by declaring four unsigned characters up_v, down_v, left_v, and right_v to represent the four ordinary direction which are up, down left, and right as shown in Figure 3.21. Then, equal the unsigned character to the four direction of the PS2 Starter Kit protocol.

```
up_v=skps(p_joy_ru);
down_v=skps(p_joy_rd);
left_v=skps(p_joy_ll);
right_v=skps(p_joy_lr);
```

Figure 3.20: The declaration of four unsigned character for analog control

Next, the unsigned character is used to determine the direction of the joystick. By using loop in the loop programming technique, the other four direction which are up-left, up-right, down-left and down-right can be determined.

```
void loop()
{
  servoKK.write(posKK);
  servoAB.write(posAB);

  if(skps(p_R1)==0)          //Check whether Up button is pressed
  {
     digitalWrite(led,HIGH);
  }

   if(skps(p_L1)==0)          //Check whether Up button is
pressed
  {
     digitalWrite(led,LOW);
  }

   if(skps(p_Circle)==0)
  {
    posAB=posAB+2;

    if(posAB>=180){posAB=180;}
    else{posAB=posAB;}
    servoAB.attach(AB);
    servoAB.write(posAB);

  }

   if(skps(p_Square)==0)
  {
    posAB=posAB-2;

    if(posAB<=0){posAB=0;}
    else{posAB=posAB;}
    servoAB.attach(AB);
    servoAB.write(posAB);
   }



   if(skps(p_Triangle)==0)
  {
    posKK=posKK+2;

    if(posKK>=180){posKK=180;}
    else{posKK=posKK;}
    servoKK.attach(KK);
    servoKK.write(posKK);
   }
```

```
if(skps(p_Cross)==0)
{
  posKK=posKK-2;

  if(posKK<=0){posKK=0;}
  else{posKK=posKK;}
  servoKK.attach(KK);
  servoKK.write(posKK);
 }


 if(skps(p_Up)==0)
 {

 digitalWrite(left1, LOW);
 digitalWrite(left2, HIGH);
 analogWrite(pwmLeft,  150);
 digitalWrite(right1, LOW);
 digitalWrite(right2, HIGH);
 analogWrite(pwmRight, 150);

  }

  if(skps(p_Down)==0)
 {

 digitalWrite(left1, HIGH);
 digitalWrite(left2, LOW);
 analogWrite(pwmLeft,  150);
 digitalWrite(right1, HIGH);
 digitalWrite(right2, LOW);
 analogWrite(pwmRight, 150);

  }

  if(skps(p_Left)==0)
 {

 digitalWrite(left1, LOW);
 digitalWrite(left2, HIGH);
 analogWrite(pwmLeft,  150);
 digitalWrite(right1, LOW);
 digitalWrite(right2, LOW);
 analogWrite(pwmRight, 0);

  }
```

```
if(skps(p_Right)==0)
 {

 digitalWrite(left1, LOW);
 digitalWrite(left2, LOW);
 analogWrite(pwmLeft,  0);
 digitalWrite(right1, LOW);
 digitalWrite(right2, HIGH);
 analogWrite(pwmRight, 150);

  }

   if(skps(p_Start)==0)
 {

 digitalWrite(left1, LOW);
 digitalWrite(left2, LOW);
 analogWrite(pwmLeft,  0);
 digitalWrite(right1, LOW);
 digitalWrite(right2, LOW);
 analogWrite(pwmRight, 0);

  }


else                          //Check whether no button is pressed
{ ;
  //digitalWrite(led, LOW);
```

Figure 3.21: Syntax of PS2 Starter Kit (Analog Control)

