

**DESIGN AND FABRICATION OF UNMANNED AERIAL VEHICLE
FOR MONITORING OF OIL AND GAS PLANT**

By

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14470

Dissertation Report submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronics Engineering)

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CERTIFICATION OF APPROVAL

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UNIVERSITI TEKNOLOGI PETRONAS

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September 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in references and acknowledgements and the original work contained herein have not been undertaken or done by unspecified sources or person.

WAN ABDUL HAKIM BIN WAN ARIF

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LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicle
PC	Personal Computer
GUI	Graphical User Interface
ESC	Electronics Speed Controller
DC	Direct Current
BLDC	Brushless Direct Current
LiPo	Lithium Polymer
MCU	Microcontroller Unit
WSN	Wireless Sensor Network
PID	“Proportional, Integral, Derivative”
3D	3 Dimension
PWM	Pulse Width Modulation
PPM	Pulse Position Modulation
USB	Universal Serial Bus
UTP	Universiti Teknologi PETRONAS
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
RC	Remote Control
IDE	Integrated Development Environment
DMP	Digital Motion Processor
MEMS	Micro Electromechanical System
ZB	Zigbee
I2C	Inter-Integrated Circuit
SPI	Serial Peripheral Interface

ABSTRACT

An Unmanned Aerial Vehicle or UAV is a vehicle that can fly with minimal intervention. This project involves in designing and integrating UAV technologies into a prototype that stabilizes itself while navigating in the harsh conditions of oil and gas plant. The project does not use existing commercial UAVs and flight controller board in the market. A self-fabricated prototype of UAV is built from scratch. The prototype consists of a structure made of aluminum and four brushless DC motor to provide lift-off and maneuver the flight motion. The controls is embedded in a microcontroller and is equipped with electronic speed controllers to drive the motor, sensors such as gyroscopes and accelerometers to give orientation feedback and uses wireless communications via Xbee modules. The microcontroller receives command from a personal computer via the Xbee modules. A Graphical User Interface (GUI) is developed in software called Processing for monitoring and maneuvering purposes. For the chassis, it is modeled using Autodesk Inventor software to ensure design is applicable. The expected outcome of this project is a complete prototype that can be controlled from a personal computer (PC).

CHAPTER 1

INTRODUCTION

This chapter presents the research introduction starting with the background study of a UAV, followed with the problem statements that occur in oil and gas platforms and the UAVs itself. Next are the objectives of this project. Lastly the scope of the study is briefly described.

1.1 Background Study

UAVs have been proved to be very useful in doing certain tasks. Also known as drones, they are the perfect specimen to enter hazardous and dangerous environments thus avoiding potential harm to a pilot. The expense is also relatively much lower. Currently, the uses of UAVs are mostly military surveillance and reconnaissance purposes [1]. By manipulating what already exists to adapt to the surroundings of an oil and gas plant, we can monitor for known threats more efficiently and possibly nullify it directly.

In the market there are existing ready built UAVs and even hobby kits for consumers to plug and play them. For more advanced consumers there exist flight controllers boards that are fully equipped with the components required to control the UAV and can be programmed at their disposal. However these boards are also supplied with a firmware that consumers can use if they do not have programming knowledge beforehand.

1.2 Problem Statement

Threats like fire, gas leakage in oil and gas plants are still major issues that plague the industry. Even with tight HSE implementation, these accidents can occur unexpectedly and can cause serious damage and even fatal deaths to the employees. When these accidents do occur, it is usually detected towards at the end when the damage is done.

Also personnel monitoring is not convenient when it comes to a large and complex organization like an oil and gas processing plant. Current monitoring coverage is also not effective as it so vast. Most likely the cost of the equipment used would be very high due to its amount.

Lastly the commercial UAVs are hard to control. An experienced individual is needed to maneuver the UAV without crashing.

1.3 Objectives

To fully develop a sophisticated UAV built for an oil and gas plant, it needs a substantial amount of time. Due to time constraint, the project is focused in the objective as follows:

Hardware:

- To develop a complete integrated and robust UAV system which covers motoring systems and signal conditions.

Software:

- To develop an intuitive flight motion that can be controlled by a PC.

1.4 Scope of Study

The first scope of study is the framework of the UAV. There are several types of UAV frames and each of these frameworks has its advantages over the other such as weight capacity, camera's field of view and the overall speed of the UAV. The author needs to understand the principle of operation the UAV.

Exploring of 3D modeling software (Autodesk 2014) is needed to model the UAV chassis. By having a 3D model, fabrication can be done much smoother based on a design that can work.

The next one is the movement of the motors. The author needs to identify the electronics best suited for the UAV. Electronic speed controllers (ESCs) are used to convert signals from the flight controller board and converts into pulses to control the speed of a motor. By manipulating different signals to the ESCs, an algorithm can be developed to control the UAVs maneuvering capabilities.

After that the author needs to explore Arduino Microcontroller and its language preferences. Xbee modules are also need to be understood on how to set up and configure the network.

Also, understanding and identifying the critical parameters such as angles of rotations to determine the orientation of the UAV. Lastly is to implement of stabilization algorithm based on the sensor's feedback system for smooth flight motions.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses the literature related to the current research for this project in detail. The chapter starts with an introduction to UAV discussing the types of the UAV whereby the author selects the type of UAV and its materials to be used in this project. Then the author explores how UAV moves by manipulating the speeds of each motor. Also the general info about Electronic Speed Controllers is explained. Next is the controls that are used for the navigating and maneuvering the UAV.

2.1 Introduction to UAV

There are generally two main classified UAV types, the aircraft type and the multi-rotor type.



Figure 1: Types of UAVs

Aircrafts type or plane platforms are easy to get in the air and land if there is enough room or field to land in. If there is a lot of trees or building and no smooth areas to land it would not work well. The benefit of this type of UAVs that it can fly very fast from one point to another compared to a multi-rotor UAVs.

However the suitable type in this project would be the multi-rotors because of its ability to hover in place. Also it has more flexible maneuvers than the aircraft type UAVs. The most common multi-rotor frames are the quadcopter which consists of four motors[2]. There are multi-rotors that have six and eight motors called hexacopter and octacopter respectively. These UAVs have more lifting power than a quadcopter.

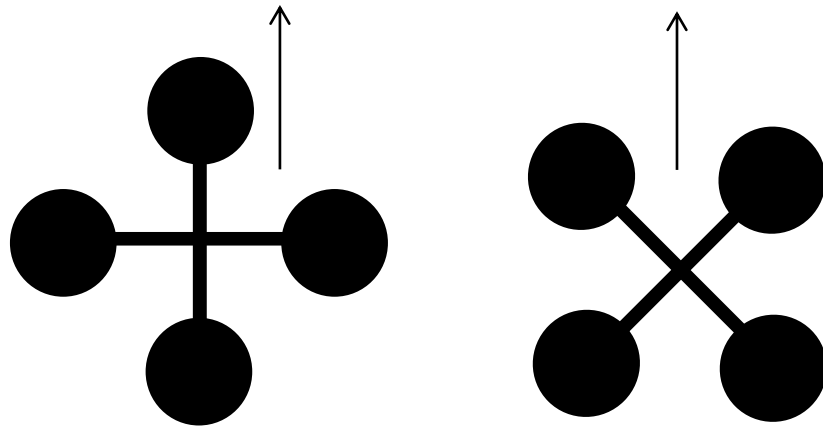


Figure 2: + and X orientation of a Quadcopter

For the materials to be used in fabricating the platform of the UAV, it needs to be as light as possible without sacrificing the strength. These materials are commonly aluminum, plastic or carbon fiber[3].

