A Major Project Report

ON

DESIGNING OF DRONE FOR CAPTURING OF VJIT AND ANALYSING ITS LIVE VIDEO USING DEEP LEARNING FRAMEWORK

Submitted in partial fulfillment for the Degree of B.Tech.

In

Artificial Intelligence

by

Janmanchi Snigdha (19911A3521)

Mangali Yagnesh (19911A3531)

V Sri Datta Bharadwaj (19911A3552)

Under the guidance of

Dr. A. Obulesh

HOD-Department of Artificial Intelligence

DEPARTMENT OF ARTIFICIAL INTELLIGENCE

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)

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DEPARTMENT OF ARTIFICIAL INTELLIGENCE

CERTIFICATE

This is to certify that the project report **“Designing of Drone for capturing of VJIT and analysing its live video using Deep Learning Framework”** submitted by **J. Snigdha (19911A3521), M. Yagnesh (1911A3531)** and **V Sri Datta Bharadwaj (19911A3552)** to Vidya Jyothi Institute of Technology (Autonomous), Hyderabad, in partial fulfillment for the award of the degree of **B. Tech. in Artificial Intelligence** a bonafide record of project work carried out by us under my supervision. The contents of this report, in full or in parts, have not been submitted to any other Institution or University for the award of any degree.

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Dr. A. Obulesh	**Dr. A. Obulesh**
Supervisor	**HOD**
Department of Artificial Intelligence	**Department of Artificial Intelligence**

DECLARATION

We declare that this project report titled report **"Designing of Drone for capturing of VJIT and analysing its live video using Deep Learning Framework"** submitted in partial fulfillment of the degree of **B. Tech. in Artificial Intelligence** is a record of original work carried out by under the supervision of **Dr. A. Obulesh, HOD-AI** and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in reporting scientific information, due acknowledgments have been made wherever the findings of others have been cited.

Janmanchi Snigdha - 19911A3521

Mangali Yagnesh - 19911A3531

V Sri Datta Bharadwaj - 19911A3552

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Janmanchi Snigdha - 19911A3521

Mangali Yagnesh - 19911A3531

V Sri Datta Bharadwaj - 19911A3552

ABSTRACT

Drone is defined as an Unmanned Aerial Vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expandable or recoverable, and can carry a lethal or nonlethal payload. It is controlled either autonomously by on-board computers or by remote control of a pilot on the ground. A Drone has been built that can be operated by radio frequency controller. Micro-controller based drone control system has also been developed where a RF transmitter and receiver operating in the frequency of 2.4 GHz are used for remote operation for the Drone. In addition, using an Android mobile device incorporation with GPS has been used for live position tracking of Drone. The developed drone in this work can be used for a number of applications, such as shipping and delivery, Surveillance, Agricultural usage, Weather forecasting, Disaster management and many more.

The basic Drone includes a frame, flight control board, motors, electronic speed controllers, a transmitter, a receiver, Lipo battery, propellers. Individual components were tested and verified. Tuning and calibration of the proportional–integral–derivative (PID) controller were done to obtain stabilization on each axis. This work aimed to design a quad copter that will try stable its position according to preferred altitude. Also here stability check has been done with pitch and roll. Currently, the drone can properly stabilize itself. The data captured by drone is now classified by using Deep Learning YOLO V5 framework. This works by analysing the data into different categories such as vehicles (2 wheelers and 4 wheelers), pedestrians (Humans) and provides the count of each category. Drones are becoming increasingly popular tools for gathering information and conducting surveillance in a wide range of applications, including on college and university campuses. By using drones equipped with integrated cameras, campus security and management teams can gain a unique and comprehensive view of the campus, including areas that may be difficult or impossible to access using traditional methods.

