DESIGN AND IMPLEMENTATION OF ANTI-COLLISION QUADCOPTER USING ULTRASONIC SENSOR TO AVOID OBSTACLE

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DECLARATION

I declare that this report entitled "ANALYSIS AND IMPLEMENTATION OF ANTI-COLLISION QUADCOPTER USING ULTRASONIC SENSOR TO AVOID OBSTACLE" is the result of my own work except for quotes as cited in the references.

Signature : ....

Author : Norhasifi Zharif Bin Noridan

Date : 25 June 2020

APPROVAL

I hereby declare that I have read this thesis. In my opinion, this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ………………………………….

Supervisor name : PROFESOR DR ZULKALNAIN MOHD-YUSSOF

Date : 2 July 2020

DEDICATION

I dedicate this effort to both of my parents Seri Marzalinda Kerya and Noridan Turiman, who had been supporting me through thick and thin while achieving this project successfully. Besides that, I also dedicate all of this to my Supervisor, Professor. Dr Zulkalnain bin Mohd Yussof who had been teaching and supporting me since my integrated Design Project. Finally, I dedicated this to all my lovely siblings and friends who gave effort to this project.

ABSTRACT

In this project, a quadcopter equipped with four sets of ultrasonic sensors capable of avoiding obstacles was designed. The purpose of this work is to reduce the duties that a pilot would have to crash avoidance. The quadcopter is required to possess the following characteristics that the flight controller will assess the stability, an array of on-board sensors will provide obstacle tracking, and an Arduino microcontroller will perform the avoidance algorithm. As a result, the quad must remain fixed in a relative point and space until an obstacle causes the aircraft to conduct an escape manoeuvre, thereby guiding the craft to a safe position.

ABSTRAK

Dalam projek ini, sebuah "quadcopter" (juga dikenali sebagai "Quad" dalam pendeknya) yang mampu mengesan dan bertindak balas terhadap objek yang berdekatan diterokainya. Tujuan penyelidikan ini adalah untuk mengurangkan tanggungjawab yang dimiliki oleh juruterbang dalam usaha mengelakkan kemalangan. "Quadcopter" diharapkan mengandungi ciri-ciri berikut aitu kestabilan yang akan ditentukan oleh "Flight Controller", array sensor di litar akan memberikan pengesanan objek, dan mikrokontroler Arduino akan menjalankan algoritma penghindaran. Hasilnya, "Quad" akan tetap di titik relatif di ruang sehingga objek memicu pesawat untuk melakukan proses penghindaran, kemudian, mengarahkan kapal ke lokasi yang selamat.

ACKNOWLEDGEMENTS

First and foremost, the biggest gratitude to Allah SWT for the chance of letting this project runs very well, and without him, none matters. Thank you also to both of my parents who keep pushing me forward back then till now. The biggest thank would not be comparable to all of the blessings. My deepest and sincere gratitude will be given to my only supervisor Prof. Dr Zulkalnain who leads me throughout this project from zero knowledge about the drone to a drone loving person. I will not waste the knowledge and continue pursuing drone hobby either for work purposes or hobby purposes. Last but not least, thank you to all my siblings and my friend who help me with this project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

CAS	:	Collision Avoidance system
UAV	:	Unmanned Aerial Vehicle
MAV	:	Micro Air Vehicle
ESC	:	Electronic Speed Controller
UAS	:	Unmanned Arial System
GCS	:	Ground Control System

CHAPTER 1:

INTRODUCTION

This chapter consists of a project overview of the anti-collision system of quadcopter for obstacle avoidance applications. It also states the problem statement that needs to be solved and the purpose of the research that needs to be achieved to make sure the project is a success. Furthermore, this chapter also explains the scope of the project and project significance related to the anti-collision quadcopter system.

1.1 Project motivation

It project seeks to lead to the appropriate advancement of drone technology by developing a framework for avoiding preliminary collisions for unmanned aircraft. This project involves assembling an aircraft capable quadcopter from scratch and implementing collision avoidance as an additional subsystem. To this end, the quadcopter is surrounded by a series of ultrasonic retention devices. Their raw data is stored in an auxiliary Arduino microcontroller board that sends the trajectory corrections to the quadcopter flight controller dependent on distance knowledge.

1.2 Problem statement of the project

The demand for unmanned aerial vehicles was characterized by a dramatic growth in recent years, by widening its variety of uses and being one of the most advanced innovations in the world. Flying drones are risky operations, especially in inhabited areas, involving risks to public health. Pointless was the attempts of many large internet distribution organizations to use unmanned aerial vehicles as package distributors. There will still be further growth, though, to maintain health and safety standards in urban areas. GPS has been used in waypoint trip navigation and an specified role or path may be carried out separately by the drone. At the other side, traveling or unforeseen objects, including a truck, a person and another drone, also create issues. Some of the most critical challenges posed by a drone is the possibility of collisions with other items in the flight area. This issue will affect houses, people or the drone. An algorithm has been established to avoid drones from colliding with another entity.

1.3 Project objective

This project aims to:

- Develop a flight-capable drone to incorporate the collision avoidance device as a concept.
- Prove the new flight test capability.
- Obstacle Collision Device architecture.
- Introducing a version of the Hazard Collision Method..

1.4 Scope of work of the project

A specific scope is required to be determined to attain the objectives of this project. This project consists of three stages, hardware, software, and the hardware and software interface. The central part of this project is to implement the drone’s anti-collision system and test whether this is reliable enough to be considered as one of the new obstacle avoidance drone strategies. The hardware component requires the quadcopter assembly process. The project hardware was assembled entirely from the given manual with the guide, and a microcontroller on the Pixhawk handled every process and function. Besides, four Electronic Speed Controller (ESC) can help transmit Pixhawk signals to the four motors. Once the hardware is fully assembled, some of the calibration and tuning processes will be done to test the hardware properly before doing a test flight. This project will also cover the analysis of the Anti-collision system that has been implemented to the drone. In this project, we did not cover the market price, increasing flight time, and material used to build the drone.

CHAPTER 2:

BACKGROUND STUDY

Unmanned aerial vehicles (UAVs) include a range of specific forms of programs. Organizations in this area have based their energies to have UAVs available to fulfill their demanded commitments productively; to establish a communication with a portion of the equipment and to give consumers a secure platform for communicating and dealing with UAV.

2.1 UAV (Unmanned Aerial Vehicle)

Unmanned aerial vehicles (UAVs) for an airplane operating without a pilot on board is described or articulated. UAVs is a member of a UAS that involves UAVs, a ground-based controller and the coordinating system for these two [7]. A Micro Air Vehicle

(MAV) and an F450 quadcopter below 2 Kg were included. MAV was used by drones weighing less than 2 kg to more than 50 g to varying from 15 cm to 100 cm [8]

2.1.1 Category of Micro Air Vehicle

There are various styles of MAVs. The following was illuminated, according to a description reviewed in 2017[8].

- Fixed-wing MAVs: which usually have inflexible wing, fuselage and fins, and have a propeller engine attached. The MAVs are flexible in different environments, such as the forest, coastal, mountain and even the Arctic. Information gathering and tracking are the most critical of the applications. These MAVs have the greatest potential selection and perseverance, in comparison to the majority of the existing MAV.
- Flapping wing MAVs: their lightweight and flapper wings are the basic part of such MAVs. We have switched in species from little gross animals to massive aerial species. A big crucial benefit of this form of MAV is its superb drifting cap. This feature makes them perfect for finding and saving missions. The MAV is equipped in different wing configurations: pair, monoplane and biplane.
- Rotatory wing MAVs): these MAVs are characterized by their incredible drifting capacity and versatility. A MAV rotator with straight spinning edges and propeller heads. Their willingness to switch on some contract path leaves them very nervous. Based on the amount of cut-out edges, twin-copters,

tricopters, quadcopters, pentacopters, hexacopters, occopters, decacopters and dodecacopters may be listed.

2.2 Detection of the distance between the object

Figure 2.1: Micro Air Vehicle Class

Range identification is the core concept that occurs across several construction departments. Applied to UAVs, the new workmanship status suggests that the initial use of UAVs is for state analysis, terrain type, height estimate and crash shirking[9].

2.2.1 Light Detection and Ranging (LiDAR)

The Light Detection and Ranging (LiDAR) system is an advancement in the precise measurement of the time slipping between sending and interpreting a beat optical laser pulse. Accordingly, in this sort of estimation technique, there are two types of signs: the transmitter reference signal and the target signal. This method is called a partnership where the deviation from the target is calculated by the time interval and use light speed continuously [10]. LiDARs work at various electromagnetic frequencies, depending on their use range. LiDAR meteorology operates continuously in ultraviolet wavelengths (1500 nm to 2000 nm) and in light frequencies (250 nm). The LiDARs' operating theory is based on this equation:

$$L = c\frac{t}{2} \quad (1)$$

Where L is the separation, it is the time slipped by among sending and getting the beat and c is the light speed steady. There at present exist in the market LiDAR sensors for drones with extraordinary high exhibitions.

Figure 2.2: Two UAV applied LiDAR sensors currently in the market

2.2.2 Sound Navigation and Ranging (SoNAR)

SoNAR depends on transmitting and accepting sound waves signals. By estimating the time delay between the sent heartbeat and got beat, it is conceivable to process the good ways from the objective [13]. Among its applications, a significant one is estimating the profundity of water surfaces when introduced on ships. SoNAR sensors are significantly more helpful in water situations as opposed to extreme conditions since the engendering of sound through water s quicker. It is similarly utilized in submarines to identify vessels and in ships to find fish targets. On the medication field, SoNARs sensors are typically utilized for disease recognition and checking unborn kids. Separation estimation s processed comparatively as on account of LiDARs. The main component that changes is the speed that for this situation is one of the sounds, which changes relying upon the mechanism of spread. An elite SoNAR utilized in the UAV area is shown in figure 2.3

Figure 2.3: MB1010 LV-MaxSonar-EZ1[14]

2.2.3 Radio Detection and Ranging (RaDAR)

Radar is an elective innovation that utilizes radio waves to gauge separations. The rule of working depends on the reflected transmitted signs. RaDAR sensors are aggravated by a radio wire, a transmitter, and a collector. The transmitter sends the radio-wave that spreads at the speed of light c. When arriving at the goal, the wave hits the objective and returns reflected to the collector. The reflected signal is distinguished and broke down as radio reverberation by the reception apparatus, and the sign is amplified by the beneficiary.

Regular citizen and military applications are inside the line of uses of RaDARs [15]. They are typically utilized in the airplane to quantify good ways from ground control stations and different items inside the airspace. Moreover, they are used in geography for identification of zones for mineral prospection, in farming for crop observing, in cartography for altimetric rises, in hydrology for soil dampness discovery, or oceanography for ship recognition and illicit fishing checking [16].

2.3 Collision Avoidance System in Unmanned Aerial Vehicle

The most utilized impact evasion framework in the current flight is TCAS. Also, as indicated by current enactment, drones expecting to cover courses inside controlled airspace ought to have it prepared.

Notwithstanding, the industry is creating drones for recreative use with impact evasion innovation consolidated. Automatons are likewise utilized in many swarmed zones and occasions since they can catch films with inaccessible plots for the customary cam administrators. Tragically, there have been a few mishaps and security of the individuals is an absolute necessity that ought to be protected without exceptional cases.

As of late, a few models with impact shirking gear have been discharged to the market. They are altogether furnished with one to six sensors situated during the four sides, top and base. The most well-known ones are Kespry 2, DJI Spark, and DJI Phantom 4 Pro. The most noticeable one s Kespry 2, which has five headings of impediment detecting and four bearings of snag shirking. Aside from that, some canny flight modes are given, just as too smooth dependability and a top 4k camera.