2.2 UAV Movements

2.2.1 Propeller Rotations

To develop an algorithm for the flight motions of the UAV, controlling the motors is critical to provide lift to the chassis. A pair of motors attached with propellers on the same axis should rotate in the

opposite direction of the other pair. By manipulating the speed of these motors, the UAV should be able to move in various directions [4]. An illustration has been prepared below:

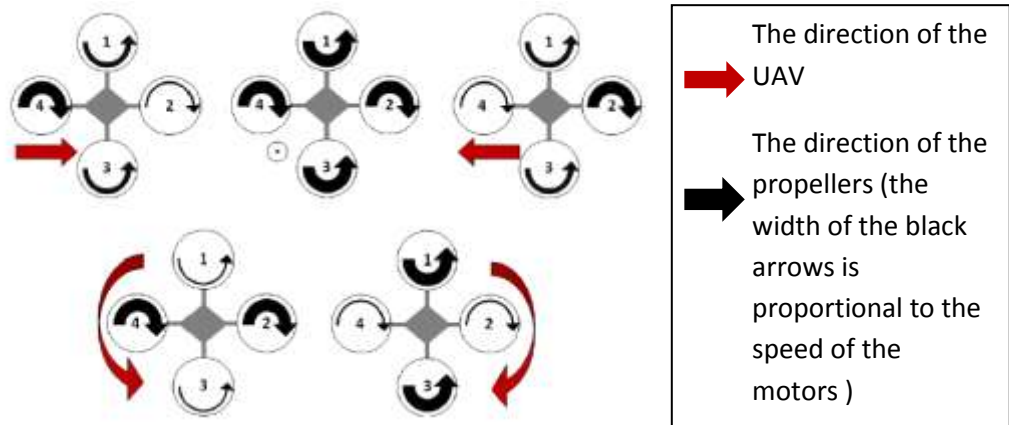


Figure 3 Movements of a Quadcopter

2.2.2 Electronic Speed Controllers

The use of this device is to convert PPM (Pulse Position Modulation) signals received into PWM signals to run the motor. The frequency of the PWM signal will affect the speed of the motor. The special features that differentiate it from normal drivers are its beep codes which indicate any abnormalities of the signals or voltage inputs [5]. The normal configuration of the ESC is as below:



Figure 4: Standard configuration of ESC

R/C transmitter and receiver use PPM signals. Therefore ESCs are basically designed to work with remote controllers. However, PPM is actually a “specialized form of a PWM wave” working at frequency 50HZ with an interval of 20us. By changing the duty cycle of the pulse, different speeds are achieved.

2.3 UAV Controls

2.3.1 3D Orientation

A motion of a quadcopter depends on the roll, pitch and yaw moments [6]. These values are represented in the figure below:

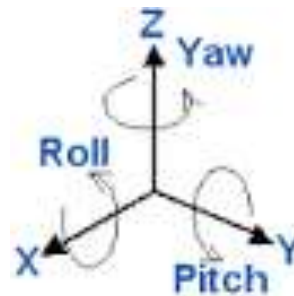


Figure 5: Roll, Pitch and Yaw

Assume the X-axis represents the front of the UAV, the roll value will be tilting angle side to side, pitch is tilting angle from front to back and yaw is the rotation angle of the UAV in a perpendicular plane. In a commercial controller as shown in Figure 6, the yaw and pitch are operated by the left stick, and the right stick for roll and throttle/thrust. These controls however are not intuitive for flight motion of the quadcopter[7].



Figure 6: A commercial 2-Stick Remote Controller

2.3.2 Wireless Communications

In order to communicate wirelessly, there needs to be a transmitter device and a receiver. Xbee modules are a very popular solution for wireless communication. Two will be needed where one is the sending device which is connected to the serial port of a PC and the other one is the receiving device which is attached to the Microcontroller Unit (MCU) of the robot. Indoors it can reach about 30 meters and outdoors can range up to 100m. The modules are designed based on IEEE 820.15.4 which is popular for its advantages on low power consumption of WSN (Wireless Sensors Network) [8].

Also, the established communication link between the PC and the MCU allows the data to be transferred in both directions [9]. This allows for sensors to give feedback data back to the PC for analysis purposes.

CHAPTER 3

METHODOLOGY

This chapter is aimed at presenting methods used in this research. Following the methodology is the key milestones for when the author needs to prepare the reports for submission. Then the author states the components and the tools required for this project. Lastly the Gantt chart of this project is presented.

3.1 Research Methodology

The flowchart below is the process of building the project:

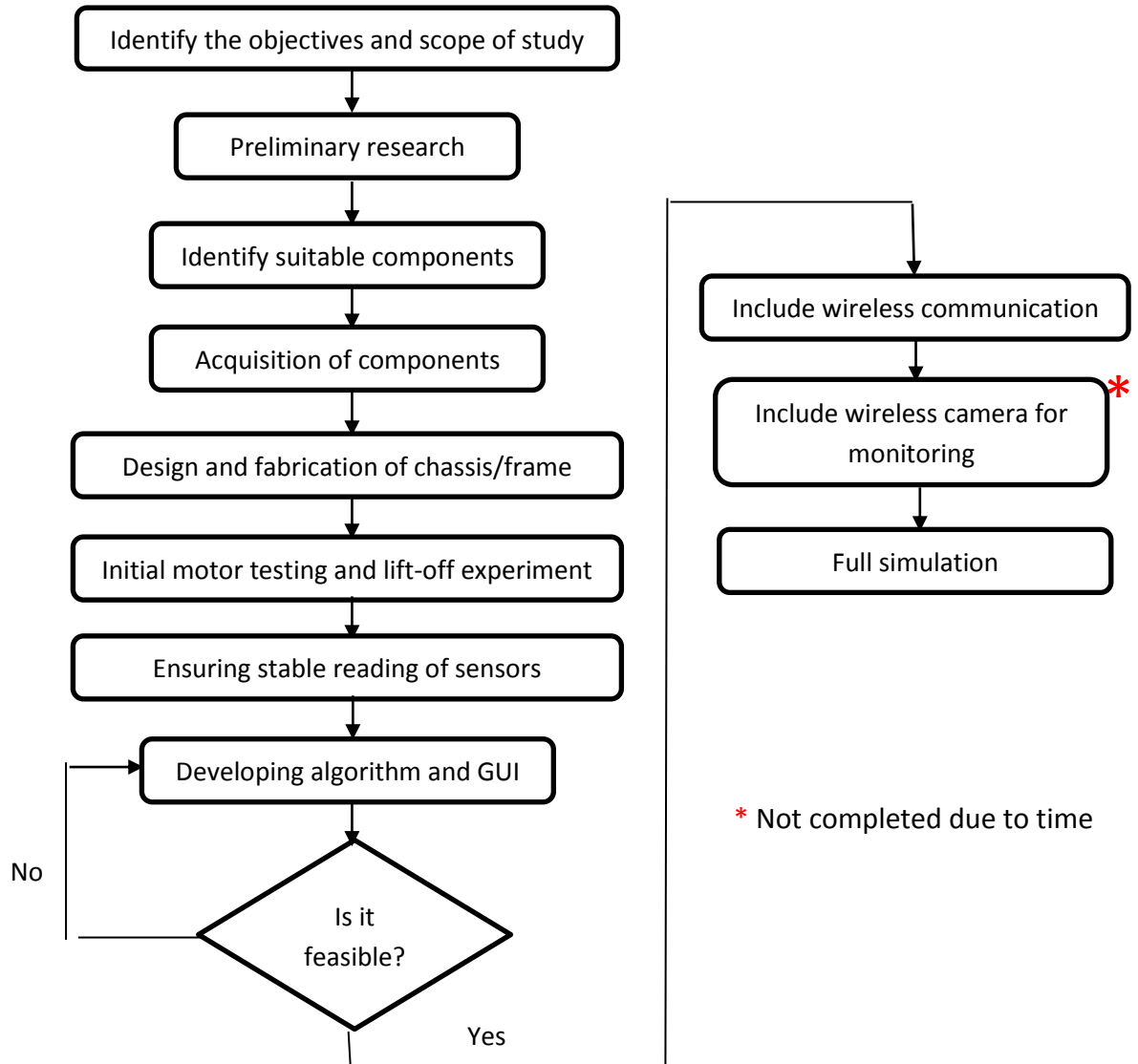


Figure 7: Flowchart of project activities

First of all, the objectives and scope of studies are identified. Then the preliminary research is done. Obtaining a basic knowledge of aerodynamics is critical for this project. After that, the author surveys and selects suitable components to build a prototype. When received the components, the author starts to fabricate the frame or chassis of the prototype. After the prototype is finished, an initial motor testing must be done to ensure the prototype can lift up from the ground. Next is getting a stable readings of yaw, pitch and roll values as orientation feedback signals. This is followed with developing the algorithm using the feedback signals for stabilization during flight. During this stage the prototype is in a controlled environment in case the algorithm is not feasible. The GUI is also developed simultaneously to give commands in order to maneuver the prototype. When the controls and flight motions are smooth and stable, then the author can add cameras for wireless monitoring. Then the prototype is ready for full simulation and project presentation can be prepared.

3.2 Key Milestones

The following table indicates the documentations that need to be submitted:

No.	Milestones	Due
FYP1		
1	Extended Proposal	Week 6
2	Proposal Defense	Week 9
3	Interim Draft Report	Week 13
4	Interim Final Report	Week 14
FYP2		
5	Progress Report	Week 22
6	Final Report	Week 26
7	Project Presentation	Week 28

Table 1: Key Milestones of the Project

3.3 Hardware and Software Required

These are tools needed for this project:

	Components	Details
Hardware	Arduino Uno	the Microcontroller Unit
	Xbee Series 2 + SKXbee	wireless communication modules
	Electronic Speed Controllers	to control speed of motors
	Brushless motors	provide propulsion and movement of UAV
	MPU-6050	Measure Roll, Pitch and Yaw values
Software	Arduino IDE	environment to develop algorithms
	Processing.js	to develop interface software program

Table 2: The tools required for the Project

3.4 Gantt Chart

The following table is the amount of work needs to be done in certain periods within the two semesters given:

	Week																												
Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
Identify objectives	█	█																											
Preliminary Research			█	█																									
Identify suitable components					█	█																							
Components acquisition							█	█																					
Components testing							█	█	█	█	█	█	█	█															
Design and frame fabrication															█	█	█												
Motor testing for lift-off																█	█												
Sensor testing																			█	█	█								
Algorithm development																					█	█	█	█	█	█	█	█	█
GUI development																								█	█	█	█	█	█
Add wireless communications																									█	█	█		
Add camera *																										█	█		
Full Simulation Testing																											█	█	█
Extended Proposal			█	█	█																								
Proposal Defences							█	█																					
Interim Draft Report										█	█	█																	
Interim Final Report														█															
Final Report																								█	█	█	█	█	█
Project Presentation																											█	█	█

Table 3: Gantt chart of the Project

* Not completed due to time constraint

CHAPTER 4

RESULT AND DISCUSSION

This chapter presents the results of this project. This chapter starts with the UAV Design. The design is first simulated in 3D using Autodesk Inventor 2014 followed by the fabrication process. He the author analyzes and discusses the motor testing part of this project. The feedback systems is presented next. After that, flight testing is explained and is followed by PID implementation to stabilize the flight motion of the UAV. Next the author elaborates on the design of the Graphical User Interface. This is followed by steps to configure the wireless 2 way communications via Xbee modules. Finally, all the schematics of the circuitry is drawn to give a better understanding of what components are used by the author and how it is connected.

4.1 UAV Design

The UAV's base design was based on the criteria below:

- Simple frame design
- Easy to fabricate
- Robust material
- Low cost
- Safety priority

The first step is to simulate the design in 3D. After confirming the design is applicable, the fabrication process starts and is based on the reference to the selected 3D design.

4.1.1 3D Simulations

There are 3 designs that have been simulated in Autodesk Inventor 2014. The first design and the second design are rejected because not fulfilling the criteria's above.

Below are the designs of the structure using the Autodesk Inventor 2014 software:

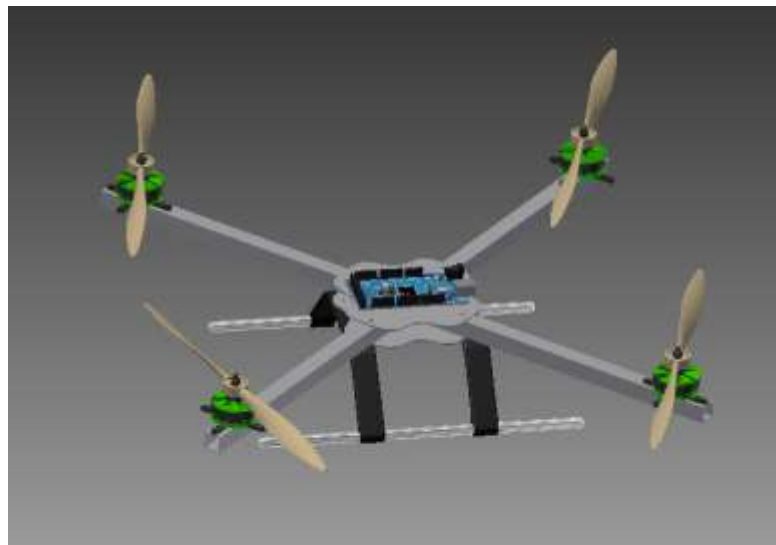


Figure 8: UAV Design 1

This structure of Design 1 was primarily designed for ease of fabrication. It has a simple chassis and very clean. The maximum length across the center of the design when all the propeller blades face outward is 884.473 mm. However there is no protection to the propeller blades. Thus the author needs to design a new structure.