One major advantage of drones is their ability to move quickly and easily through the air, allowing them to reach areas that might otherwise be difficult or impossible to access. This can be especially useful in large or complex campus environments, where there may be many blind spots or areas that are hard to see from the ground.In addition, drones can be used to gather real-time data and images, providing campus security and management teams with a powerful tool for monitoring and analyzing activity on campus.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

Abbreviations:

APM	: Arduino Pilot Mega
ARES	: Amateur Radio Emergency Service
BLDC	: Brush less Direct Current
CPU	: Central Processing Unit
CSI	: Camera Serial Interface
CSP	: Communications Service Providers
DARPA	: Defense Advanced Research Projects Agency
ESC	: Electronic Speed Controller
FPN	: Feature Pyramid Structure
GPS	: Global Positioning System
GPU	: Graphics Processing Unit
HDMI	: High Definition Multimedia Interface
HDR	: High Dynamic Range
IoT	: Internet of Things
IPv4	: Internet Protocol version 4
LiPo	: Lithium Polymer
NMS	: Network Management System
PID	: Proportional Integral Derivative
RF	: Radio Frequency
TCP	: Traffic Uses Port
UAV	: Unmanned Aerial Vehicle
USB	: Universal Serial Bus
VTOL	: Vertical Take-off and Landing
YOLOv5	: You Only Look Once Version 5
YOLOv7	: You Only Look Once Version 7

CHAPTER 1

INTRODUCTION

1.1 Introduction

Unmanned aerial vehicles, or drones, are sophisticated flying robots that can operate without the need for a human pilot on board. They are typically equipped with a range of advanced technology, including GPS, sensors, and cameras, that enable them to fly safely and efficiently.Drones can be controlled remotely by a human operator using a handheld device, such as a smartphone or tablet, or a dedicated controller. The operator can see a live video feed from the drone's camera, enabling them to navigate the drone and control its movements in real-time.

Alternatively, drones can be programmed to fly autonomously using pre-determined software-controlled flight plans. These plans take into account the drone's location, speed, altitude, and other parameters, enabling it to fly a specific course or perform a particular task.Most drones are designed with four arms and fixed pitch propellers, which provide lift and propulsion for the vehicle. The propellers are connected to electric motors that are powered by a battery, which typically provides enough power for a flight time of up to 30 minutes.

In recent years, the manufacture and sales of drones have seen a massive growth, as these versatile vehicles have proven useful in a wide range of applications. Drones are commonly used in aerial photography and videography, surveying and mapping, search and rescue operations, agricultural monitoring, and environmental monitoring, among other applications.

They are sometimes referred to as Quad-copters, Drones or Quadcopters. In the standard format two propellers will spin in a clockwise direction with the other two spinning in an anticlockwise direction allowing the craft to vertically ascend, hover in the air and fly in a designated direction.

The Drone is a simple format with very few moving parts and has rapidly become a favorite vehicle for remote control enthusiasts and is widely being used as an effective Aerial photographic platform. A large majority of the Drones were originally built by hobbyists who understood the simplicity of the vehicle. By adding four motors and four propellers to a lightweight frame constructed of carbon fiber then connecting it to a remote control transmitter via a small control board fitted with a gyroscopic stabilization system and connected to a Lipo battery these craft were relatively simple to construct. Experimentation has led to the configuration of variations of the Quadcopter by using different amounts of arms we have seen Tricopters, Hex copters and Octocopters (with eight arms). Other configurations include a V tail and an H frame variation

The rapid advances in computing power, the efficiency of the core-less or brushless motors, smaller microprocessors the development of batteries and gyroscopic and accelerometer technology has all led to a proliferation of Drone designs. Micro and even Nano Quadcopters are being produced mainly in China that can perform intricate aerobatic moves, flips and barrel rolls that years ago would have been unthinkable. Chinese companies like Hubsan have made tiny Nano Drones. Drones differ from conventional helicopters which use rotors which are able to vary the pitch of their blades dynamically as they move around the rotor hub.

In the early days of flight, quadcopter (then referred to as 'drones') were seen as possible solutions to some of the persistent problems in vertical flight; torque-induced control issues (as well as efficiency issues originating from the tail rotor, which generates no useful lift) can be eliminated by counter-rotation and the relatively short blades are much easier to construct.

As UAV technology continues to evolve, camera equipped UAVs or general-purpose drones have been rapidly deployed for various applications, including agriculture, aerial photography, public safety, ecological protection, and more. Therefore, the requirements for an intuitive understanding of visual data collected from these platforms are getting higher and higher. Object detection technology based on deep learning is more and more closely applied to UAVs.