Ardupilot, an open-source unmanned vehicle Autopilot Sofware, have an augmentation for Collision Avoidance calculations in multicopters, by utilizing front line closeness sensors, for example, Ligthware SF40C and TeraRanger Tower. This is an attainable path for drone novices to consolidate impact evasion usefulness into their handcrafted multicopters. The present status of improvement of this innovation lets arducopter clients separate the territory around the automaton into eight divisions. Every area covers 45 °. The impact shirking calculation the automaton is modified to stop the MAV when a deterrent is distinguished under the scope of 2 meters.

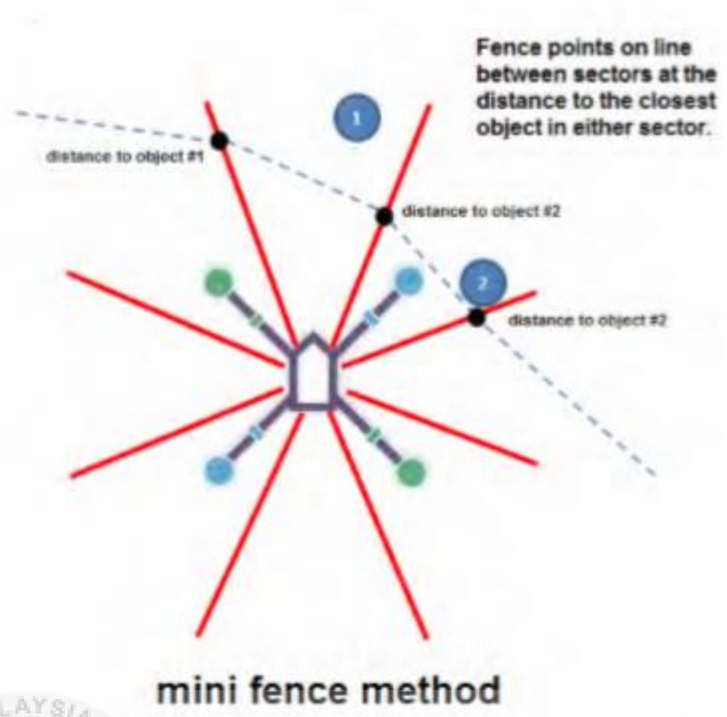


Figure 2.4: Arducopter collision avoidance environment sector divisions [17]

Figure 2.5: High-performance LiDAR sensors

2.4 Hardware components

As recently clarified, to execute the impact evasion framework into the automaton, it was first expected to get together and to test a proficient flight drone. The chose drone was a quadcopter F450. It is imperative to comment that the vast majority of the parts utilized inside this undertaking has a place with the Universiti Teknikal Malaysia Melaka. Consequently, a quadcopter was chosen because of the way all the necessary parts to mount was at that point present. Besides, a quadcopter is one of the most appropriate MAV types to demonstrate and actualize such an unpredictable framework. Quadrotors give the clients the chance of floating flights, making the crash evasion testing increasingly achievable and straightforward, considering the invalid understanding inside guiding those vehicles of the author of this proposition before inundating in this undertaking. The following areas acquaint with the peruser the equipment parts utilized in the execution of this task.

2.4.1 Drone frame type

The frame is the MAV portion that links all subsystems and provides MAV with physical uprightness. There are a range of multirotor models operating on the existing market, varying from bicopters (two MAVs) to octacopters (eight MAVs). The situation is basically the MAV framework comprising all parts inside the MAV. The weapons, landing gears, rotor bases, and concentrating plates were strengthened. Many of the focal plates have a double power. This is the conference center, where landing systems and weapons connect and the power distribution wiring for monitoring the other segments are integrated. The F450 kit contour used in this mission comprises of two focal tiles. The top plate is lined as a communication channel and the bottom plate is a PDB and a communicating channel. There is an significant judgment to describe: the position of the edge in relation to the condition of the flight controller.Three possible configurations may be selected for quadcopters: +, H and X.

Figure 2.6: Different rotor configurations

The option of frame will be based on the continued application of the automaton. The number of engines selected will be compatible with the MAV 's vital potential. The number of engines relies on two switches: efficiency and perseverance. In operations where reliability is a big concern, the usage of copters without four engines is beneficial. For tasks such as foundation analysis or harvest tests, vehicle strength is an essential concern that can be strengthened undeniably by growing the amount of rotors. Two separate configurations are available: flat and coaxial. Growing arm's level design calls for one engine, whereas the coaxial design aims to combine two coaxial comparable motors on each limb. The design selected was a quadcopter machine F450. The rotor orientation was X and the design chosen was square.

Figure 2.7: F450 kit

2.4.2 Brushless Motors

Brushed DC motors rely on a mechanical current transfer device while AC and brushless DC gear motors use an electronic current control mechanism. The brushed motors are designed with a wrapped armature at the core of a permanent magnet attached to a steel framework around the rotor. The current flows over to the armature coils when the brushes come into touch with the commutator. AC induction motors and BLDC motors for controlling current are not dependent on the mechanical system (brushes). The AC and BLDC motors pass through the stator (electromagnet) directly or via a solid-state circuit, which is connected to the AC power. For AC induction motors, when the current is flowing, the rotor spins for response to the "induction" of a spinning magnetic field inside the stator. Instead of triggering the rotor of a brushless DC motor, permanent magnets are bound directly to the rotor when the current flows through the stator, the rotor poles move of response to the electromagnetic poles generated within the stator, producing motion.

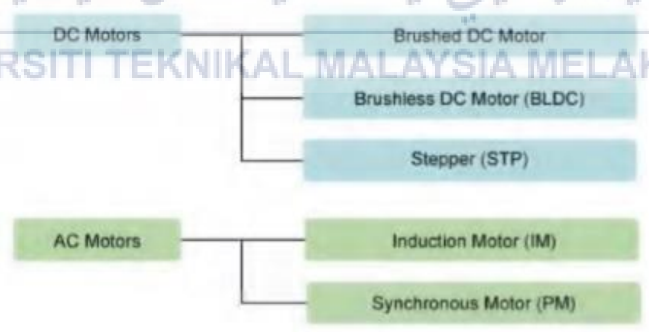


Figure 2.8: Motors classification [21]

In the UAV business, For a brushless DC engine, also known as a BLDC engine, there is never any reason to think about the state of the brushes, which might allow the engine to be taken out of operation and replaced. Brushless motors can be just as efficient for high-speed operation as a brushed motor, if not more, and a brushless can have a life expectancy of more than 10,000 hours because there are no brushes to replace. A brushed DC motor can be adequate and cost efficient for a project where a motor is only going to be needed for a limited period. But if it's going to be in continuous use, especially if a lot of power needs to be taken on, a brushless motor is a much better choice.

Figure 2.9: 2212 900 Kv Brushless rotor

2.4.3 Drone Propellers

One of the most important elements of a drone is the propellers. Knowing how drone propellers operate is crucial to learning how quadcopters truly fly. All UAVs (unmanned aerial vehicles) are virtually propelled by a set of spinning wings, lifting them forward to make them fly. Drone propellers are the spinning blades which act as the wings of the quadcopter which create airflow to lift it into the air. A significant plan boundary of propellers is the pitch esteem. The pitch esteems the point that structure the sharp edge with the propeller breadth focus. The higher the estimation of the pitch, the higher the edge of the assault of the air with the propeller. Higher pitch esteems mean higher separation progressed by the vehicle in one pivot. Figure 2.10 represents the difference among high and low pitch esteems.

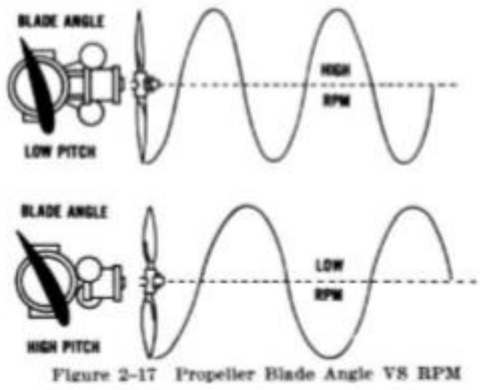


Figure 2.10: High Pitch and Low Pitch values [22]

The most suitable plan choice when producing propellers is their turn sense. Propellers can be clockwise or counter-clockwise turning. Clockwise propellers must be stably mounted on clockwise brushless engines, and the equivalent occurs with counter-clockwise propellers. An off-base mounting of the propellers could prompt a push power pushing the quadcopter to the ground as opposed to pushing it upwards—this misstep is fundamental in UAV apprentices.

The propellers utilized in this task were Gemfan 10x4.5 APC SF style, where the first number relates to the breadth in inches, and the subsequent worth represents the pitch esteem.

Figure 2.11: Selected Propellers [23]

2.4.4 Electronic Speed Controllers (ESC)

Electronic Speed Controllers (ESCs) are the flight controller's relation with the engines. All they do is shift the electric movement from a battery (Direct Current) to a DC. The rotor speed is dependent on the modulated pulse width (PWM) sent by the ESC controllers.

Figure 2.12: PWM cycle [24]

ESCs have the most extreme current, and pressure esteems allowed just as rotors. That is a significant issue to think about while choosing a rotor good with an ESC. The most extreme current bolstered by the ESC must be consistently equivalent to or higher than the greatest one upheld by the rotor. It additionally unequivocally proposed that ESCs have an edge between most extreme permitted current among rotors and ESCs.

The selected ESCs for this venture were four units of 30A ESCs.

2.4.5 Power source

Lithium polymer batteries (LiPo) power nearly all UAVs. Such batteries have extraordinary strength limits and light loads. These two highlights make them the perfect source of the vitality of a gadget that will fly and has low-weight payloads to build its perseverance and its range. LiPo batteries are intensified by cells, each with a certain voltage and are connected in series. The jargon of the number of cells in a LiPo battery is XS, where X is the serial cell number and S. For eg, (the battery used for the development of this enterprise), a 3-cell battery paired with a 3S LiPo battery. LiPo batteries are classified according to their capacity and release (C) ratings. Force limits are given every hour in milliamperes (mAh). (c) the rating determines essentially the pace at which the battery will produce its power. The battery chosen from the enterprise has a limit of 2200 mAh and a C rating of 25C, so it can produce 2.2 x 25=55 A at the most extreme current.

Figure 2.13: Selected Battery [25]

2.4.6 Flight Controller

The flight controller needs to test all procedures of the quadcopter. A Pixhawk 2.4.8 was used in this company. Pixhawk is described as an individual opening equipment to enable the autopilot UAV to be applied regularly for daily, mechanical and military applications[26]. The flight controller Pixhawk uses an inwardly coherent system called nuttX. The flight controller solution actually available on the market is the one that ArduPilot produces and develops: the Ardupilot Mega (APM). Pixhawk's is known to be an advanced APM flight controller. It has an internal compass, external telemetry ports or a co-processor for floating points that accelerates each mathematical measurement.

Figure 2.14: Pixhawk 2.4.8 [27]

2.4.7 Firmware

Flight controllers need an internal firmware. Firmware is described as programming composed of non-volatile memory equipment gadget [28]. The software used in this company is part of ArduPilot's open source programming. Ardupilot provides all bolstered vehicles with firmware: multicopters, UAVs with fixed aircraft , helicopters, meanderers, and submerged vehicles. APM Copter, 3.4.6 s is running firmware on the quadcopter in this company. This software which is accessible unreservedly on the official website of ardupilot is now configured to be installed in the flight controller and the interface assignments are first set. It incorporates its flight modes to perform dealing activities from now on.