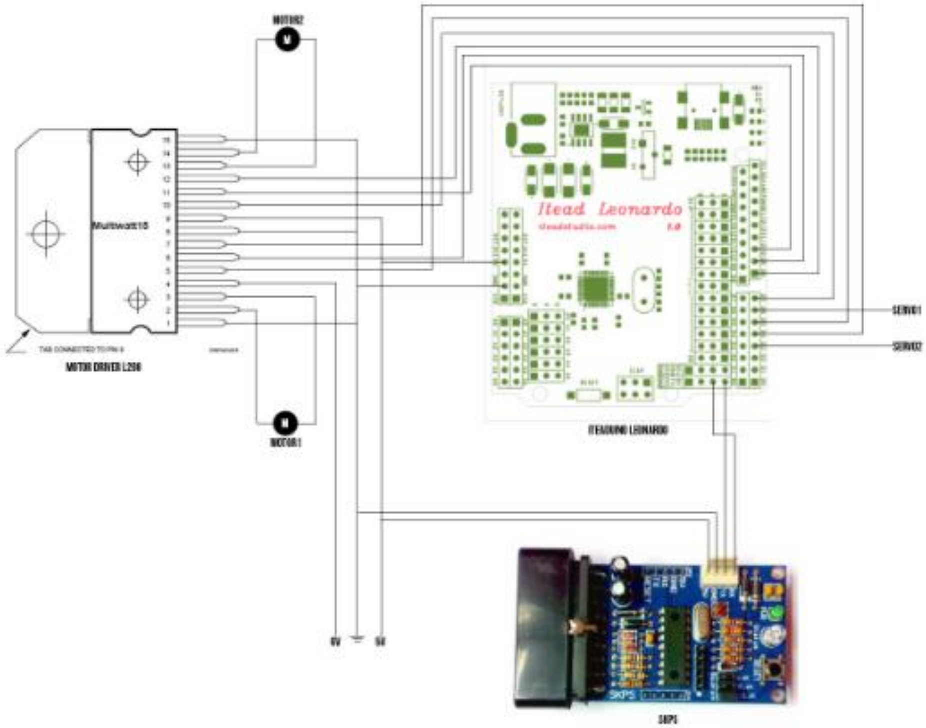
3.4.4 Pulse Width Modulation Module

The registers CCPICON and CCP2CON is set to 0b00001 to enable the PWM mode of the microcontrollers. This is substantial in order to use the microcontroller to control the motors speed. The PR2 register is set to 255, which means that the period of the PWM is set to 255. T2CON is set to 4 that enables the timer. Figure 3.23 shows code to initialize the PWM.

```
PR2 = 255;
T2CON =
0b00000100;
CCP1CON =
0b00001100;
CCP2CON = 0b00001100;
```

Figure 3.22: PWM Module Initialization

3.4.5 Circuit Diagram



3.5 Summary

In designing the CAMBOT, hardware, electrical and software need to be integrate together in order to produce a functional product.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Actual Robot

In this chapter, it discussed on results of CAMBOT and it application in daily life. A few simple movement also shown in this chapter.

Figure 4.1: Front view of Rescue Robot

4.2 Applications

Since the rescue robot are used to monitor an unknown situation of a disaster area in which it is unpredictable and unsafe. Thus, this rescue robot can move in the most surfaces. Figure 4.3 to Figure 4.6 show the robot move in the various surfaces.