Figure 9: UAV Design 2

Design 2 concentrates in the safety of propeller blades. This structure consists only of 2 main frames. First is the upper frame which protects the propeller blades and stores the electronics. The second is bottom base which holds the motor. The maximum length across the center of this design is 949.624 mm. The problem of this is design is it is impossible to fabricate. There is no material in the market that fits the thickness and the size that the author wants for the upper base. The facilities in UTP also are not capable to fabricate the design if there were materials for it.

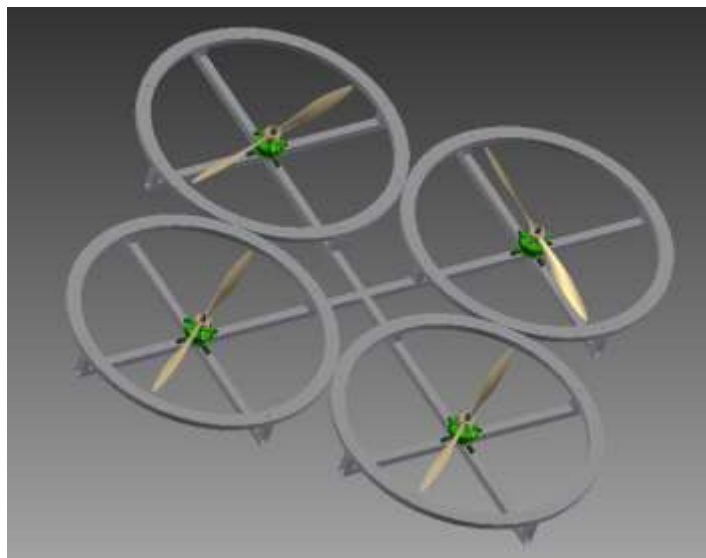


Figure 10: UAV Design 3

Design 3 is the simplified version of Design 2. Replacing the upper base, there are 4 separate rings which is attached to the bottom base. This design has protective measures, easy to fabricate, simple and robust thus fulfilling all the required criteria. This is the final design before moving to next phase which is fabrication.

4.1.2 Fabrication Process

For fabrication process, the author tries to implement Design 3. The criteria or aim implementing the design is as follows:

- Robust mounting
- Less screws
- Available material
- Light weight

The trickiest part is the rings. The rings need to be of sufficient diameter bigger than the 13" long propeller blades. There were several tries before the author finds the solution.

First the author uses a bicycle rim. The picture below is before and after the bicycle rim is modified:



Figure 11: Ring Materials 1

The author finds a bicycle rim 14” diameter which is suitable. But after cutting the unnecessary rods and drilling holes on the rim, the weight of the ring is still too heavy.

Next the author tries to design the ring itself using aluminum bars because of failing to find a suitable circle shaped material for the ring. The picture below shows how the calculations are simulated and the parts ready to be welded:

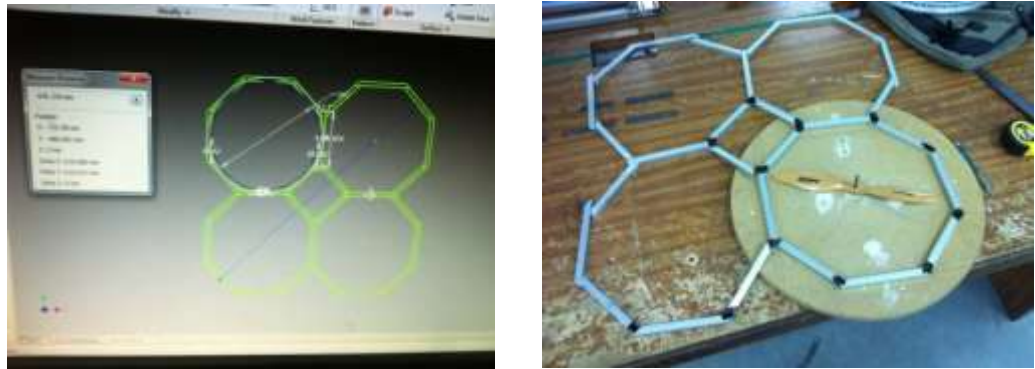


Figure 12: Ring Material 2

Aluminum bars of 0.5”x0.5” which are very light weight are cut and prepared as shown as in Figure 10. However during the welding process, it takes a lot of time and precision because there are too many joints. The finished product is not satisfactory.

After not succeeding to build a hexagon ring, the author decided to use an aluminum rod to shape a circle. The pictures below are the aluminum rod bent into an almost circle:



Figure 13: Ring Material 3

An aluminum rod 0.5” diameter was bent forcefully by the author to form a perfect circle. However it was not possible so the author decides that an almost circle is sufficient enough for the rings. This material was finalized and the other 3 rings are fabricated. This method promises robust and light weight rings.

The rings than was welded together. For the bottom base the author decided to use a more simple and efficient structure than in Design 3. The processes are shown in the steps below:-

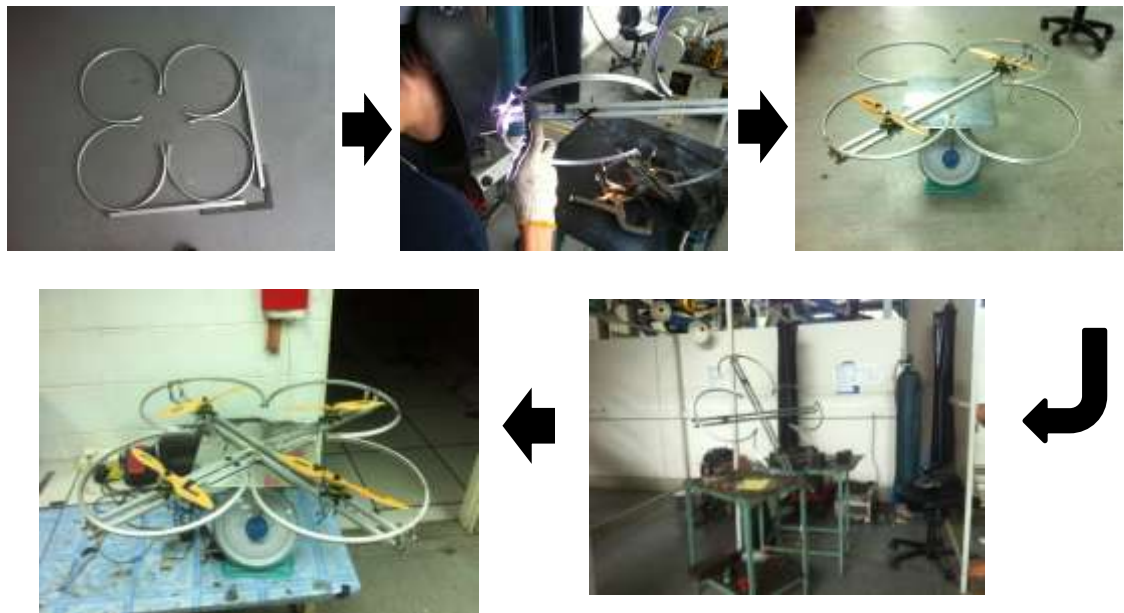


Figure 14: Fabrication Process

The finished product is a quadcopter UAV chassis with propeller blades protection which overall weighs below than 2kg. However due to human error in the welding process, the UAV is slightly off symmetrical.