- **Pixhawk sensors**

The Pixhawk flight controller is equipped with internal sensors that capture the requisite data for its valid show.

1. inertial sensors: The inertial sensors are mounted in an inertial measurement unit (IMU) electronic frame. The first inactivity indicator is a 3-wheel drive, which recuperates 3-wheel drive that speeds. The second inactivity monitor is a three-pivot accelerometer that retrieves speeds up straight. The reason for the IMU is to retrieve the data necessary to keep the quadcopter tracked during its activity. The flight controller forms that data and output required rakish speeds throw the ESCs into an even parity between the longitudinal and parallel hub to keep the automobile stable.

2. Gauge: an meter is used to collect pneumatic force details from the flight controller. This detail is planned and an elevation is measured over the ground floor. For eg, in

the mode elevation keeping, when the choc is acclimated to sustain a deal height, this sensor is extremely helpful.

3. Magnetometer: a magnetometer is used to reflect the enticing north-facing heading of the flight controller.

4. External sensors: external sensors can be attached to the I2C, SPI and Serial ports by flipping the Pixhawk flight controller. A GPS sensor attached to the Pixhawk through the GPS port is a primary sensor required for the best possible presentation of controlled flight modes. It can also be attached to a new compass (magnetometer) through the I2C connection. The frame is allowed to obtain more accurate headings by an external magnetometer despite the association between the electromagnetic fields measured in the Pixhawk magnetometer and the outside.

- **Safety switch and Buzzer**

The flight controller pack of Pixhawk includes a wellbeing switch and a signal. The protection switch point obstructs the communication of PWM between the flight controller and the ESCs, allowing for secure UAV controls when the battery is connected. The signal is a device that radiates various kinds of sounds based on the quadcopter level. It is a way that the flight controller and the pilot communicate without the usage of the ground control center. As the UAV is mounted, for example, a signature beep is generated for two seconds.

2.4.8 Arduino Uno

Arduino Uno is a microcontroller with a single plate. It is the basic equipment of the shirking frame and the ultrasonic sensors. Arduino is an open-source Computing and programming company that manufactures microcontroller packs to create device hardware, with simple implementations in practical and advanced environments for the identification and controlling of articles [29].

In this endeavor, the Arduino Uno board prepares all separation sensor data and thus discharges the order on the flight controller for avoidance of obstacles. In specific, it sends overwriting pitch or rotation calculations (depending on the region of impediment) to insure that the auto driver shifts away from the deterrent. The relation between the Arduino and the Pixhawk controller shall be formed by correspondence, via the integrated circuit of the Universal Asynchronous Receiver / Transmitter (UART) equipment which is used by sequential port for subsequent correspondence. In the following regions, more insights are provided as to the relations between the segments.

Figure 2.15: Arduino Uno [30]

2.4.9 Telemetry

The interaction of telemetry between the ground control station and the automaton is important to display the flight arrangement of the vehicle, even like some frustration or event is recorded during the ride. Telemetrie is often crucial in certain flight modes, especially for self-regulating flight modes, where the UAV assumes a flight path centered on route points established at the ground control station.

A SiK Telemetry Radio was used for this task. This layout has a length of less than 300 m. The telemetry kit comprises of two transmitters and recipients; one on the UAV and the other on the GCS. The recurrence is 433 MHz and the communication protocol is MAVLink with the Pixhawk flight controller.

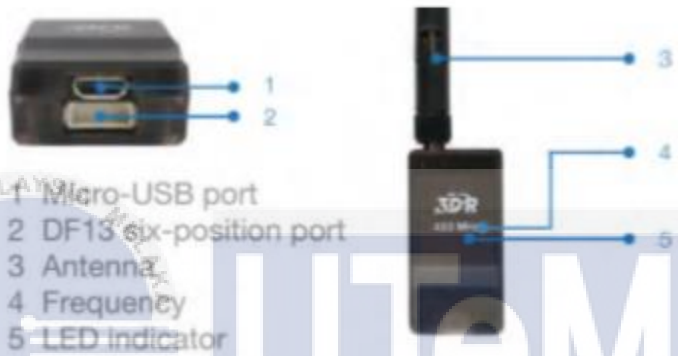


Figure 2.16: Sik Telemetry Radio [31]

2.4.10 Radio transmitter and receiver

One of the most important angles in pilot command flight modes is the correspondence between the pilot and the quadcopter. A Radio Control (RC) transmitter and a Radio Control (RC) receiver complete this transmission. Radio indicator recurrence is 2.4 GHz. The collector is mindful that the radio sign is modified to a pulse width modulated signal (PWM). The Pixhawk flight control is used in this project, and it does not have PWM data, but PPM. PPM represents the regulatory beat position. Many beats of fixed length adjust the sign in PPM. There are stops of variable length between the beats. Throughout this way, a PPM encoder was used to adjust the PWM signal from the RC to PPM to reach the Pixhawk flight controller. On these lines the PWM signals are registered in a single PPM signal on all five channels used (move, turn, yaw, shock and flight mode). Since the Flysky FS-i6 RC transmitter used for this role comprises of six channels, the one remaining is not included. For eg, this non-useable channel may be used for servo engine power, usually used when a camera is ready for the quadcopter as payload.

Figure 2.17: Flysky FS-i6 RC transmitter and receiver [32]

2.4.11 Ultrasonic range finder

Ultrasonic range finder is a SoNAR sensor, and it has the work rule clarified already in the previous section. The used sensor in this undertaking is the HC-SR04 sonar, which is associated with the Arduino Uno microcontroller board, where the sensor distance processing happens.

Figure 2.18: HC-SR04 Ultrasonic Finder [33]

2.5 Software elements

2.5.1 Windows 10

The operating system employed in this project is Windows 10.

2.5.2 APM Planner

ArduPilot is an open-source AutoPilot Software package for autonomous vehicles designed to handle and monitor autonomous systems. Such programming is accessible on the vehicle controller (e.g. firmware) as well as programming on the ground control system, such as Project Planner, APM Planer, QGroundControl, or MavProxy. Strategics, the configuration of the Ground Control Station utilized by a wide range of consumers. Land control station programming is extremely helpful in advanced missions and in valid vehicle synchronization where the range limits that the range circle demands for continuous measurements need to be changed. When coupling the vehicle with a GCS, the power is not only on the RC transmitter 's six channels. High-level instructions can be transmitted to the spacecraft from the ground control center, as can continuous reports on UAV configuration and state. The vehicle can be connected to the GCS by the USB wire with the software update and modification strategies. Nevertheless, when the quadcopter transmitting in real time, both continuous data monitoring and transmission instructions (for the control of modes) are carried out by the telemetry association whose equipment has been demonstrated.

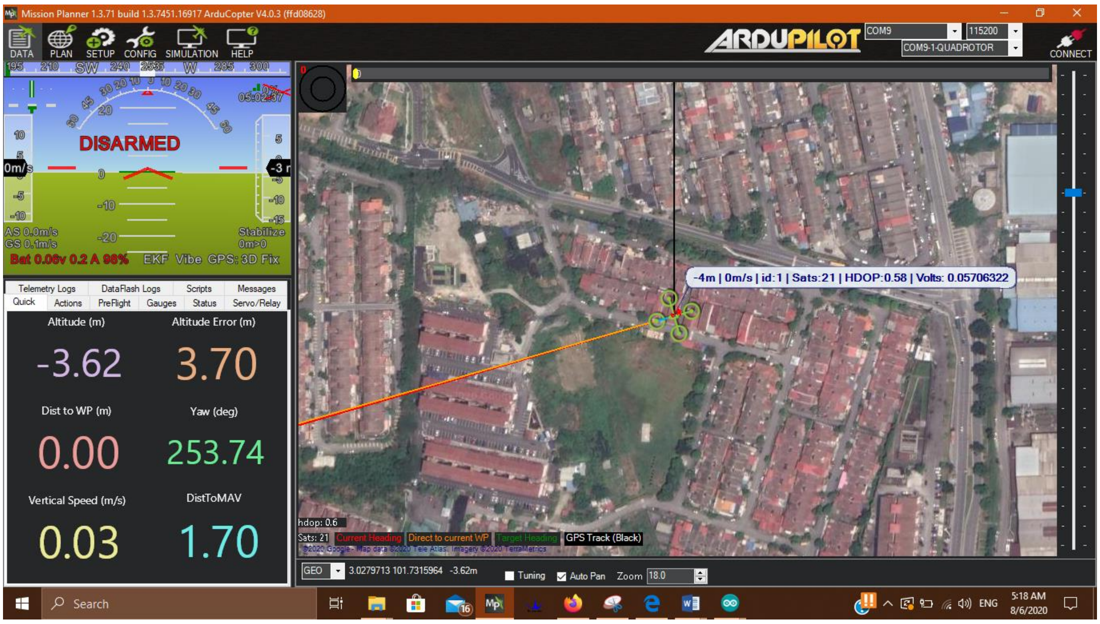


Figure 2.19: APM Planner interface

The Arducopter software, the basic programming passed to the quadcopter, is revised to various flight modes, each with separate propelled highlights. There are various flight types, several for very complicated and complex activities. For this endeavor, only two of them were used to test the best functioning and proof of the evasion hindrance frame in the quadcopter.STABILIZE and POSITION HOLD modes were used[35].

• STABILIZE MODE: this flight mode uses the IMU demeanour data given to monitor the quadcopter in the flight controller. The pilot monitors the thin edge of the copter 's exposure at roll and pitch positions. At the stage where the pilot discharges the sticks from the respective channels (channel 1 and channel 2) the car lowers itself in compliance with the flight controller by providing pitch and shifting values recorded based on open and closure power. Nevertheless, the pilot will adjust pitch and shift calculations when flying outside and hold the aircraft on its location and account for the wind impact. Yaw's pilot input guides the advancement of the heading. If the stick of this (channel 3) is heard, the quadcopter will maintain its heading constantly forward.

The driver's choke feedback determines the average engine rpm, and thus his constant adjustment is necessary to sustain the vehicle's elevation. The shock sent to the rotors is generally calibrated, based on the tilt point of the aircraft, to minimize the pilot's pay during the adjustments in the attitude [36].

• POSITION HOLD MODE: flight mode of the PosHold holds the field, heading and height constant. The pilot sticks inputs directly influence the thin edge of the engine, creating an increasingly "natural" feeling.

2.5.3 Arduino IDE

The Arduino Intergrated Development Environment (IDE) is a cross-stage Java application. It offers a code proofreader that can quickly connect and pass projects to the Arduino board using a single tick instrument[29].It also includes the territories of notifications, text convenience, a daily grab toolbar and a progressive task interface. Arduino IDE bolsters dialects C and C++ programming. The composition of the code only has two main capacities:

• Setup: the variables and constants are mounted.

• Loop: simple software chain.

Arduino IDE uses the 'avrdude' software to convert the executable code into a hexadecimal book file that a loader system stores in the Arduino thumbnailed scale controller frame.

Throughout this undertaking, an Arduino design is produced to process the data feedback from the sensors and to generate different abrogation qualities, which adjust the trajectory of the quadcopter and retain a strategic gap.

2.6 Communications

As referenced in past segments, a quadcopter may be limited by two different means. The initial is directly controlled by the pilot via an RC transmitter. The second is from a ground control facility, which is linked to both the GCS and the vehicle by a telemetry transmitter.

2.6.1 RC control

The receiver is the easiest way to control a UAV. This is typically seen for day-to-day and leisure trips. All the networks remain strongly controlled by the operator, who will be prepared to order the vehicle.