1.2 Issues

Issues of drones can be classified in different ways like morally, ethically and legally. In many country's drone is not permitted to fly openly, but in some advance country is now allowing drone for social purposes. Also there is a build up a decent drone marketplace in Singapore but from ethical point of view it has some conflict using drone. Military drone manufacturers are also looking for an upgrade civilian uses for remote sensing drones to spread their markets and this includes the use of drones for surveillance where it's needed. Drones will no doubt make possible the dramatic change in the surveillance state. With the convergence of other technologies it may even make possible machine recognition of faces, behaviors, and the monitoring of individual conversations.

The use of drones for surveillance raises significant ethical, legal, and moral concerns. While there may be some benefits to using drones for surveillance, such as increased public safety and security, the potential for abuse and infringement on civil liberties cannot be ignored.

From a legal perspective, the use of drones for surveillance must comply with privacy laws and regulations, which vary by country and region. In some jurisdictions, the use of drones for surveillance is heavily restricted, while in others, it is largely unregulated. This creates a challenge for law enforcement agencies, who must navigate a complex legal landscape in order to use drones for surveillance.

From an ethical standpoint, the use of drones for surveillance raises questions about the appropriate balance between public safety and individual privacy. While there may be some instances where the use of drones for surveillance is justified, such as in the case of a serious crime, there is a risk that the use of drones will become normalized and accepted as a routine part of law enforcement, even when it is not necessary.

From a moral perspective, the use of drones for surveillance raises questions about the dignity and autonomy of individuals. There is a risk that the use of drones for surveillance will lead to a dehumanization of individuals, reducing them to mere objects to be monitored and controlled. This could have a chilling effect on free speech, association, and other fundamental rights.

Finally, the use of drones for surveillance raises concerns about the potential for abuse by government agencies and other powerful actors. With the convergence of other technologies, such as machine learning and artificial intelligence, it may become possible to monitor and analyze individual behavior on a massive scale, potentially leading to the creation of a surveillance state, while there may be some benefits to using drones for surveillance, it is important to consider the potential risks and consequences. Governments and other organizations must take a thoughtful and cautious approach to the use of drones for surveillance, ensuring that they are used in a way that is consistent with the principles of privacy, autonomy, and dignity.

However, the high altitude at which UAVs fly, the large number of objects in the captured images, and the complex background noise interference between dense objects lead to a significant decrease in detection accuracy. This makes it difficult to detect objects in UAV capture scenes, so it is important to design a method to improve the detection in images.

1.3 Motivation for the work

Many methodologies have been tried to improve real-world aircraft with vertical take-off and landing abilities. First, Nikola Tesla introduced a vertical take-off and landing vehicle concept in 1928. Advanced VTOL aircrafts uses a single engine with thrust vectoring. Thrust vectoring illustrates that the aircraft can send thrust from the engine in different directions, so that vertical and horizontal fight can be controlled by one engine. The Harrier Jump Jet is one of the most famous and successful fixed-wing single-engine VTOL aircraft. In the 21st century, UAVs are becoming progressively conventional. Many of these have VTOL capability, especially the quad copter type. We were also interested by the requirements of DARPA's UAV forge, while studying large and tiny UAVs competition which was posted around the time we started our project[2]. The UAV forge contest us basically to design and build a micro-UAV that can take off vertically, go to the destination and surveillance the area for three hours.

The DARPA program initiated in 2010 to develop a four-person vertical takeoff and landing vehicle is an example of the military's ongoing efforts to improve transportation and resupply capabilities on the battlefield. Lockheed Martin's Skunk Works group, in collaboration with Piasecki Aircraft, is working to improve the next generation of dynamic vertical takeoff and landing (VTOL) transport systems under the ARES program.

The ARES VTOL flight unit is designed to work as an unmanned platform capable of transferring a variety of payloads. It has built-in digital flight controls, remote command-control interfaces, power system, and gasoline, allowing it to operate autonomously in remote and dangerous environments. The unit is equipped with twin tilting ducted fans, which deliver effective flying and landing abilities in a compact structure. This allows for rapid changes to high-speed travel and efficient transportation of troops and supplies.