4.2 Motor and Propeller Blade

4.2.1 Brushless DC Motor

4 units of Multistar brand of brushless DC outrunner electric motor are used as thrusters for the flight motion of the UAV. These outrunners have been specifically designed from the ground up for multi-rotor use and are not based on aeroplane motors.



Figure 15: BLDC outrunner motor

The specifications of the motor are as follows:

Specifications	Details
KV(RPM/V)	700
LiPo cells	4s
Max Surge Watts(W)	650
Working current	29 amps
Max.current(10s)	50 amps
No Load Current	1.9 amps

Internal Resistance	0.080 ohm
Number of Poles	20
Dimensions(Diameter x Height)	47.5 x 33 mm
Shaft	3/6 mm
Prop	14 x 4-15 x 5

4.2.1 Propeller Blade

As 4 units of motor are used, there are 4 units of propeller blade which are attached to each one. Purchased from Gemfan, they are a 13x4.5 wood propeller which have an 8mm diameter center hole and have an average weight of 26 grams. The propellers feature an elliptical shape that produce a more uniform thrust distribution across the entire blade surface for maximum lift and thrust efficiency.



Figure 16: GemFan Wood 13x4.5 Multirotor Prop

4.3 Motor Testing

To develop the flight motion of the UAV, the understanding of how the motor works is very crucial. In this situation, the motor is driven from the ESC and how to control the ESC from an Arduino is the main objective in this

experiment. This experiment is divided into 3 stages; the circuitry, the code and the test analysis.

4.3.1 The Circuitry

First of all, since controlling the ESC is not from a 2-stick controller receiver, we need to connect it to the Arduino. The ground connection is connected the GND pin of the MCU and the signal line is connected to one of the PWM pin on Arduino. On this experiment, the author connected the signal to pin 9. On the Arduino, a PWM pin can be identified with “~” sign before its respective pin number on the board.

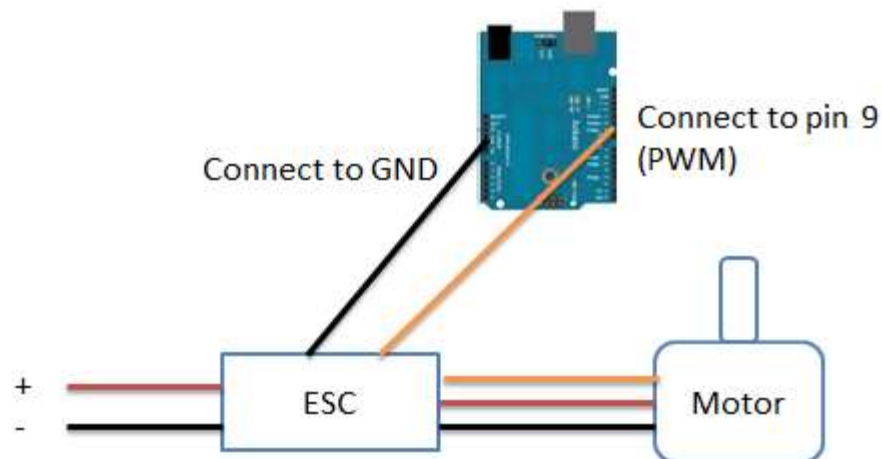


Figure 17: Schematics for Motor Testing

The Arduino is powered by the PC while the ESC and motor is supplied with the power from the battery 4 cell LiPo battery which is 14.8V. The reason the author did not connect the power line to the Arduino board is because it could damage the board. The board does not have protection on the 5V connector pin. This voltage pin is directly connected to the ATmega328P microcontroller which can be damaged by voltages exceeding 6V. Another consequence of applying more than 5V

to the 5V connector pin is possible damage to the PC's USB port. If the Arduino is powered from USB then this excessive voltage can cause current to flow backwards through the voltage-switching MOSFET T1 and back to the PC's USB port.

4.3.2 The Program

In order to start building the code, we need to know the nature of the ESC input signal. The input needs to be a RC standard PWM signal which is just a specialized form of PWM. Typically the signal repeats every 20 ms (so 50 HZ PWM frequency), but this can vary. The pulse itself most often ranges from 1 ms to 2 ms with ~1.5 ms being the neutral position.

A Servo motor also uses the RC standard PWM signal to function. Therefore in order to supply the ESC with the RC standard PWM, the code uses servo library and be based on how to code a servo.

Also the author needs to know the behavior of the ESC. According to the manual datasheet, the ESC beeps one time when the battery is connected. Then the ESC beeps once more when the throttle of the 2-stick controller is at its lowest point. After that the motor is supposed to start rotating by moving the throttle upwards a bit. This means that the ESC needs a starting point in order to calibrate the range of its throttle.

In order to know the starting point or in this case, range value of the ESC to start controlling the motor, the code is used:-

```

// print the integer
Serial.println("Printing the value: ");
Serial.println(val);

/*
 * We only want to write an integer between
 * 0 and 180 to the motor.
 */
if (val > -1 && val < 181)
{
  // Print confirmation that the
  // value is between 0 and 180
  Serial.println("Value is between 0 and 180");
  // Write to Servo
  myMotor.write(val);
}
// The value is not between 0 and 180.
// We do not want write this value to
// the motor.
else
{
  Serial.println("Value is NOT between 0 and 180");

  // IT'S a TRAP!
  Serial.println("Error with the input");
}
}

```

Figure 18: Part of the motor testing code

The value is inserted in from the serial monitor. This method allowed the author to know and monitor the starting point and the speed of the motor with each varying value.

4.3.3 Test Analysis (Results)

So after the code is compiled and burned into the MCU, the author connects the ESC with the battery. A beep sound was emitted indicating the ESC is on. After that the serial monitor is opened and the author inputs value from 0 to 20 with increment of 5. No beep is heard.

After that when value 25 is entered, a beep sound was heard indicating it found its starting point. Then when the authored entered 55, the motor starts to run and accelerates each time the author increments the value and decelerates when the value decrements.

The experiment is repeated but the result of the starting point value varies. Much more analysis needs to be done including the amount of current the ESC outputs for each value that is entered.

4.4 Feedback System

4.4.1 MPU-6050

In order to stabilize the UAV midair, an orientation feedback system is needed. The common used sensor in a UAV especially a multi-rotor type is a gyroscope. A 3-axis gyroscope gives the angular velocity and orientation of the 3 axis in deg/s. However gyroscopes only give the angular velocity not the absolute measure. If the UAV was started on a crooked floor, the initial pitch and roll values is 0 in the program even though it's not flat. Therefore, an accelerometer is needed. An accelerometer is used to determine the acceleration and the tilt of the UAV. For a non-moving object, a 3-axis accelerometer gives the value of the gravity field on all the 3-axis. One of the downside of using accelerometers is it is very sensitive to vibrations. By integrating both sensors, the vibrations sensitivity and the lack of smooth and accurate reading of the angles are being compensated by each other.