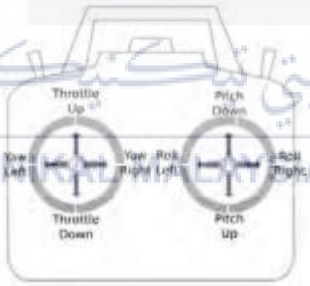


Figure 2.20: RC transmitter Euler angles and throttle sticks [37]

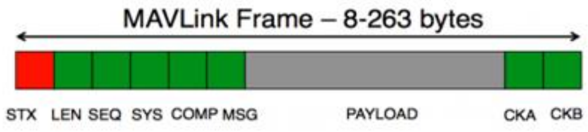
The Euler points and shock are the four first main channels to order an car, as defined in Figure 2.20. The fifth channel is also used to monitor the automated flight system in this mission. The data is sent to the RC receiver flipping radio waves. In each of the six channels the beneficiary must proselytize this sign to PWM and give it to the PPM encoder that transfers the PPM sign to the flight controller.

2.6.2 MAVLink

The MAVLink is a Micro Air Vehicle Connection and a communications arrangement with the primary goal of data exchange between GCS and MAVs. It was intended to build tiny and light libraries that comprise the data required to share messages during the GCS-MAV correspondence. Throughout all kinds of GCS and automobile, MAVLink is very plausibly scalable, as the message description is written throughout C. While the current libraries provide a vast variety of messages, customers will generate new messages through the development of new libraries [38]. The messages are byte scrap and the GCS, the flight controller or some other miniaturized scale system board like Arduino Uno, the one used to execute this function, will understand and decode the messages.

The GCS or smaller scale control panel will say signals, for example, that are heart-beat, outfitting, incapacitating, flight mode shift or overwriting networks, and easily decode and execute them by the flight controller from this stage. The MAVLink package contains a codified byte structure. Table 2.1 indicates the configuration and ability of each byte modifying a message package. Of the autopilots that endorse this communication agreement, there are many[38]:

- Autopilots: ArduPilot Mega, pxIMU Autopilot, SLUGS Autopilot, FLEXIPILOT, MatrixPilot, SenseSoar Autopilot, SmartAP Autopilot, AUtoQuad 6 AutoPilot, Pixhawk Autopilot.



Byte Index	Content	Value	Explanation
0	Packet start sign	v1.0: 0xFE (v0.9: 0x55)	Indicates the start of a new packet.
1	Payload length	0 - 255	Indicates length of the following payload.
2	Packet sequence	0 - 255	Each component counts up his send sequence. Allows to detect packet loss
3	System ID	1 - 255	ID of the SENDING system. Allows to differentiate different MAVs on the same network.
4	Component ID	0 - 255	ID of the SENDING component. Allows to differentiate different components of the same system, e.g. the IMU and the autopilot.
5	Message ID	0 - 255	ID of the message - the id defines what the payload "means" and how it should be correctly decoded.
6 to (n+6)	Data	(0 - 255) bytes	Data of the message, depends on the message id.
(n+7) to (n+8)	Checksum (low byte, high byte)	ITU X.25/SAE AS-4 hash, **excluding packet start sign, so bytes 1..(n+6)** Note: The checksum also includes MAVLINK_CRC_EXTRA (Number computed from message fields. Protects the packet from decoding a different version of the same packet but with different variables).	

Table 2.1: MAVLink bytes explanation

- GCS Software: DroneCtrl, QGroundControl, HK Ground Control Station, APM Planner, Mission Planner, MAVProxy.

One of the critical points of this venture, just as an ultimate target, is making an appropriate correspondence interface among the fundamental parts of the UAV. Coordinating the Collision Avoidance System into the remainder of the UAV had numerous difficulties. Without a doubt, one of them was set up a MAVLink correspondence between the Arduino board and the flight controller. The necessary move execution request was sent from the Arduino Uno by MAVLink convention of correspondence.

This assignment was finished after an efficient methodology, from exceptionally straightforward orders testing, to progressively entangled ones, finalizing in a useful idea confirmation of a crash evasion move.

It is additionally excellent to consider that the separation information handling had nothing to do with MAVLink. A program was made to process that data inside the Arduino board, and dependent on that, sending through MAVLink overwriting estimations of Euler edges to play out the move. This way, the utility of MAVLink convention of correspondence inside this undertaking lied on sending mentality revisions, rather than separations.

MAVLink correspondence s built up in this task toss two physical associations:

- USB association: built up through subsequent correspondence, by the Universal Asynchronous Receiver/Transmitter (UART) equipment incorporated circuit, when the Pixhawk flight controller is associated with the GCS to perform adjustments and firmware refreshes; and for the Arduino Uno-flight controller association.
- Radio telemetry association: when the quadcopter is flying, to screen in the GCS constant data and to define control boundary esteems in the GCS without the need of incapacitating the vehicle.

CHAPTER 3:

METHODOLOGY

In this part clarifies in subtleties how the venture was drawn closer and concentrated on the task stream outline while building up the control arrangement of quadcopters for the multi-specialists framework. This segment is clarified about the exploration strategy just as the systems took to finish this report. Furthermore, this area of the report clarifies all the equipment and programming parts that are to be utilized. Issues experienced in this area of the report and answers for these issues are not referenced. The final product of this venture could be utilized for some applications in future improvements in this field. This venture was separated into four principal stages: the examination stage, the development and interface stage, the tuning and adjustment stage and the programming stage. in the accompanying areas of this record, each stage is clarified all the more altogether.

3.1 Overall project

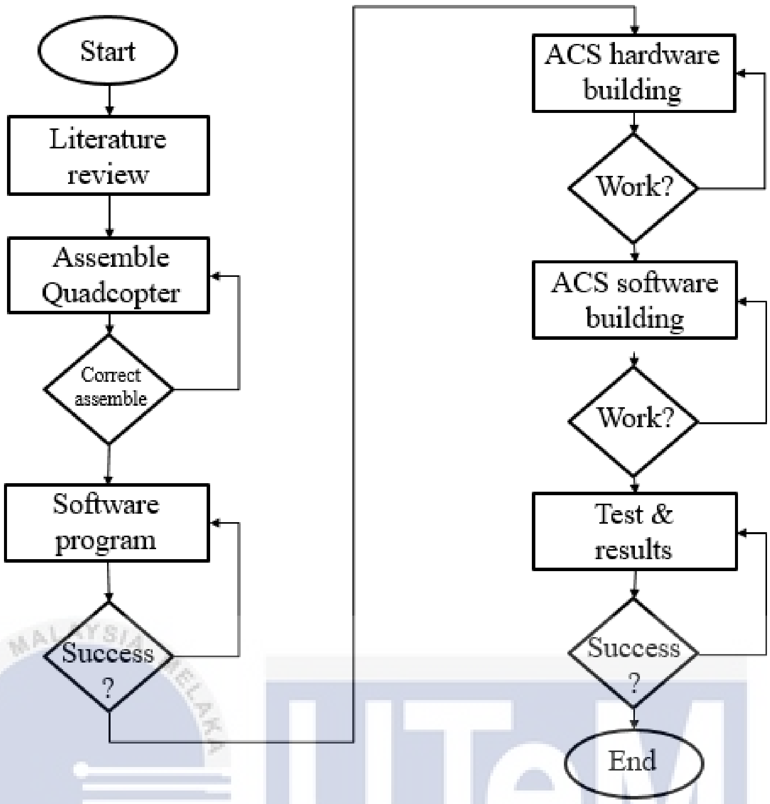


Figure 3. 13: Overall project flowchart

3.2 Literature review

Background research has been done in order to select the most suitable and reliable components in order to achieve the goal of this project.

3.3 Quadcopter assembly and wiring

The first goal of this project s building a flight-capable drone from scratch, utilizing the equipment presented in part 2. Despite the fact, that is building the automaton is not the primary motivation behind this venture, it is an essential and moderate advance to have a testing stage on which incorporating the CAS and demonstrating ts presentation. A portion of the fundamental get together stages, and head associations will be point by point in this segment.

3.3.1 Power distribution board soldering:

The initial step when mounting a quadcopter comprises on fastening the electronic speed controllers and the battery connector port to the force appropriation board. Each ESC is stopped to its comparing cushion in the force dispersion board, soldering the dark wire to the negative (-) cushion and the red one to the positive cushion (+). Since the PWB has a place with the F450 unit, it has four cushions for the four ESCs. From that point forward, the force link s bound to the primary force minstrel, following a similar method: red link to positive cushion (+) and dark link to negative cushion(-). The force link is soldered on its opposite end to an XT60 connector to get vitality from the battery. Figures 3.2 and 3.3 delineate the ESCs welding and the XT60 connector.

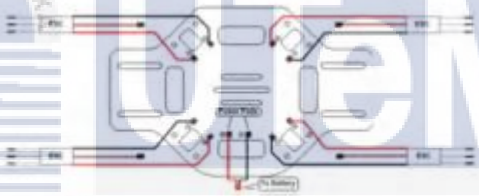


Figure 3. 14: ESCs connections

Figure 3. 15: XT60 connector

3.3.2 Frame assembly

The subsequent stage comprises on gathering the F450 outline, hence the four arms to the base (for example PWD) and upper plate. Each arm is in a wrong way to the plates by utilizing M2.5*6 mounting screws and the hex-wrench. Figure 3.4 shows the subsequent edge in the wake of being amassed.

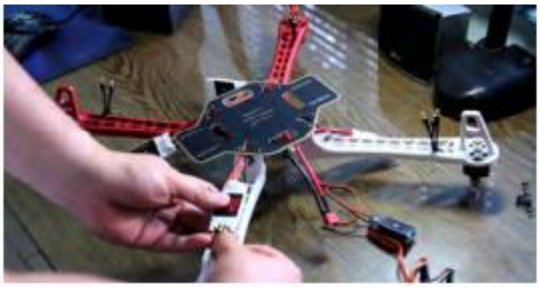


Figure 3. 16: F450 assembled frame

3.3.3 Motor assembly

The subsequent stage comprises on screwing the four engines to the furthest limit of each arm by using M3*6 mounting screws. It is pertinent to comment that two sorts of engines are utilized: clockwise pivoting and counter-clockwise turning. To recognize them, clogged pore engines are counter-clockwise turning, and silver-head engines are clockwise pivoting. Figure below outlines the chose rules of revolution for the quadcopter. As watched, askew adjusted engines pivot a similar way. This engine air is not chosen futile, t has ts physical explanation. At the point when a rotor incites, it makes a torque impact on the vehicle body. Along these lines, if all the engines pivot a similar way, the quadcopter will yaw because of the impact of this torque. To check this impact, two rotors are turning one way, and the other two on the contrary one, to get a stable quadcopter, whose yaw pivot just relies upon the flight controller inputs.