The project has similarities with Lockheed Martin's research in that it also involves the use of a VTOL system for transportation. While the methodology may be partially similar, it is important to note that there may be differences in terms of design, capabilities, and intended use[6]. Furthermore, as the ARES program is still under development, it is unclear how the final product will ultimately compare to your project, the ongoing efforts by the military and private companies to improve transportation and resupply capabilities on the battlefield are critical for the safety and success of troops. While your project may draw inspiration from similar research, it is important to carefully consider the unique needs and constraints of your project and to develop solutions that are tailored to those specific requirements.

On the other hand, using drone in firefighting has already been taken place in history. An unmanned Predator B aircraft helped firefighters and saved many lives in 2007 in southern California. It delivered firefighters up-to-the-minute information.

In addition to the military practices of the drones, we were concerned in evaluating applications in the industrial, commercial and as well as government sector. In addition, new markets and uses will emerge if small drones are very available. Potential new markets in business and modern applications incorporate reviewing pipelines or actually investigating perilous regions like an emergency site at an atomic force plant. Harvest evaluation or natural disaster aid seems also to be possible areas where small drones could be beneficial. Although the designs of different UAVs are charming, our interest was in attempting to produce a small UAV which could support a broad mission capability.

1.4 Objective

As has been already stated in the abstract, this thesis is turning around an unmanned flying vehicle called drone.The development of an appropriate mathematical model and control architecture is critical to achieving vertical flight with stability for a drone. This requires a deep understanding of the physics and dynamics of the drone, as well as the ability to design and implement an effective control system.

One advantage of an electric-powered drone is its low power consumption, which makes it more efficient and environmentally friendly compared to other aerial vehicles such as helicopters. This is particularly important for applications that require the drone to operate for extended periods of time, or in areas where noise and emissions must be minimized.

The small size of the drone also enables it to hover in tiny spaces, making it useful for a wide range of applications such as surveillance, inspection, and search and rescue. This is particularly valuable in environments where larger aerial vehicles are unable to operate effectively. The development of an efficient and stable electric-powered drone has significant potential for a wide range of applications, particularly in situations where safety, efficiency, and environmental impact are critical factors. The use of an appropriate mathematical model and control architecture is essential to ensuring the safe and effective operation of the drone, and will be critical to its success in real-world applications.

Object feature extraction and fusion of existing detection methods are critical for accurate detection of objects in aerial remote sensing images. However, there is still room for improvement in this area, particularly when it comes to avoiding the loss of feature information, which can result in a decrease in detection accuracy.One of the key challenges in object detection in aerial remote sensing images is the large size of the images. When the feature of a tiny object is easily covered by the feature of a larger object, this can lead to a reduction in detection accuracy. If the detection algorithm places too much emphasis on larger objects, it may miss smaller objects entirely, leading to a significant reduction in overall detection accuracy.

To address this challenge, researchers are exploring new approaches to object feature extraction and fusion that are designed to minimize the loss of feature information and ensure that small objects are not overlooked. This may involve the use of machine learning algorithms that are specifically designed to identify and extract features from small objects, or the development of new detection methods that are optimized for the unique challenges of aerial remote sensing.As well as improving object feature extraction and fusion in aerial remote sensing images is critical for ensuring accurate detection of objects, particularly in situations where small objects are present. By developing new approaches to this challenge, researchers can help to improve the accuracy and reliability of object detection in aerial remote sensing images, with important implications for a wide range of applications, from disaster response to environmental monitoring and more

1.5 Organization of the project

This paper is organized into five major parts, each of which provides a detailed examination of different aspects of drones and their applications.

Chapter 1 serves as an introduction to the topic of drones, providing a brief history of their development and an overview of their various uses and applications. This chapter also includes a detailed review of the current state of drone technology and its potential for future development.

Chapter 2 focuses on the existing literature and surveys related to drones, providing an in-depth analysis of the current state of research and development in this area. This chapter covers a range of topics related to drones, including their design, construction, control systems, and applications.