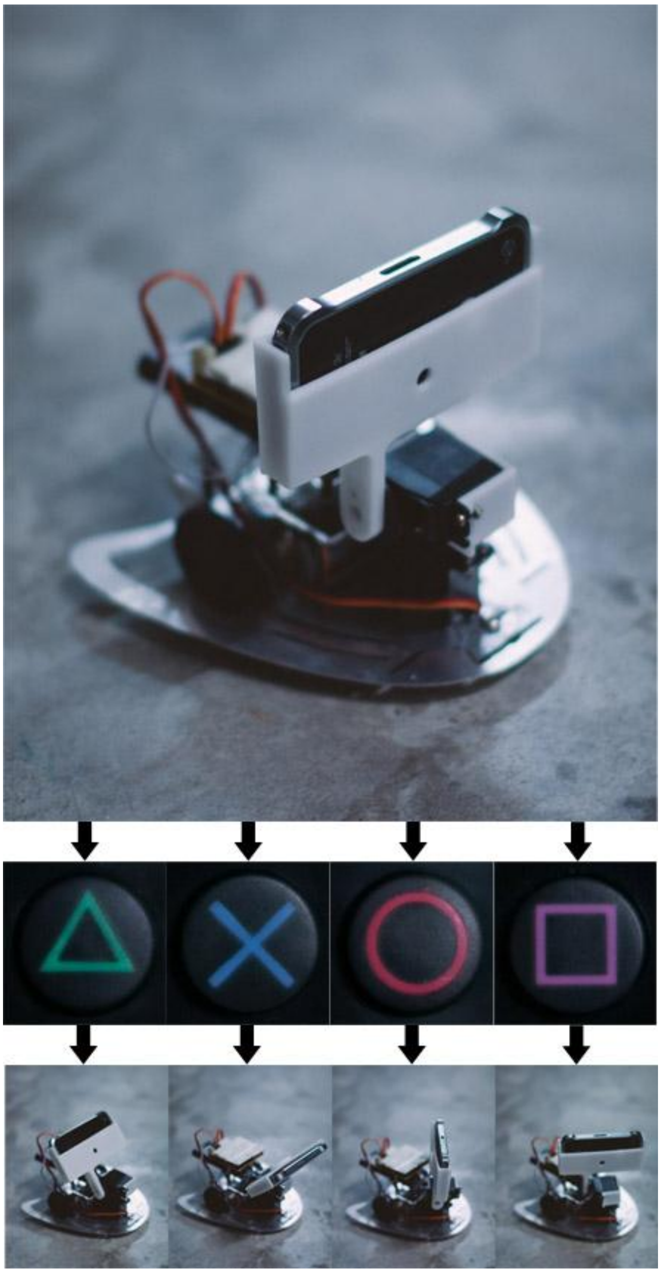


Figure 4.2: CAMBOT Movement

4.3 Live Video

Figures 4.7 and 4.8 show the live video received from Apexis Wireless IP Camera by laptop and smart phone. Although the resolution of the IP camera is moderate, the live video received is clear enough for the Rescue Robot applications.