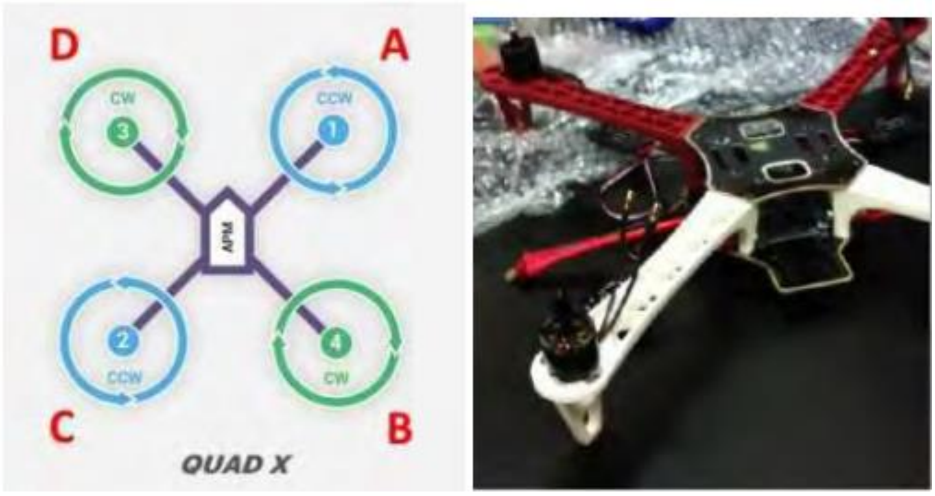


Figure 3. 17: Spinning criteria and rotor assembly

3.3.4 Propellers attached to the brushless motors

Following stage is gathering the propellers to the engines. As referenced in the anterior segment, their turning bearing must be predictable with the orientation of the rotors. Propellers are fabricated depending on ts pivot. Along these lines, counter-clockwise turning propellers are curled in its rotors, and clockwise propellers are looped in silver-head rotors.

3.3.5 Attaching legs to the drone frame

Legs give the quadcopter assurance in landing activities just as soundness in take-off tasks. Moreover, its utilization is pivotal in this task, taking into account that the fundamental component of the CAS (the Arduino microcontroller) is situated in the base plate. Arriving without legs would harm the microcontroller board since t would contact the ground legitimately.

Figure 3. 18: F450 legs

3.3.6 Soldering ESC to brushless motors

ESCs has three wire contributions from the engines. The request for the associations differs the pivot of the rotors, as indicated by figure 3.7. in this way, the wiring must be done steadily with the deal revolution.

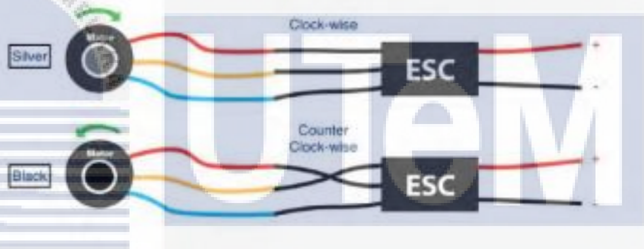


Figure 3. 19: Wiring order

3.3.7 Pixhawk flight controller placement

The Pixhawk flight controller is not taped legitimately to the upper plate of the edge. Those vibrations would, without a doubt, influence the presentation of the flight controller IMU sensor. The upper plate has loads of vibrations during flight. The solution to the problem is by adding a padding wipe in the centre to retain those vibrations.

Figure 3. 20: Cushioning sponge

3.3.8 Radio receiver and PPM encoder assembly

The radio recipient is taped to one of the arms of the quadcopter. It must be guaranteed that the cutting edges do not contact this thing while pivoting. Close to it, the PPM encoder is additionally tapped.

Figure 3. 21: Radio receiver and PPM encoder

3.3.9 Pixhawk flight controller wirings

The figure underneath shows the pins sources of info and yields of the Pixhawk flight controller. The ESCs have connected 1 to 4 yield pins, and the PPM encoder is stopped to the RC pins.

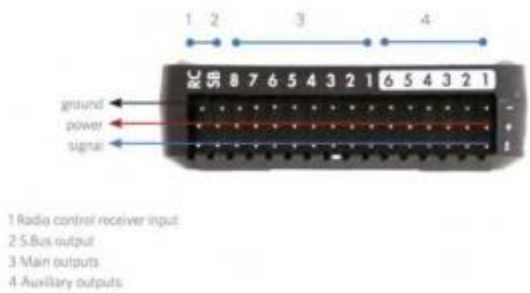


Figure 3. 22: Pixhawk flight controller pins

3.4 Software Program

3.4.1 Calibration

To enable quadcopter flight, some preliminary flight tests should be carried out. Most significantly, it is appropriate to select the casing configuration. For the quadcopter used in this project, the design of the X outline was used. From that stage on, the Pixhawk flight controller 's internal compass must be properly matched. The flight controller must be connected with the ground control station via the USB link or telemetry interface.

APM Organizer has a pre-determined synchronization technique within its modules to change the inner sensors of the flight controller chosen and the transmitter of the RC picked. At the compass correction, the GCS contacts the consumer for 60 seconds to transform the automaton along the Euler lines. By doing so, the GCS needs adaptation checks and the GCS provides the following equilibrium figures at the conclusion of the process. The accelerometer change must be made at that stage. The GCS has also preset usefulness to do so. This prompts the customer to find the car in six directions: nose up, nose down, left, right, level and back. The accelerometer will be matched when done. The RC transmitter is aligned following the stage.

The explanation for this change is that the client's exposure to the four canals of the RC transmitter is the most serious and the least possible. The GCS prompts the customer to move the clamps to the maximum and the essential points. The GCS displays the medium, most extreme and least estimated movement, pitch, law and push channel when the procedure is complete. Finally, the constant obligatory advance includes setting the flight modes. Throughout this mission, the flight mode option was moved to the RC transmitter 's fifth line. The quadcopter flies in the pre-selected flight modes according to the condition of the fifth channel button. For this company only two modes were used: level out and elevation keep mode. Accordingly, the fifth channel stick had only two arbitrary locations. Once the correction process is done, the quadcopter will be able to operate from the start.

Figure 3. 23: GCS calibration display

3.5 Anti-Collision hardware building

3.5.1 Arduino Uno – Pixhawk flight controller

The figure underneath shows the physical wiring associations between Arduino Uno and Pixhawk flight controller. The correspondence type is sequential, by UART.

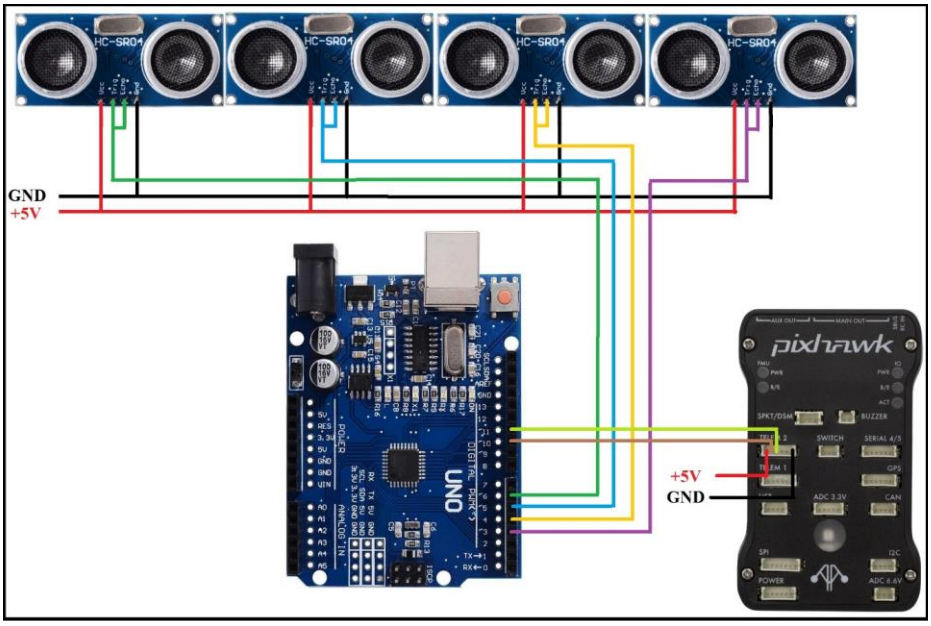


Figure 3. 24: Arduino Uno-Pixhawk flight controller pin connection

3.6 Anti-collision software building

The title of this segment speaks to without a doubt, one of the most testing parts inside this venture. The key and critical obligation to effectively execute the CAS into the UAV framework lies on building up a legitimate correspondence between the flight controller and the Arduino microcontroller load up. As recently referenced, the pitch and move adjustment orders are sent from the Arduino board, because of the right ways from the quadcopter to an item. As presented in the First section, MAVLink convention of correspondence s the device used by those two gadgets to send and get messages. Following segments will cover the product-related errands to make the CAS effectively work in the quadcopter.

3.6.1 Distance data acquisition and processing

The first task was to establish a match between the ultrasonic discoverers and the Arduino Uno microcontroller. The HC-SR04 sensors generate heartbeat and record the time required for reflecting and returning to the receiver. That is the time it takes to launch the microcontroller. A program was designed to process and convert the time data to delete. This is why Arduino IDE was included. The composition of the code has only two fundamental capabilities: arrangement and circle. Within those capacities, additional and sophisticated capabilities can be used only once if they are part of the arrangement or if they are run continuously wherever they are included in the cycle. The separation work was within the Arduino sketch circle and beats were sent continuously to view the planet. The quadcopter must reach 1 meter in height to start experiencing the even general state. This essential base height level is updated as a necessary condition to ensure that the horizontal ultrasonic discoverers work. The mechanism for prevention of consequences was built into the four sides of the quadcopter. However, the Arduino system was programmed to clearly activate one of the four sides on each flight. Four separate experiments were carried out on the side of the vehicle, checking the crash avoidance framework.

3.6.2 Arduino board as a UAV system

The collision prevention system operates with adjustments of the pitch and roll to change the direction of the auto and prevent it from being obstructed. The adjustments in the pitch and the motion are overwritten by the pilot through the RC transmitter. In order to carry out blessed overwriting messages, the GCS must first recognize the impact shirking framework as a further UAV framework. This can be shown by forming a link between the Arduino microcontroller and the Pixhawk flight controller. For this purpose, the MAVLink correspondence convention is used. MAVLink has a broad array of GCS, flight controllers and additional microcontroller loads to send and get messages. A heartbeat message is used for the D of the Arduino Uno. The reason for the Heartbeat message is D of two subsystems and establish a legitimate relationship between them. The message will be transmitted continuously from the

Arduino load to the Pixhawk flight controller to warn the flight controller that the evasion module is indeed alive. If the pulse beats did not occur, the flight controller may activate a safeguard system and would tell the GCS about the frustration with the crash avoidance method. The Pixhawk flight controller shall be told of the start of the packet, its duration, succession number, the transmission frame D, the transmission segment D (the loading of the Arduino), the packet D, the payload and the checksum (heartbeat message 0 counted). This data is pre-packaged in the Arduino load and sent to the Pixhawk flight controller via the two-port serial.

3.7 Anti-Collision system test run

3.7.1 Obstacle alert and collision avoidance

The Collision Avoidance System sends pitch and roll remedies to change the direction of the automobile and prevent deterrents. The programs were translated into the Arduino microcontroller board and the side of the quadcopter was tested. The four phases of the impact frame were executed on each of these four codes: lowest initiation level, flat condition detection, obstacle location and crash evasion movement. The data isolation and power planning is repeatedly carried out in the Arduino plate. Thus, the horizontal sensor chosen proceeds to infer a potential obstacle to the separation. When the separation below 1.2 m is distinguished, the program makes a request to abrogate a figurative pitch or change the estimation depending on the side where the item is recognized.