Chapter 3 provides a detailed overview of the development and construction of the drone, including a discussion of the various components and subsystems that make up the system. This chapter also includes a detailed discussion of the control system and simulation results of the Deep Learning Framework (YOLO V5), which is used to help guide the drone in flight.

Chapter 4 focuses on the results and discussions related to the applications of drones. This chapter covers a range of topics, including the use of drones in agriculture, surveying, environmental monitoring, and disaster response. The chapter provides a detailed analysis of the potential benefits and limitations of using drones in these applications.

Chapter 5 provides a conclusion and summary of the key findings of the paper, as well as a discussion of the limitations and future directions of research in this area. Overall, the paper provides a comprehensive examination of drones and their applications, drawing on a range of different sources and methodologies to provide a detailed analysis of this important technology.

Chapter 6 provides a detailed explanation of hardware construction of the drone and software installation including the controlling of the drone.

Finally, **Chapter 7** presents details regarding the sources and references that were consulted for creating the drone project, as well as the technological tools and methods employed for conducting the analysis.

CHAPTER 2

LITERATURE SURVEY

2.1 Introduction

The performance of a quadcopter is closely related to the performance of its propellers, as the propellers are responsible for generating the lift and thrust necessary for flight. There have been many studies in the literature that investigate the performance of propellers for various applications, including aviation, marine transportation, and wind turbines. However, the number of studies specifically focused on quadcopters is limited.

In order to understand the performance of propellers for quadcopters, it is important to determine the thrust force generated by the propellers. This requires a thorough understanding of the aerodynamics of the quadcopter system and the forces acting on the propellers during flight. Studies that focus on the determination of thrust force for quadcopters are therefore important for gaining insight into the performance of these systems.

The literature survey conducted for this paper includes studies that investigate the performance of propellers for quadcopters from a variety of perspectives, including analytical, numerical, and experimental methods. The studies included in the survey provide valuable insight into the design and optimization of propellers for quadcopters, as well as the performance of these systems under different operating conditions. The limited number of studies focused specifically on quadcopter propeller performance highlights the need for further research in this area. By gaining a better understanding of the performance of propellers for quadcopters, it may be possible to design more efficient and effective quadcopter systems for a variety of applications.

2.2 Aerodynamics of propellers

Quadrotors are a type of multirotor aerial vehicle that are commonly used for various applications, including aerial photography, surveying, and inspection. They are made up of four propellers, each consisting of two or more blades and a central hub that fits directly onto the motor rod[1]. The propellers are arranged in a cross shape, with two propellers rotating clockwise and two rotating counterclockwise.

When the motors spin the propellers, a force is generated by the blades pushing air downwards, creating lift. This lift force is used to counteract the force of gravity and lift the quadrotor off the ground. By varying the speed of the motors and the pitch of the propeller blades, the quadrotor can be controlled in three dimensions: roll, pitch, and yaw.

The lift generated by the propellers is proportional to the square of the rotational speed of the blades, and is also affected by the angle of attack and the size and shape of the blades[1]. The thrust generated by the propellers is also affected by the motor power and efficiency, as well as the weight and aerodynamics of the quadrotor itself.

In order to achieve stable flight, quadrotors require a sophisticated control system that adjusts the speed and pitch of the propellers in response to changes in the quadrotor's orientation and position. This control system typically uses sensors such as accelerometers, gyroscopes, and barometers to measure the quadrotor's motion and orientation, and adjusts the motor speed and propeller pitch accordingly. The design and performance of the propellers are crucial to the performance of a quadrotor, as they directly affect the vehicle's lift and thrust capabilities. By understanding the principles of quadrotor propulsion, it is possible to design more efficient and effective quadrotor systems for a variety of applications.

Fig. 2.1 shows the air passing through the propeller which is defined as the free flow of air within the stream tube; the highlighted region of the air outside the area of the stream tube is undisturbed. As the rotational velocity of air is increased, the thrust generated is also increased as a result. Since propellers are the sole generators of aerodynamic loads.