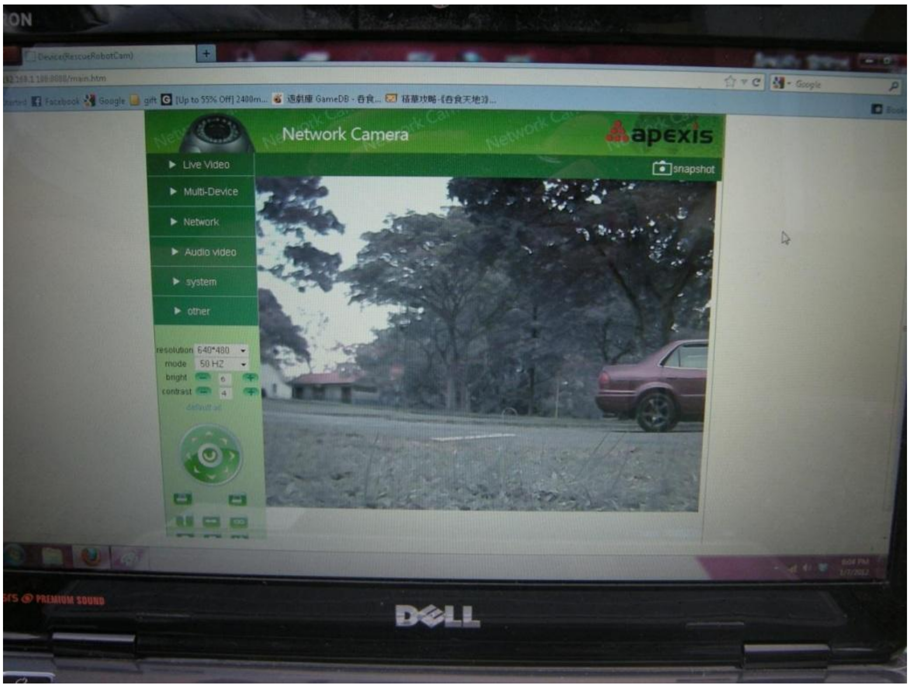


Figure 4.3: The live video received by laptop

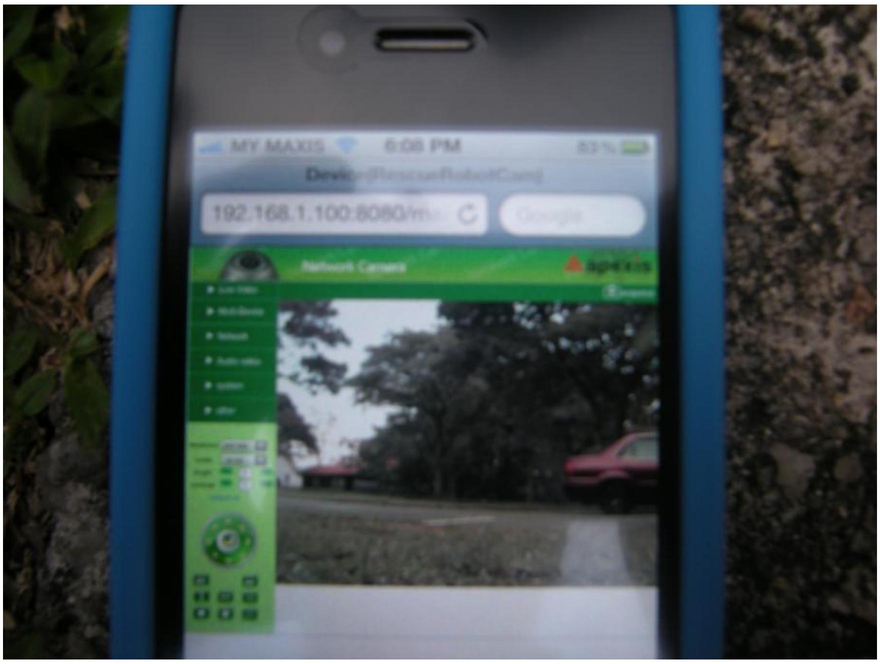


Figure 4.4: The live video received by smart phone

As mention in the previous chapter, the video from Apexis Wireless IP Camera can be view simultaneously by computer, laptop and smart phone. Figure 4.9 show the simultaneous video received by laptop and smart phone.