When sensors 1 or 3 are complex, the system offers pitch predictions to slant the quadcopter to hold it out of dissuasion.If sensors 2 or 4 are dynamic, theprogram yields move to tilt and disconnect the quadcopter. Roll and pitch esteem compare to the radio transmitter channels 1 and 2. The radio receiver delivers 6 PWM signals to the PPM encoder, one per each wave. The PWM signals on each channel operate somewhere between the 1000 and 2000 range and have a clear relation to the telling element. For eg, in expectation of a base approximation-45 ° of the pitch point and the most important estimation of 45 °, the corresponding signs for the PWM are 1000 and 2000 respectively. In case a PWM signal is transmitted via the running, turning or rotating channels, the flight controller's PID controller demands an automobile's rakish rotation speed to complete the appropriate point. The GCS design, APM Planner in this company, will set the most drastic edges. The most extreme and least quality values are set at 45 ° and-45 ° for pitch and move. The pitch and roll adjustment was provided to the aircraft master, based on the extent at which the challenge exists. The isolation of the deterrence identification in the Arduino system in which the context of crash evasion exists. The size is 1.2 m. Under this separation, the flight controller is sent the pitch and the move value to encourage a pitch or roll an amendment. But this design is adapted for it, based on the sheltered separation below 1.2 metres, and on this line a delicate or aggressive movement depends on equal and square risk, relative to the separation from the obstacle.

The pitch and roll redress are overwritten by the pilot through the RC transmitter. To complete blessed overwriting texts, the GCS will consider the crash shirking mechanism as a new UAV system. This identifiable proof is supported by the communication between the microcontroller Arduino and the flight controller Pixhawk.

For this purpose, theMAVLink correspondence convention is used. MAVLink has a broad array of GCS, flight controllers and additional microcontroller loads to send and get messages. A heartbeat message is used for the D of the Arduino Uno. The explanation for the Heartbeat message is the identification of two subsystems and the creation of a mutual partnership between them. This notification will be continuously transmitted from the Arduino load to the Pixhawk flight controller to illuminate the flight controller that the module crash shirking is indeed intact. If no heart beats were to occur, the flight controller will initiate a safeguard system and warn the GCS of the frustration with the crash shirking process. Figures 48 and 49 display the correct identifying evidence of the impact shirking as a device and the distortion of the person failure of the interchanges. The Pixhawk flight controller must be told of the beginning of the packet, its duration, the schedule number, sending frame D, sending section D (loading up to the Arduino), packet D (heartbeat message s defined as 0), payload and checksum. This data is prepackaged in the Arduino load and sent to the Pixhawk flight controller via serial 1 cable.

CHAPTER 4:

RESULTS AND DISCUSSION

This area covers exploratory tests performed to demonstrate the flight abilities of quadcopters and the execution of the crash shirking frame. The exploratory experiments was mainly conducted on flight testing to illustrate the two common modes of operation: settle and height lock.A deliberate methodology is used for the impact avoidance framework, which first attempts the parts independently, then the interchanges and finally the MAV framework, through ground tests and flight tests.

4.1 Evaluation of flight technologies and performance

As shown in a few lines, the F450 quadcopter 's flight capabilitiesshould be tested later on when the crash evasion framework is updated.

4.1.1 Stabilize flight mode

Now in Segment 4, the vehicle automatically settle down due to IMU sensor reading and adjusts its course just under the pilot needed turn, twist, throttle and lagoon contributions. Once the auto was completely calibrated, external flights were carried out. At first the car was awful as planned, because it wasn't able to float for those seconds.

This issue has been overcome by testing the PID limits in the ground control center, which can be controlled. The PID controllers are the component used by the Pixhawk flight controller toconstantly calculate the error as the difference of the deal yield factors with the sensor estimates. Despite this disparity, the inspectors submit corrections dependent on subjective, required and subordinate terminology. The figure below shows the suggested PID limits on the official website of Ardupilot [41].

Figure 4. 11: PID recommended parameters [41]

The performance of the quadcopter flight was slowly enhanced as these characteristics were fixed.Numerous flight tests were carried out and documented in order to verify the stability. Note that strength during flight was important to demonstrate the ability to evade crash in flight. In order to lawfully transmit beats and yields slipped by details to the Arduino microcontroller, ultrasonic field finders need a fairly steady drift.

4.1.2 Altitude hold mode

The height keep flight mode functions exactly to the equilibrium flight mode for Euler 's sides. The basic distinction is that the flight controller thus manages the choke in order to sustain a set height.

The F450 quadcopter attempted and tested this flight mode. The primary definition had an alternative flight mode to illustrate the mechanism for evasion. Segment 3 clarified the phase of the evasion of impact. A significant concern arose as the car flips or turns. The lifting power is not in line with the z-hub at this point and the Auto tumbles down. Once the lifting mode is initiated, the auto will hold its height up, freely from the pitch or push movements. Throughout this case, the avoidance action will be carried out at a set height.

In specific, altitude keep mode was attempted without the inclusion of the crash shirking system.Overall , the findings were satisfactory, given some usual problems.

As stated above, the auto holds the height depending on the pressure readings of the gage within the Pixhawk device.It is a big and big drawback. Once the flight controller is introduced to the propeller washing correctly, the internal gage is subjected to adjustments in the vibration that annoy the flight controller, allowing t to move between the range between one to two metres. This issue can be addressed by finding the Pixhawk flight controller between the dispersion plate and the top connection plate. That way, the propeller wash impact does not theoretically influence the flight controller as it is assured. This solution was attempted, yet another issue arose. The separation between the upper and the base plate is not very large and the flight controller has been tapped quite strongly.This led to a significant vibration transmission of the flight controller during flight tests. Vibration in the flight controller is by no means attractive. We cause the car to travel with a variety of motions and shake odd gestures, and make it literally wild.

It is suggested to react to the successful flight mode of working altitude in the quadcopter employed during this undertaking. The flight controller will continue in its current state, led up by a padding scrub and the upper contact to assimilate the vibrations. A small case could be printed to be fittedto the F450 pack to remove the propeller wash effect. That will clarify the propeller wash impact and at the same time protect the flight controller from future accidents because it is shielded. This structure resides in the work to be performed on this quadcopter in future.

4.2 Component testing and results

The segments which are the protection of obstacles must first be isolated in order to test their effectiveness before co-ordinating them through the rest of the quadcopter.

4.2.1 HC-SR04 Ultrasonic range finders

Four finders were obtained from the ultrasonic spectrum to the quadcopter. The chosen versions of the finders relied primarily on the expense. HC-SR04 is the cheapest finder on the market. I see that a financial plan is one relevant necessity and confines to the advancement of this undertaking.

Right off the bat, after the wiring drawing depicted, the range finders were independently attempted to halt the Arduino Uno microcontroller module. An Arduino software was created to intentionally isolate the sequential monitor. It should be noted that the nature of the ultrasonic sensors is a fundamental requirement for the display of the impact avoidance framework. Several sensors displayed no separations as they attempted separately. Upon contemplating this information, over four HC-SR04 have been acquired to select the best exhibitions alone.

The research strategy of the pioneers of the ultrasonic range is clear. The accompanying Arduino IDE screen should allow the sensors to intentionally split.This undertaking is modified with the Serial.write) (function in the language.A wooden rectangular façade was used as a snack and was slowly withdrawn and gravitated to the sensors in order to test the correct separation reaction in the sequential panel. The figure indicates the cm separations in the Arduino IDE after showing.

Figure 4. 12: Prompted distances (cm) from the four ultrasonic range finders

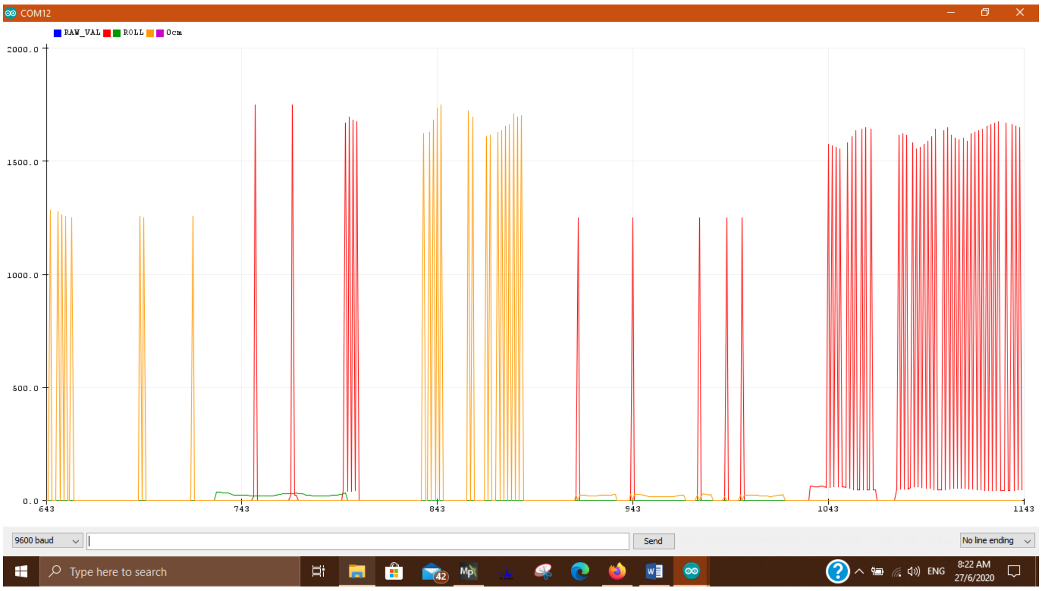


Figure 4. 13: Distance sensing through the serial plotter

4.2.2 Arduino Uno

Arduino Uno has implemented a miniaturized scale device in the MAV system adopting the design of wiring of the flight controller. Legitimate driving was tested while checks were conducted on the HC-SR04 region discoverers on the quadcopter. This test was done simply to flexibly ensure the appropriate force in all segments of the Framework for Impact Evasion.

4.3 MAVLink communication testing and results

A software was developed to transmit heartbeat messages from Arduino Uno to the Pixhawk flight controller continuously. The utility of such MAVLink messages is that the communication between Arduino and Pixhawk flight controller is constantly being controlled. The UAS frameworks screen shown in the APM Planner GCS programming is an advisory to test that the link has been developed and whether the Arduino Uno is dentified by the ground control station as another US system. Any complications appeared to precede positive communications. A ability called mavlink msg heartbeat pack was sent to deliver a Heartbeat alert.This ability has a mavlink library and its data sources are mentioned in Table 2.1. The inputs of Machine D, Part D and Message D are extremely skeptical to learn. They have a definition that relies on the different components that form the UAS. This count relies primarily upon the equipment segments being used and instead determines how correct quality are being applied, uniquely as both records are formed through communication, and nothing alerts the clarification.