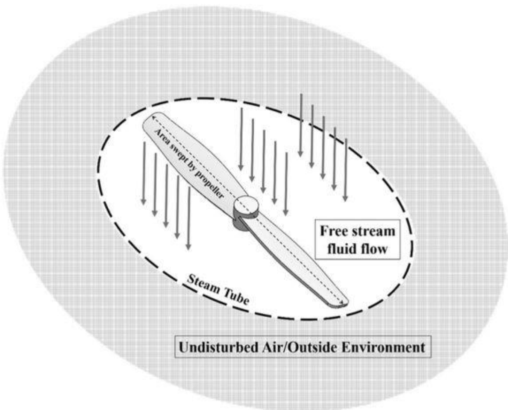

Fig. 2.1: Air flow along the stream tube as the actuator disk rotates during flight.

Choosing the size, weight and material of these components is necessary in order to achieve an efficient flight. For instance, applying a large propeller to an actuator will increase the stream tube size resulting in an increased flight speed but will also consume more power[1]. Thus, the primary task in finding a suitable propeller in Quadrotor aerodynamic design is to firstly find the thrust and drag coefficient of the blades which are generally presented by the manufacturer.

Since propellers are the sole generators of aerodynamic loads. Choosing the size, weight and material of these components is necessary in order to achieve an efficient flight. For instance, applying a large propeller to an actuator will increase the stream tube size resulting in an increased flight speed but will also consume more power. Thus, the primary task in finding a suitable propeller in Quadrotor aerodynamic design is to firstly find the thrust and drag coefficient of the blades which are generally presented by the manufacturer

The thrust and drag coefficients of the propeller blades are crucial in determining the aerodynamic performance of a Quadrotor[5]. These coefficients are generally provided by the manufacturer and are based on a range of factors, such as the blade geometry, material properties, and operating conditions.

Choosing the right size, weight, and material of the propeller is important for achieving efficient flight performance[3]. For example, a larger propeller will generate more lift and increase the flight speed, but it will also consume more power. A lighter propeller will reduce the overall weight of the Quadrotor, which can increase its flight time and maneuverability. In addition to the thrust and drag coefficients, other factors that must be considered when selecting propellers include the pitch, blade count, and rotation direction. The pitch of the propeller determines how much air is pushed by each rotation, while the blade count affects the overall thrust and stability. The rotation direction can also impact the flight stability and control, as well as the efficiency of the propulsion system.

Overall, selecting the right propeller for a Quadrotor requires careful consideration of a range of factors to achieve optimal aerodynamic performance, stability, and efficiency.

2.3 Control Strategies

Although the particular UAV (Quadrotor) presented previously may have several advantages over other UAVs with regard to movement, motion control and price. They do however require a more vigorous adaptive control algorithm in order to effectively stabilize these systems. According to previous studies, many control techniques are being implemented on robotics systems today. With regard to Quadrotors, each control algorithm has a unique method of implementation where some are linear while others are non-linear.

Quadrotors have complex dynamics that are difficult to model and control due to their non-linear nature. Nonlinear controllers are more capable of accounting for these complexities and can operate in a much wider range of operating conditions. They can effectively stabilize the system by accounting for non-linear aerodynamic effects, which can be crucial in unpredictable and unstable environments. However, the theoretical complexity of non-linear controllers can make them challenging to implement and require extensive study to understand their functionality.

On the other hand, linear controllers have a simpler design and are easier to implement. They are effective in stable operating conditions but have limited operation in non-linear regions. The restricted operation of linear controllers can result in unstable flight behavior, making them less suitable for Quadrotors.Therefore, in order to achieve stable and effective control of Quadrotors, it is necessary to use more advanced and adaptive control algorithms, such as non-linear controllers, that can handle the complex dynamics of the system[8]. These controllers require extensive study and may be more challenging to implement, but they offer improved performance and stability in a wider range of operating conditions.

According to previous studies, many control techniques are being implemented on robotics systems today. With regard to Quadrotors, each control algorithm has a unique method of implementation where some are linear while others are non-linear.

In simple terms, linear controllers assume that the relationship between the input and output of a system is linear, which means that a change in the input will result in a proportional change in the output. This assumption makes the design and implementation of linear controllers relatively easy, but it also limits their performance in handling non-linear systems or in situations where the system's operating conditions are beyond the linear range[2]. On the other hand, non-linear controllers can handle a wider range of operating conditions and are able to account for non-linear effects in the system's dynamics, but their design and implementation require a more extensive understanding of the system's behavior and mathematical models, making them more complicated in theory.