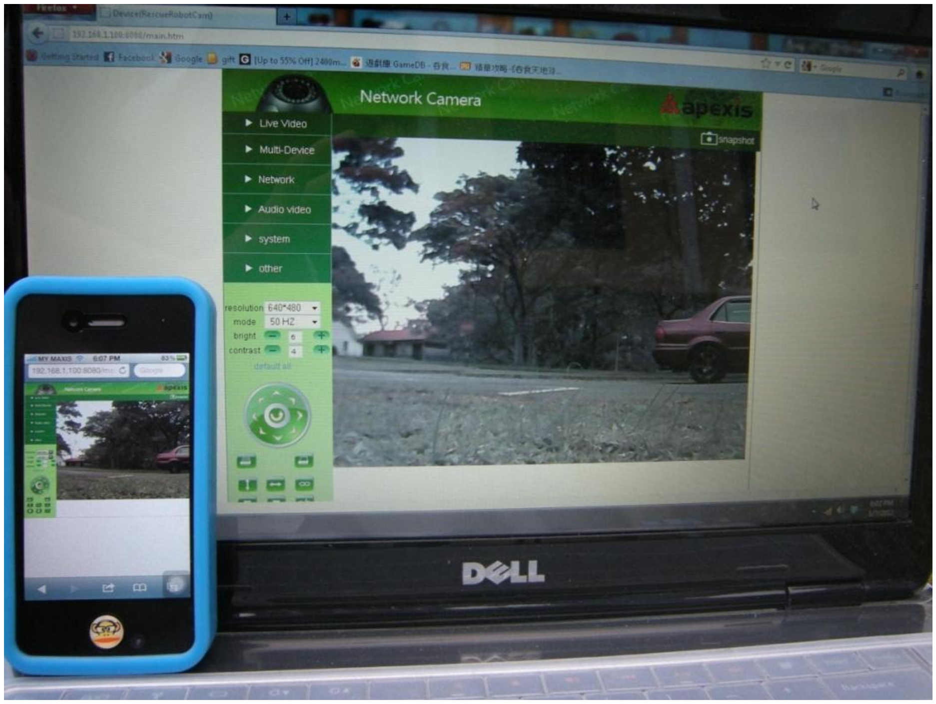


Figure 4.5: The live video received by Laptop and Smart Phone simultaneously

4.4 Summary

After the CAMBOT had been made, the performances of the CAMBOT need to be tested in order to check whether it had achieve the project scope and objectives. The objective had been achieved within the scope of the project.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the CAMBOT can be controlled by a human being (operator). The live video recorded by the CAMBOT can gives feedbacks to the operator by using the wireless IP camera. Since the operator can control the CAMBOT and monitor ay resurgence around the CAMBOT, the rescue worker can act upon the situation and get away from any danger.

In addition, the CAMBOT are capable to travel on most surfaces and avoid specific obstacles using a modified conventional wheel structure. Thus it enables the CAMBOT to execute its duty obediently, and gracefully. Thus, the main obejctives of the project has been achieved.

5.2 Limitations

There are some limitations of this project, which are stated follows:

1. The robot structure is too hard and the holes provide is limited so difficult to drill more holes.
2. The PS2 controller is able to the rescue robot in the range of 2 m only.

3. The wireless IP camera consume a high power, a big battery are needed to operate the wireless IP camera.

4. The impact of servo motor is very high, and it will result that the recording stability.

5.3 Recommendation

For future development purpose, few suggestions are recommended as follows:

1. Do not modify the original Rover 5 Tank Chassis Set, but direct made a new tracked wheel platform with metal material.
2. Use other stronger wireless control device to replace the PS2 controller and PS2 Starter Kit in order to control the rescue robot in bigger range.
3. The Apexis wireless IP camera can be replaced by a lower power consume camera or any live vision device.
4. Chose a suitable servo motor that low impact.

REFERENCES

[1] Mary Bellis(2012). *The Definition of a Robot*. About.com Guide

[2] Engineering Seismology and Earthquake Engineering Research (e-SEER). (2009). Research Group: Retrived June, 28, 2012, from http://utm.simple.my/content.php?id=109&cid=81&lang=1

[3] Joseph Loh, and Rashvinjeet S. Bedi (2009, October 11). *Unshaken Complacency*. The Star. Retrieved October 11,2009, from http://thestar.com.my/news/story.asp?file=/2009/10/11/focus/4882460&sec=focus

[4] Lee, W., & Park, C. (2004). RoboCup2004 – US Open.

[5] Lee, W., Kang, S., Kim, M., & Park, M. (2004). *ROBHAZ-DT3 : Teleoperated Mobile Platform with Passively Adaptive Double-Track for Hazardous Environment Applications*, *1*, 33-38.

[6] Ohno, K., & Yoshida, T. (2009). RoboCupRescue 2009 - Robot League Team < *Pelican United (JAPAN)* > Rescue Robot League Pelican United (Japan).

[7] Germany, H. D., Graber, T., Kohlbrecher, S., Meyer, J., & Petersen, K. (2011). *RoboCupRescue 2011 - Robot League Team*, (1).