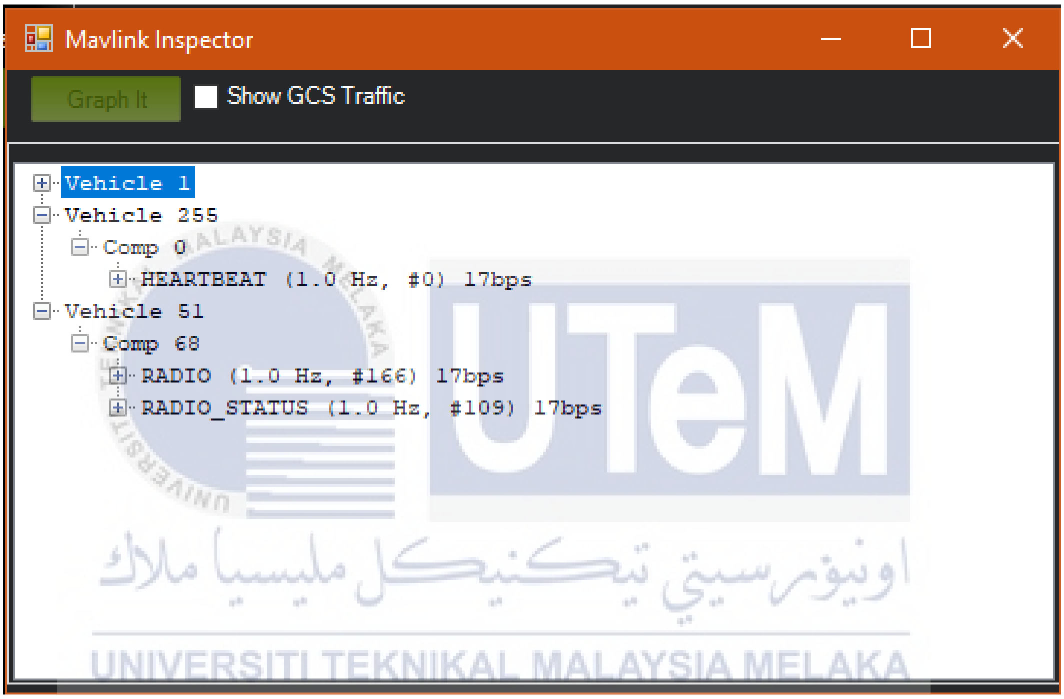


Figure 4. 14: MAVLink inspector

4.4 Obstacle collision avoidance ground tests

Such field experiments have been carried out to show the reliability of the accident accident case. In this way, flight execution can be assessed and the flight tests do not show a crash-shirking framework for first time, which could lead to deception and emotional consequences for the true honesty of the quadcopter.

4.4.1 Field test Crash Avoidance device

The Arduino code for primary crash evasion was tested on the ground before the flight test. Note that the ride can be replicated by retaining and pushing the car into a space physically, warding it off and positioning it between the dividers. The knowledge is gathered by the sensors and treated within the Arduino microcontroller module, which sends a pitch and transfers corrections to the aircraft controller. The automaton is disabled during these tests. It is difficult to determine whether or not the test results.

There is a likelihood in any case to check whether the Arduino microcontroller board yields changes to pitch and roll. It is by checking the contributions and changing the following screen usefulness of the Arduino IDE. To test the implemented Arduino system, Arduino must be connected to the PC with a USB device. The automatic development is therefore limited by the length of the wire. There is ample engineering potential to place the car in a few good ways from a splitter and test if instructions are received.

During this test, the customer should always hold the automaton over a height of one meter. Nothing more can not be achieved to identify an even state and no pitch or roll output is incited in the following frame.

The four codes on the four car sides have been inserted into the Arduino and victories have been acquired. Throughout the following screen of the Arduino, real PWM values relevant to pitch and shift were triggered as shown by the distinction between the auto and a splitter. During the time the automaker was put under a height of 1 meter from the air, there were no PWM signs to pitch and switch channels. Consequently, the foundation elevation point was also filled in.

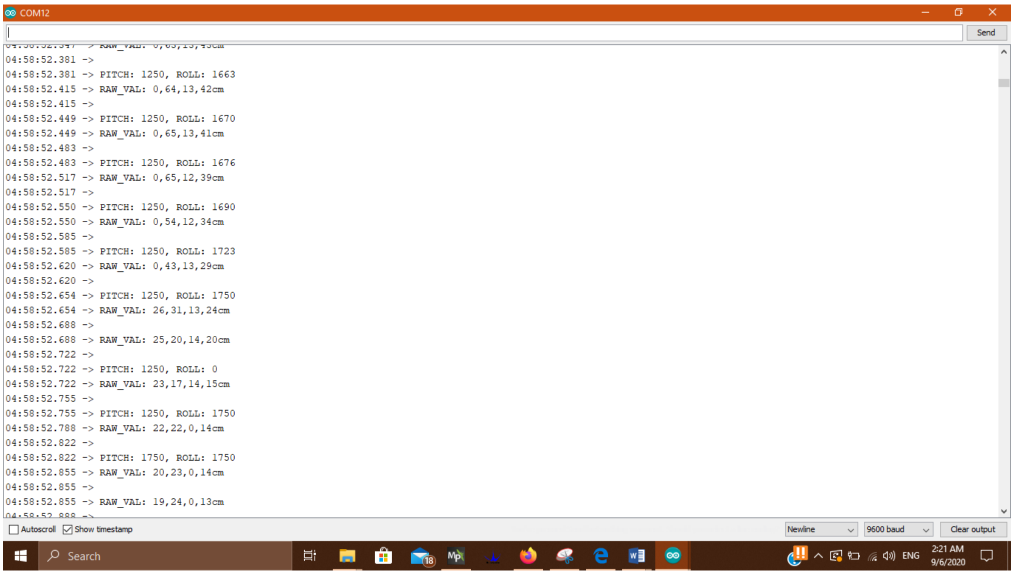


Figure 4. 15: Prompted PWM commands

Figure 4. 16: Original PWM

Figure 4. 17 Front sensors detected

Figure 4. 18 Right sensors detected

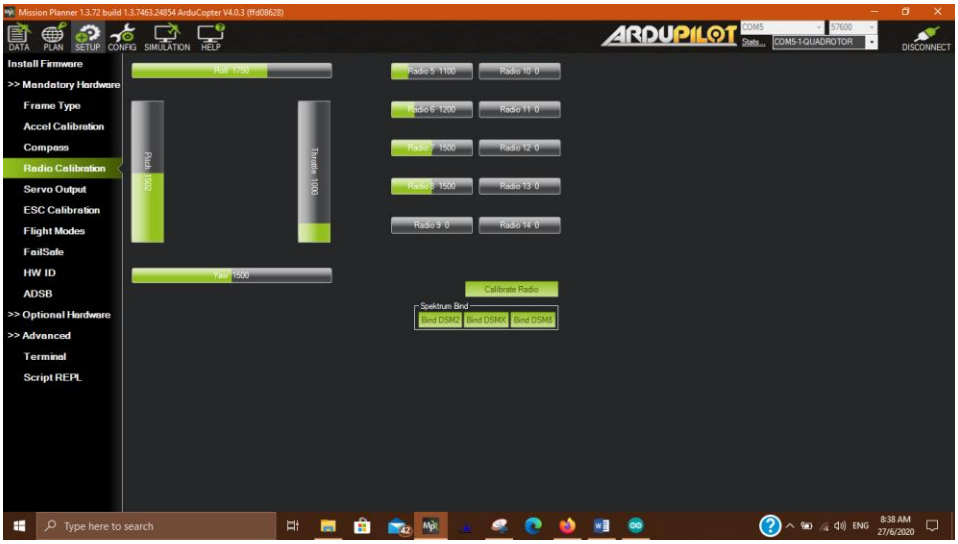


Figure 4. 19 Left sensors detected

Figure 4. 20 Back sensors detected

CHAPTER 5:

CONCLUSION

Throughout this mission, the basic framework of a collision avoidance scheme was developed, integrated into a good quad copter and tried in realistic scenarios for unmanned aerial vehicles with a Pixhawks flight controller. In order to film the flat state a strategic distance from the anticipated collisions, four ultrasonic Finder sensors have been integrated into the F450 quadcopter.

5.1 Conclusion extracted

In general, the accompanying ends can be removed:

Already best-in - class and emerging developments render crash evasion a feasible technique that can be integrated into unmanned aircraft. The shirking calculation can be done with the programming capability, but it has been seen in this assignment that important skills in the Arduino language are required to prove the concept of crash evasion.

MAVLink correspondence convention is a huge and helpful device for the execution of any kind of drone capability, the earlier similarity of devices segments. Helpful functions can be executed to improve automaton execution, such as rescue search, review and security in applications.

In reality, hardware capabilities will limit the view of unmanned airborne car frames. Due to its modest cost, the HC-SR04 Ultrasonic Finder sensors were selected in this project. We had major limitations on the precision of the calculations because certain flight tests were not effective. Communications between subsystems are a major and necessary activity to develop expertise in higher-level vehicle environments correctly. MAVLink communications was complicated in this undertaking betweenthe Arduino microcontroller board and the Pixhawk flight controller. MAVLink is a convention of communication that covers the end purpose of exchanging data between unmanned aeronautical vehicle sets, which are constantly updated and ongoing libraries are created by clients. Nonetheless, there are very few displaying properties that can be accessed to get a place from which to start making. Further improvement will be made in this respect.

Hardware resemblance is also a basic viewpoint that should be explored for autonomous airborne vehicles before selecting the hardware. The correspondence between the Arduino microcontroller, the ultrasonic range finders and the Pixhawk controller was checked before a shot was taken.To order to obtain outcomes, systematic approach is necessary to the research stage. Especially for drones, where manipulation may vanish from the considerable faith of a testing process, land based training for the program is necessary to insure that interchanges and installation of subsystems are planned. Ultimately, through this mission, a standard was developed on which more enhancements and innovations were implemented to create a increasingly stable and secure crash evasion environment.

5.2 Plan for the future

During the creation of this undertaking, only evidence of the concept of a system for evasion of fundamental effect was checked.There are still numerous enhancements and thoughts related to products and equipment. Some of them are listed here:

• In this endeavor, two flight modes were demonstrated: balanced flight mode and height keep flight mode. High flight modes will be a considerably more effective way to check the shirking system as correcting a height stops the vehicle from tumbling to the ground as pitch and push redresses are crossed. Throughout the test process, the height keep flight mode provided a big question. The propeller wash impact has distorted the flight controller gauge 's weight readings and caused it to travel between a range between 1 and 2 meters. A better solution would be to print a sheet to protect the flight controller and to avoid this.

• Calculation of the effect of evasion has actually grown to be checked on one side of each flight test. More Arduino programming advancements could require the four parallel sensors to demonstrate flight tests simultaneously. It will build changes to what can be stopped and eventually nuanced paths. It will trigger a 360 ° horizontal effect avoidance poof of the design.

• The finders in the ultrasonic spectrum will be stored more effectively on the auto board. They are essentially tapped with versatile classes. This caused troubling vibrations during flight which could lead to deception in separation readings.

• Software updates to the system may be performed. Better procurement of ultrasonic finder sensors will encourage increasingly successful display of evasion impacts.

• However, the effect shirking activity stage should be strengthened. Thanks to the isolation of impediments, gradually precise edge measurements will be feasible. With the new shirking Arduino system, the automaton typically responds by extremely vigorous motions that enable the vehicle to destabilize and tumble to the ground every now and again. Milder pitch / move remediation will hold the auto in its floating position and allow the power transfer to the pilot an feasible undertaking.