Figure 19: MPU-6050

An MPU-6050 is a chip sensor which contains a MEMS 3-axis gyroscope and a MEMS 3-axis accelerometer combining them with an onboard DMP (Digital Motion Processor). The DMP processes complex 6-axis MotionFusion algorithms to enable accurate readings. Also the MPU-6050 can be access external sensors such as a magnetometer and barometer using I2C communication protocols. However the MPU-6050 communicates to the arduino using SPI communication protocols for max performance. The figure below shows the value the author receives from the sensor via serial monitor.

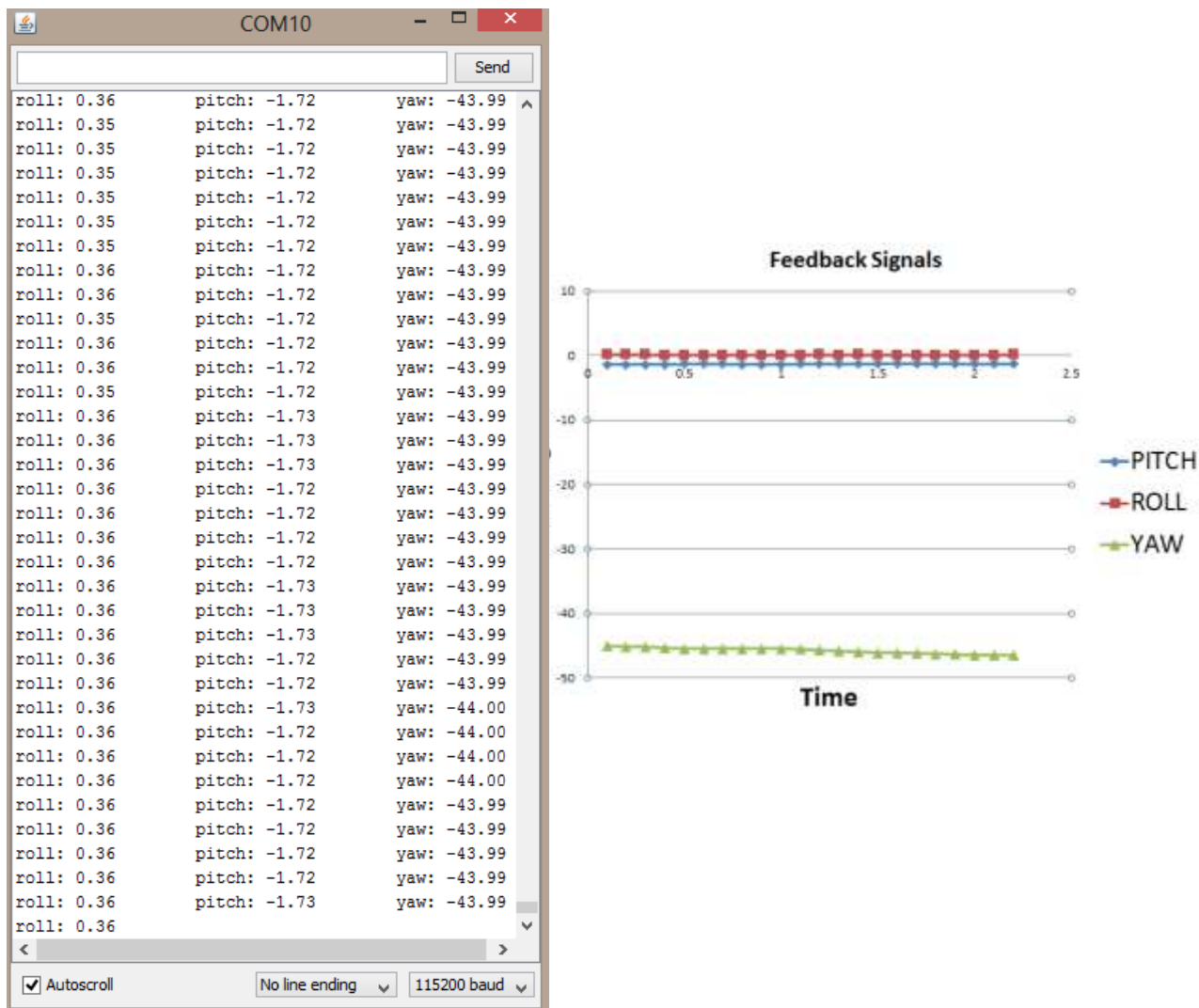


Figure 20: Values of Roll, Pitch and Yaw

The readings of the Roll and Pitch values are stable and precise. However the Yaw value seems to have a slight decrement over time. This is called a drifting. To eliminate drifting a magnetometer is needed. Since the Yaw value is not a critical parameter that affects the stabilization of the UAV, it is ignored.

To simulate the orientation motion visually, the author had used an IDE call Processing and a sketch from Jeff Rowberg to output a visual such as shown below:

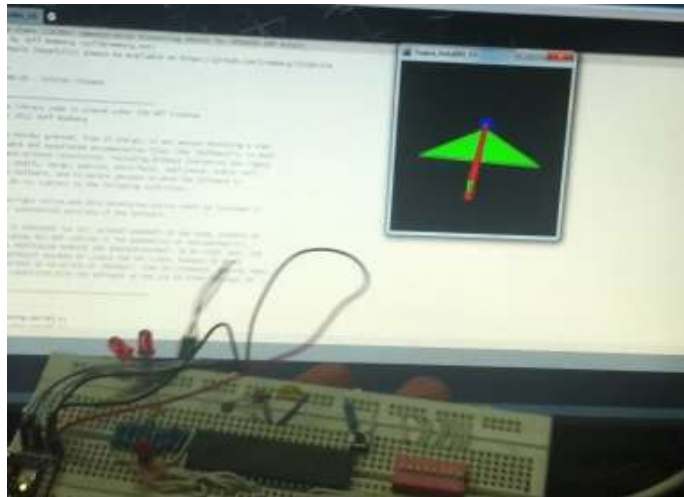


Figure 21: 3D Visualization on Orientation

4.5 Flight Testing

After mounting the controller connecting to the ESCs which is then connected to the motors on the UAV, the code for controlling the motor was uploaded into the Arduino.

```
void arm(){
  for(pos = 0; pos <= 28; pos += 2)
  {
    motor1.write(pos);
    motor2.write(pos);
    motor3.write(pos);
    motor4.write(pos);
    delay(1000);
  }
}

void initMotors(){

  motor1.attach(11);
  motor2.attach(10);
  motor3.attach(9);
  motor4.attach(6);

  delay(100);

  arm();

}
```

Figure 22: Code for starting the UAV

The author finds that the arming value of the ESC varies between 0 and 28, therefore the code seen above. After the ESC is armed, the speed can be set as normal.