[8] Soltanzadeh, A. H., Chitsazan, A., Azizah, S., & Ghazali, S. A. (2010). RoboCupRescue 2010 - Robot League Team, *2009*.

[9] Azizah, S., & Ghazali, S. A. (2009). RoboCupRescue 2009 - Robot League Team.

[10] Soltanzadeh, A. H., Rajabi, A. H., Alizadeh, A., Eftekhari, G., & Soltanzadeh, M. (2011). RoboCupRescue 2011 - Robot League Team, *1*.

[11] Billah, M., Ahmed, M., & Farhana, S. (2008). Walking Hexapod Robot in Disaster Recovery : Developing Algorithm for Terrain Negotiation and Navigation, 328-333.

[12] Kadous, M. W., Sheh, R. K.-man, & Sammut, C. (2006). Effective User Interface Design for Rescue Robotics.

[13] M.Tandy, S.Winkvist, and K.Young(2010). Competing in the RoboCup Rescue Robot League. 1 – 15. None

[14] Mohd Syawal Bin Mohamed Abdul Fatah(2006). Tracked Wheel Development and Implementation for Mobile Robot. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[15] Lim Choong Honn(2008). Development of A Wireless Mobile Robot. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[16] Lee Wai Kun(2010), Wheeled Mobile Robot with Motion Control. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[17] Singapore Robotic(2010). *Jaguar Platform User Manual*, Singapore: Singapore Robotic

[18] Cytron Technologies Sdn. Bhd(2008). *PS2 Controller Starter Kit.* Skudai, Johor: Cytron Technologies Sdn. Bhd.

[19] STMicroelectronics(2000). Dual Full-Bridge Driver L298. U.S.A: STMicroelectronicsote

[20] Shenzhen Apexis Electronic Co.,Ltd(2011), IP Camera Remote Pan/Tilt Rotate User Manual. China: Shenzhen Apexis Electronic Co.,Ltd(2011)

Appendix A

Task	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FYP Briefing	■	■	■													
Literature Review				■	■	■	■									
Writing Proposal					■	■										
Submitting Proposal							■									
Designing Flow Chart					■	■	■									
Designing Hardware						■	■	■	■	■	■	■				
Circuit Design										■	■	■	■			
Testing Designed Hardware													■	■		
FYP1 Briefing													■			
Thesis Report							■	■	■	■	■	■	■	■	■	■

Gantt chart for FYP 1

Task	Week																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hardware	■	■	■	■	■													
Circuit					■	■	■	■	■									
Programming							■	■	■	■	■	■	■					
Testing												■	■	■	■			
Presentation and Demostration																■		
Thesis Report	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Gantt chart for FYP 2