APPENDICES

Project code

```
#include <NewPing.h> #include <SoftwareSerial.h> #include
"C:\Users\norha\Documents\Arduino\libraries\mavlink\comm
on\mavlin k.h" #define RANGE 60

SoftwareSerial mySerial(10, 11); /// RX, TX NewPing
SONAR_0(8, 8, 100); /// Front NewPing SONAR_1(7, 7, 100);
/// Right NewPing SONAR_2(6, 6, 100); /// Back NewPing
SONAR_3(5, 5, 100); /// Left

unsigned long HeartbeatTime = 0; int PITCH = 0, ROLL = 0,
Pt = 0, Rt = 0;

struct Sensors { int RAW_VAL[5] = {0}, DISTANCE = 0;
bool DETECT = false; }Sensor[4];

void setup() { Serial.begin(9600);
mySerial.begin(57600); }

void loop() { if ( (millis() - HeartbeatTime) > 1000 ) {
HeartbeatTime = millis(); SEND_HEART_BEAT(); }
READ_SENSOR(); BUILD_MAVLINK_DATA(); }

void READ_SENSOR() { for (uint8_t i = 0; i < 4; i++)

Sensor[i].RAW_VAL[4] = Sensor[i].RAW_VAL[3], Sensor[i].
RAW_VAL[3] = Sensor[i].RAW_VAL[2], Sensor[i].RAW_VAL[2]
= Sensor[i].RAW_VAL[1], Sensor[i].RAW_VAL[1] =
Sensor[i]. RAW_VAL[0];

Sensor[0].RAW_VAL[0] = SONAR_0.ping_cm();
Sensor[1].RAW_VAL[0] = SONAR_1.ping_cm();
Sensor[2].RAW_VAL[0] = SONAR_2.ping_cm();
Sensor[3].RAW_VAL[0] = SONAR_3.ping_cm();

for (uint8_t i = 0; i < 4; i++) { int SUM = 0, COUNT =
0; for (uint8_t j = 0; j < 5; j++) if
(Sensor[i].RAW_VAL[j] != 0 && Sensor[i].RAW_VAL[j] < 70)
SUM += Sensor[i].RAW_VAL[j], COUNT++;

if (COUNT > 3) Sensor[i].DISTANCE = SUM / COUNT; else
Sensor[i].DISTANCE = 0;
```

```
if (Sensor[i].DISTANCE != 0 && Sensor[i].DISTANCE <
RANGE) Sensor[i].DETECT = true; else Sensor[i].DETECT =
false; }

Serial.print("\nRAW_VAL: ");
Serial.print(Sensor[0].DISTANCE); Serial.print(",");
Serial.print(Sensor[1].DISTANCE); Serial. print(",");
Serial.print(Sensor[2].DISTANCE); Serial.print(",");
Serial.print(Sensor[3].DISTANCE);
Serial.print("cm\n\r");

}

uint8_t N = 0; void BUILD_MAVLINK_DATA() {

CALCULATE_PITCH();

CALCULATE_ROLL();

if ( PITCH != Pt || ROLL != Rt ) Pt = PITCH, Rt = ROLL,
SEND_DATA(PITCH, ROLL);

}

void CALCULATE_PITCH() {

if(Sensor[0].DETECT && Sensor[2].DETECT &&
Sensor[0].DISTANCE < Sensor[2].DISTANCE ) //// FRONT +
BACK, FRONT < BACK PITCH = STICK( Sensor[0].DISTANCE, 1
); else if(Sensor[0].DETECT && Sensor[2].DETECT &&
Sensor[0]. DISTANCE > Sensor[2].DISTANCE ) //// FRONT +
BACK, FRONT > BACK PITCH = STICK( Sensor[2].DISTANCE, 0
); else if(Sensor[0].DETECT && !Sensor[2].DETECT) ////
FRONT ONLY PITCH = STICK( Sensor[0].DISTANCE, 1 ); else
if(!Sensor[0].DETECT && Sensor[2].DETECT) //// BACK ONLY
PITCH = STICK( Sensor[2].DISTANCE, 0 ); else PITCH = 0;
//// NOTHING }

void CALCULATE_ROLL() { if(Sensor[1].DETECT &&
Sensor[3].DETECT && Sensor[1].DISTANCE <
Sensor[3].DISTANCE ) //// RIGHT + LEFT, RIGHT < LEFT
ROLL = STICK( Sensor[1].DISTANCE, 0 ); else
if(Sensor[1].DETECT && Sensor[3].DETECT && Sensor[1].
DISTANCE > Sensor[3].DISTANCE ) //// RIGHT + LEFT, RIGHT
> LEFT ROLL = STICK( Sensor[3].DISTANCE, 1 ); else
if(Sensor[1].DETECT && !Sensor[3].DETECT) //// RIGHT
ONLY ROLL = STICK( Sensor[1].DISTANCE, 0 ); else
if(!Sensor[1].DETECT && Sensor[3].DETECT) //// LEFT ONLY

ROLL = STICK( Sensor[3].DISTANCE, 1 ); else ROLL = 0;
//// NOTHING }
```

```
int STICK( int VAL, bool DIR) {

VAL=constrain(VAL, 30, 60); if(DIR) return map(VAL, 60,
30, 1550, 1750); else return map(VAL, 60, 30, 1450,
1250); }

//==============================MAVLINK===================
=======// mavlink_message_t msg; uint8_t
buf[MAVLINK_MAX_PACKET_LEN]; uint16_t len;

void SEND_HEART_BEAT() { mavlink_msg_heartbeat_pack(255,
0, &msg, MAV_TYPE_QUADROTOR, MAV_AUTOPILOT_GENERIC, 0,
1, 0); // System ID = 255 = GCS len =
mavlink_msg_to_send_buffer(buf, &msg);

mySerial.write(buf, len); }

void SEND_DATA(int P, int R) {
mavlink_msg_rc_channels_override_pack(255, 0 , &msg, 1,
0, R, P, 0, 0, 0, 0, 0, 0); // CHANNEL = 1(ROLL),
2(PITCH), 3(Throttle), 4(Yaw) , 5, 6, 7, 8 len =
mavlink_msg_to_send_buffer(buf, &msg);

mySerial.write(buf, len); Serial.print("\n\rPITCH: ");
Serial.print(P); Serial.print(", "); Serial.print(" ROLL:
"); Serial.print(R);

}
```

REFERENCES

[1] Andrew R Lacher, David R Maroney, Andrew D Zeitlin, et al. “Unmanned aircraft collision avoidance–technology assessment and evaluation methods”. in: FAA EUROCONTROL ATM R&D Symposium, Barcelona, Spain. 2007.

[2] Javier Lloret. Introduction to Air navigation. Create Space, 2016.

[3] Bijan V Darryl J. “The economic impact of unmanned aircraft systems integration in the USA”. In: 2013.

[4] Dane Bamburry. “Drones: Designed for product delivery”. In: Design Management Review 26.1 (2015), pp. 40–48.

[5] Real Decreto 1036/2017. Ministerio de la presidencia y para las administraciones territoriales, Dec. 2017.

[6] Salario: ingeniero Junior en Espan˜a. url: http://espana.jobtonic.es/salary/26526/74925.html (visited on 06/02/2018).

[7] Unmanned Aircraft Systems. International Civil Aviation Organization, Feb. 2016.

[8] M Hassanalian and A Abdelkefi. "Classifications, applications, and design challenges of drones: a review". In: Progress in Aerospace Sciences 91 (2017), pp. 99–131.

[9] Gonzalo Pajares. "Overview and current status of remote sensing applications based on unmanned aerial vehicles (UAVs)". In: Photogrammetric Engineering & Remote Sensing 81.4 (2015), pp. 281–329.

[10] How does LiDAR work? The science behind the technology. URL: http://www.lidar-uk.com/how-lidar-works/ (visited on 06/03/2018).

[11] HDL-32E lidar. Url: http://velodynelidar.com/hdl-32e.html (visited on 03/02/2018).

[12] LeddarOne Single-Element Sensor Module. url: https://leddartech.com/modules/leddarone/ (visited on 03/02/2018).

[13] Sonar working principle. url: https://www.zigya.com/study/book?class=9&board=cbse&subject=science&book=science&chapter=sound&q_type=&q_topic=&q_category=&question_id=SCEN9016176 (visited on 04/02/2018).

[14] MB1010 LV-MaxSonar-EZ1. Url: https://www.maxbotix.com/Ultrasonic_Sensors/MB1010.htm (visited on 03/02/2018).

[15] Samuel S Blackman. "Multiple-target tracking with radar applications". in: Dedham, MA, Artech House, inc., 1986, 463 p. (1986).

[16] PRINCIPALES APLICACIONES DE SISTEMAS DE RADAR. url: http: //elradar.50webs.com/aplicaciones.htm (visited on 02/03/2018).

[17] Copter Object Avoidance. URL: http://ardupilot.org/dev/docs/codeoverview-object-avoidance.html (visited on 02/03/2018).

[18] LightWare SF40/C 100m Laser Scanner 360 SLAM. url: https://www. 3dxr.co.uk/product/lightware- sf40c- laser- scanner/ (visited on 02/03/2018). \

[19] TeraRanger Tower. URL: http://www.teraranger.com/product/terarangertower/ (visited on 02/03/2018).

[20] Frame Class Configuration. Url: http://ardupilot.org/copter/docs/ frame-type-configuration.html (visited on 02/04/2018).

[21] BLDC motor basics. url: https://www.renesas.com/en-eu/support/ technical - resources / engineer - school / brushless - dc - motor - 01 overview.html (visited on 03/04/2018).

[22] Constant Speed Propellers. URL: http://www.dauntless-soft.com/PRODUCTS/ Freebies/Library/books/FLT/Chapter2/Constant.htm (visited on 04/04/2018).

[23] Helice Gemfan fibra de carbono 10x4.5 (pareja) Estilo APC SF. url: http: //www.dauntless-soft.com/PRODUCTS/Freebies/Library/books/FLT/ Chapter2/Constant.htmhttps://rc- innovations.es/Helices- de carbono-aviones-rc-drones-gemfan/helice-fibra-carbono-10x4.5pareja-multicoptero (visited on 05/05/2018).

[24] Pulse Width Modulation with analog write. url: http://robotic-controls. com/book/export/html/57 (visited on 06/04/2018).

[25] Desire power V8 Series 3s 4000mAh 30C. url: https://rc-innovations. es/Baterias-lipo-3s-calidad-drones/desire-power-3s-4000-30cbateria-lipo7 (visited on 03/23/2018).

[26] Pixhawk Overview. Url: https://pixhawk.org/ (visited on 04/21/2018).

[27] Pixhawk clones good/bad. Url: https://discuss.ardupilot.org/t/pixhawkclones-good-bad/9552 (visited on 06/10/2018).

[28] Pixhawk clones good/bad. Url: https://whatis.techtarget.com/definition/ firmware (visited on 05/03/2018).

[29] Arduino. Url: https://en.wikipedia.org/wiki/Arduino (visited on 04/06/2018).

[30] Arduino Mega 2560 REV3. URL: https://store.arduino.cc/usa/arduinomega-2560-rev3 (visited on 03/05/2018).

[31] Telemetry Radio. URL: http://ardupilot.org/copter/docs/common-siktelemetry-radio.html (visited on 02/22/2018).

[32] Flysky FS-i6 AFHDS. url: https://www.tomtop.com (visited on 04/03/2018).

[33] HCSR04. URL: http://www.cordobatec.com/producto/sensor-ultrasonicohc-sr04/ (visited on 04/05/2018).

[34] Arduino DE interface. URL: https://www.pololu.com/docs/0J61/6.2 (visited on 03/04/2018).

[35] Flight Modes. URL: http://ardupilot.org/copter/docs/flight-modes. HTML (visited on 03/06/2018).

[36] Stabilize Mode. URL: http://ardupilot.org/copter/docs/stabilizemode.html (visited on 02/05/2018).

[37] RC Hardware What s an RC transmitter? URL: https://www.pololu.com/docs/0J61/6.2 (visited on 04/05/2018).

[38] Ernesto Santana. MAVLink: Protocolo de comunicaci´on para drones. url: http://www.xdrones.es/mavlink/ (visited on 02/02/2018).

[39] System Requirements. URL: http://www.sebokwiki.org/wiki/System_ Requirements (visited on 04/04/2018).

[40] David Morante Manuel Soler Xin Chen Gonzalo S´anchez. Quadcopter assembly laboratory. University Carlos II of Madrid. 2016.

[41] Advanced Tuning. URL: http://ardupilot.org/copter/docs/tuning.html (visited on 02/06/2018).

[42] Obstacle alert and collision avoidance system development for UAVs with Pixhawk flight controller. University Carlos II of Madrid. 2018.