When speed is set at value 55, the UAV still cannot fly as seen below:-



Figure 23: Speed Value 55

When speed is set at value 75, the UAV still starts fly. First the author disabled 2 motors for safety purpose if the UAV does lift up. The figure bellows show when the speed is set at 75 in the code:-

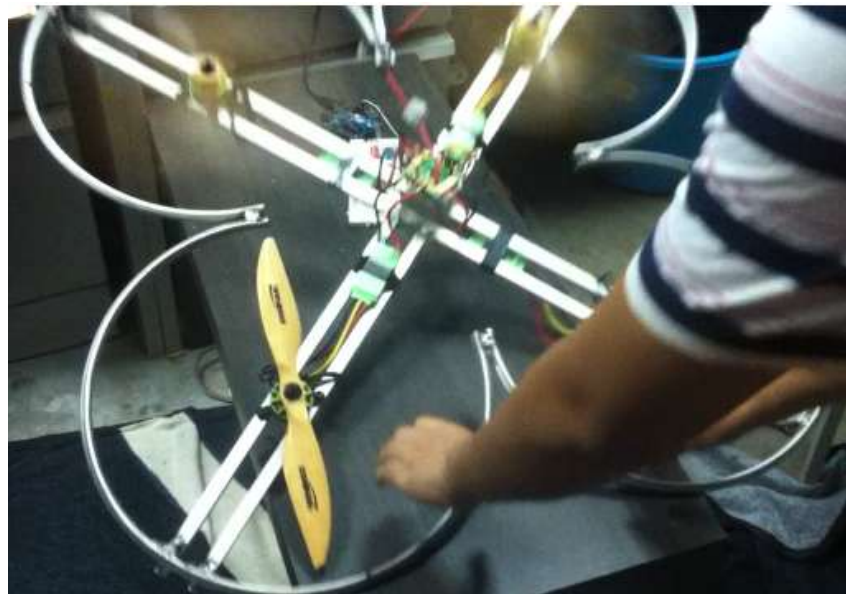


Figure 24: Speed Value 75

Knowing that the UAV can lift up from the ground, a more controlled environment for testing its flight motion is needed to ensure safety. Precautions are taken to avoid harm to the author or the UAV. Therefore the author tied the UAV with 4 ropes for each corner of the UAV. This prevents the UAV to spiral out of control. Also an emergency ON/OFF button is soldered between the battery and the ESCs in case the need to turn off the UAV midair.

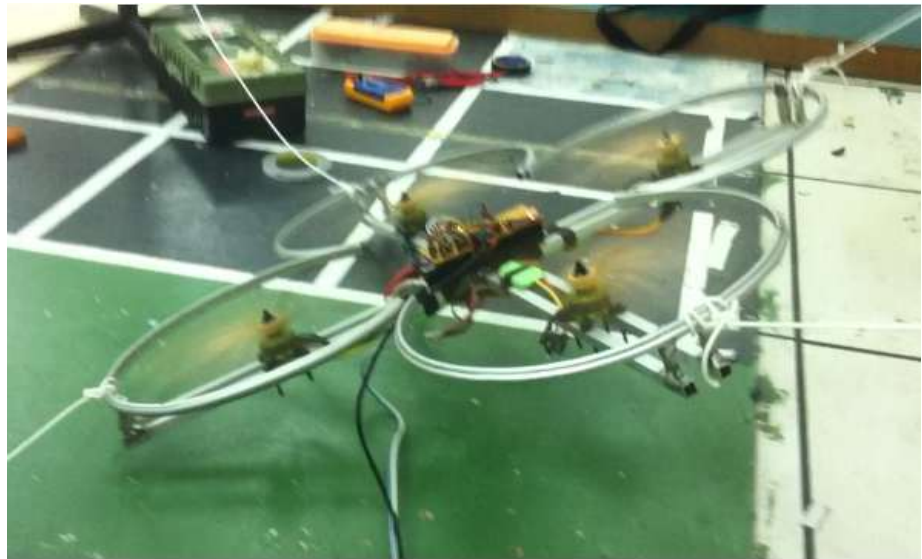


Figure 25: Flight testing in a controlled environment

However the flight motion of the UAV is still not stable. PID tuning is needed to control the orientation of the UAV from the feedback data received from the sensors.

4.6 PID Controls

To stabilize the UAV during flight, PID controls are used. The author uses 2 PID controls which are for Roll and Pitch only. The setpoint for both PID are 0. However, the author discovered that the k_i amplifies the noise of the feedback signals. This is because the UAV is in a constant vibrating condition; therefore k_i is taken out of the equation. In conclusion the equation

$$k_p \cdot e + k_d \cdot \frac{(e - e_{old})}{\Delta t}$$

is written specifically for this project's mathematical model.

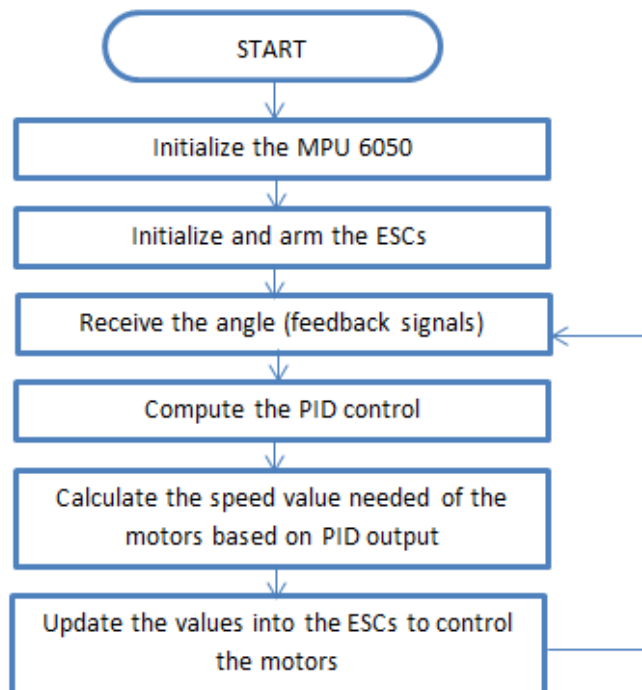


Figure 26: Program Code Flowchart for stabilizing the UAV mid-air

4.7 Graphical User Interface

Using the Processing software, a simple GUI was programmed. The design of the controls is as below:-

- Keyboard Keys
 - W : Front
 - D : Right
 - A : Left
 - S : Back
 - ↑ : Upward (increase throttle)
 - ↓ : Downward (decrease throttle)
 - → : Rotate clockwise
 - ← : Rotate anti-clockwise

By pressing the ↑ button it increases the initial thrust of the 4 motors and the ↓ button vice versa. The W and S button is to set the setpoint of Pitch PID to -45 and 45 respectively. When the buttons are released the setpoints return to value 0. It's the same for A and D buttons for Roll PID which is set to -45 and 45 respectively. The → and ← buttons increments and decrements respectively the yaw values.