Appendix B

```
#include <Servo.h>

Servo servoKK;
Servo servoAB;


///---------------------------------------------

//skps protocol
#define  p_Select    0
#define p_Joyl      1
#define p_Joyr      2
#define p_Start     3
#define p_Up        4
#define p_Right     5
#define p_Down              6
#define p_Left      7
#define  p_L2       8
#define  p_R2       9
#define p_L1        10
#define p_R1        11
#define p_Triangle  12
#define p_Circle    13
#define p_Cross     14
#define  p_Square    15
#define p_Joy_lx    16
#define  p_Joy_ly    17
#define p_Joy_rx    18
#define p_Joy_ry    19
#define p_Joy_lu    20
#define p_Joy_ld    21
#define p_Joy_ll    22
#define p_Joy_lr    23
#define p_Joy_ru    24
#define p_Joy_rd    25
#define p_Joy_rl    26
```

```
#define p_Joy_rr    27
//----------------------------------------------

//constant variable
const int rx = 0;
const int tx = 1;
const int led =13;

int posAB = 90;
int posKK = 90;
const int AB = 3;
const int KK = 6;

const int pwmLeft  = 9;
const int pwmRight = 10;
const int left1    =  4;
const int left2    =  5;
const int right1   =  7;
const int right2   =  8;


void setup()
{
  Serial1.begin(9600);      //Set serial baud rate as 9600
  Serial.flush();           //Waits for the transmission of outgoing serial data to
complete.

  //Set the mode for each digital pins whether input or output
  pinMode(rx, INPUT);
  pinMode(tx, OUTPUT);
  pinMode(led,OUTPUT);

  pinMode(left1,OUTPUT);
  pinMode(left2,OUTPUT);
  pinMode(right1,OUTPUT);
  pinMode(right2,OUTPUT);


}

void loop()
{
```

```
servoKK.write(posKK);
servoAB.write(posAB);

if(skps(p_R1)==0)           //Check whether Up button is pressed
{
   digitalWrite(led,HIGH);
}

 if(skps(p_L1)==0)           //Check whether Up button is pressed
{
   digitalWrite(led,LOW);
}

 if(skps(p_Circle)==0)
{
  posAB=posAB+2;

  if(posAB>=180){posAB=180;}
  else{posAB=posAB;}
  servoAB.attach(AB);
  servoAB.write(posAB);

}

 if(skps(p_Square)==0)
{
  posAB=posAB-2;

  if(posAB<=0){posAB=0;}
  else{posAB=posAB;}
  servoAB.attach(AB);
  servoAB.write(posAB);
 }



 if(skps(p_Triangle)==0)
{
  posKK=posKK+2;

  if(posKK>=180){posKK=180;}
  else{posKK=posKK;}
```

```
  servoKK.attach(KK);
  servoKK.write(posKK);
 }


if(skps(p_Cross)==0)
{
  posKK=posKK-2;

  if(posKK<=0){posKK=0;}
  else{posKK=posKK;}
  servoKK.attach(KK);
  servoKK.write(posKK);
 }


 if(skps(p_Up)==0)
 {

 digitalWrite(left1, LOW);
 digitalWrite(left2, HIGH);
 analogWrite(pwmLeft,  150);
 digitalWrite(right1, LOW);
 digitalWrite(right2, HIGH);
 analogWrite(pwmRight, 150);

  }

  if(skps(p_Down)==0)
 {

 digitalWrite(left1, HIGH);
 digitalWrite(left2, LOW);
 analogWrite(pwmLeft,  150);
 digitalWrite(right1, HIGH);
 digitalWrite(right2, LOW);
 analogWrite(pwmRight, 150);

  }

  if(skps(p_Left)==0)
 {
```

```
  digitalWrite(left1, LOW);
  digitalWrite(left2, HIGH);
  analogWrite(pwmLeft,  150);
  digitalWrite(right1, LOW);
  digitalWrite(right2, LOW);
  analogWrite(pwmRight, 0);

   }

    if(skps(p_Right)==0)
  {

  digitalWrite(left1, LOW);
  digitalWrite(left2, LOW);
  analogWrite(pwmLeft,  0);
  digitalWrite(right1, LOW);
  digitalWrite(right2, HIGH);
  analogWrite(pwmRight, 150);

   }

    if(skps(p_Start)==0)
  {

  digitalWrite(left1, LOW);
  digitalWrite(left2, LOW);
  analogWrite(pwmLeft,  0);
  digitalWrite(right1, LOW);
  digitalWrite(right2, LOW);
  analogWrite(pwmRight, 0);

   }


 else                         //Check whether no button is pressed
 { ;
   //digitalWrite(led, LOW);
 }
}

unsigned char receive_data(void)  //Function to wait for a byte receive from
```

```
UART
{
  unsigned char temp;
  while(!Serial1.available());    //Wait until data received
  temp=Serial1.read();
  return temp;                    //Return the received data
}

unsigned char skps(unsigned char data)          //Function to send out a byte via
UART
{
  Serial1.write(data);            //Send new data
  return receive_data();          //Return received data
}
```