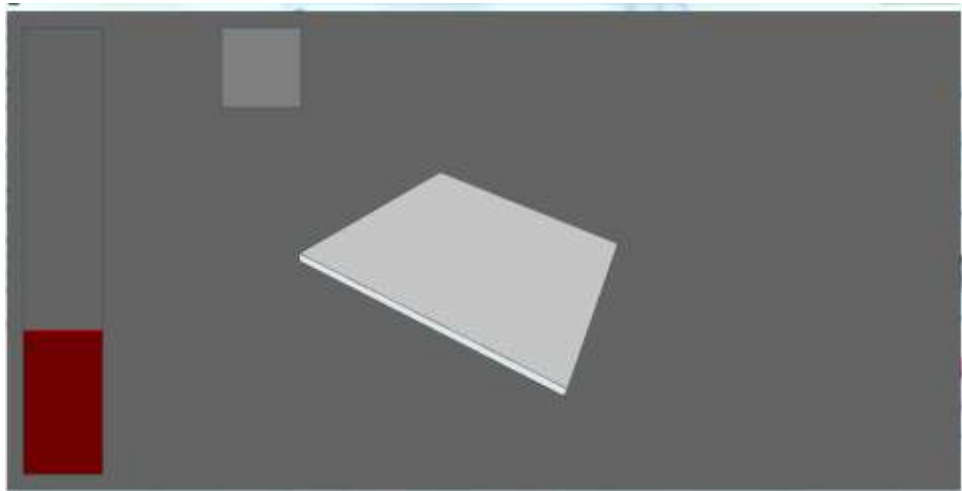


Figure 27: Developing the GUI interface

4.8 Wireless Communication Setup

2 Xbee ZB (Series 2) are configured to for point-to-point communication. As the prototype is still in the line of sight, point-to-point communication is sufficient. However, mesh topology is needed to be configured to cover the vast area in an oil and gas plant by placing node Xbees for each distance intervals.

Both Xbee modules are placed onto a starter kit SKXbee. This is because the Xbee is rated at 3.3V at the SKXbee acts as a logic shifter so that the Tx/Rx can be directly connected to the pins of the Arduino Uno. Besides that SKXbee has a mini-USB adapter which can be connected directly to the PC with a cable.

To configure the Xbee a software is used which is the X-CTU from Digi International. One Xbee is needed to be configured as the Coordinator and the other as the Router. After setting the destination address of both Xbees to each other's serial number, a 2-way communication should be possible.

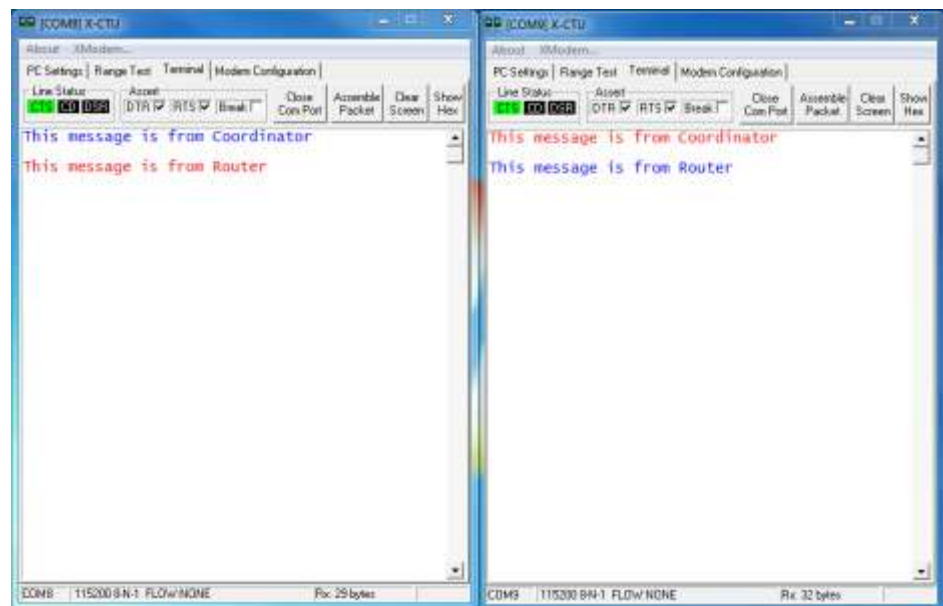


Figure 28: 2-way communication between the Xbees (Blue indicates message transmitted, Red indicates the message received)

4.8 Schematics

All the components are connected as shown below:

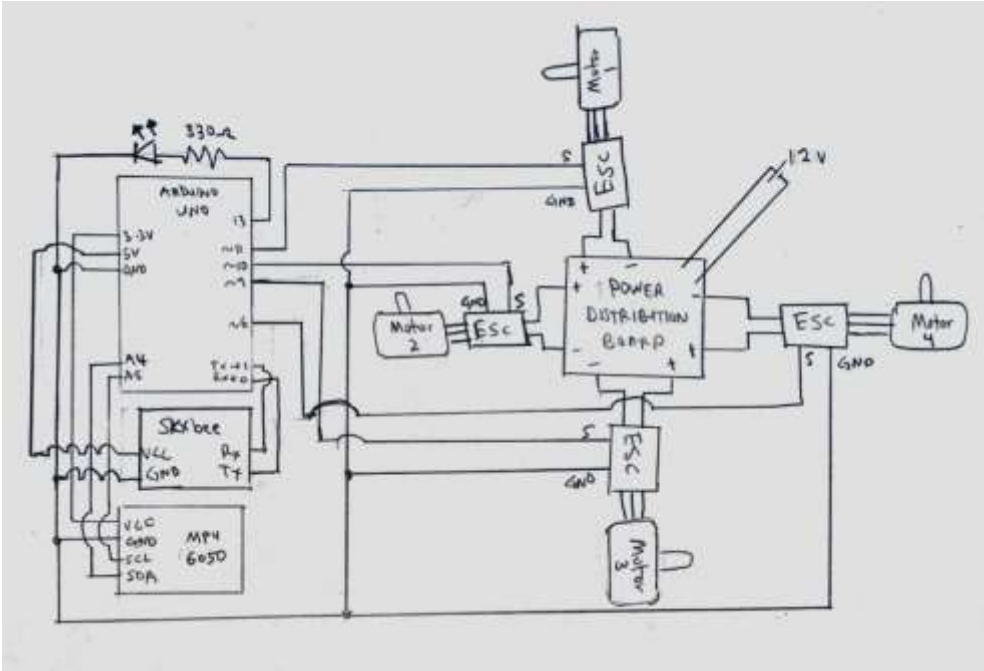


Figure 29: Circuit Schematics

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

In conclusion, much is needed to be done as UAV technology has not yet been popularized in Malaysia. More research needs to be done on the suitable UAV monitoring method for a large oil and gas platform. Since the author is also new to this UAV field, many problems arise especially in stabilizing the prototype during flight and much effort is required to achieve the objectives of this project.

Due to time constraint the author did not manage to include camera for vision monitoring and the prototype itself does not fly very well. It is recommended further effort to model the mathematical model of the UAV. It is also recommended that the chassis should consist of foam PVC material. Self-fabrication of the UAV using aluminum materials is not recommended as there is always a slight human error during the process.

Besides camera vision, various sensors are recommended to be researched to detect lethal gas leakage or radioactivity in the plant. Lastly what is needed to ensure the success of this project is the continuous effort put into it.

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