In the context of quadrotors or UAVs, the aerodynamics of these systems are highly non-linear due to their complex dynamics, which include non-linear effects such as non-constant thrust, non-uniform drag, and variations in center of mass. Therefore, non-linear controllers are often used in quadrotor applications to account for these non-linear effects and achieve better control performance[4]. However, the design and implementation of non-linear controllers require more complex mathematical models and advanced control techniques such as adaptive control or model predictive control.

2.4 Principles of the Conventional YOLOv5 Detection Framework

The YOLOv5 object detection framework proposed in 2020 by Ultralytics LLC is an improved framework based on the YOLO series. Structurally, it is a one-stage detection framework composed of four units: the Input, the Backbone network, the Neck network, and the Output. After drawing on the advantages of earlier versions of the YOLO series and other detection algorithms, YOLOv5 embeds the Focus layer into the input for data augmentation[10]. Meanwhile, it used the DarkNet53 in the backbone to extract the main features from the image. A feature fusion framework which incorporates the feature pyramid structure (FPN) and the bottom-up Path Aggregation Network is also embedded in the neck network to strengthen the short-circuit linking and cross-layer fusion in multi-scale features. The complete YOLOv5 framework is shown in Figure 1. The four constituent units in the YOLOv5 network are demonstrated as follows:

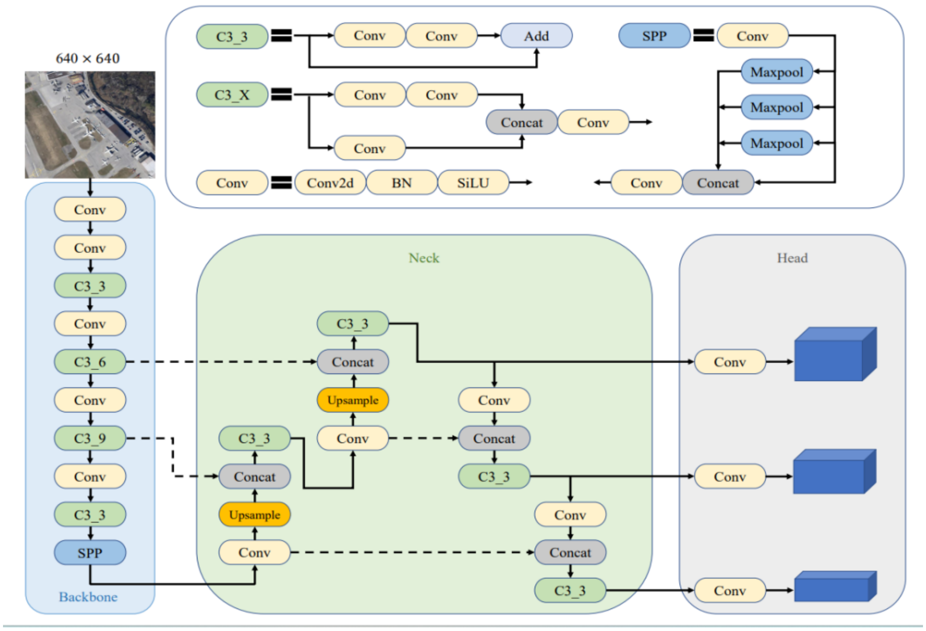

Fig. 2.2:YOLOv5 network framework.

2.4.1 Input

Similar to YOLOv4, YOLOv5 uses the Mosaic module to augment the data. It uses four photographs, thus significantly increasing the amount of data between different pictures. Fusion enhances the detection generalization ability of background information and multi-scale objects and reduces the computational burden. The improved framework adjusts the size of input images to a unified 640 × 640 pixels through the adaptive image scaling module to improve data complexity.

Meanwhile, in the process of network parameter training, the input framework generates the preset anchor box of the object through a K-means adaptive anchor box algorithm, calculates the deviation between the preset anchor and the ground truth box of the object, and update the network weight through the reverse transmission of the fusion framework.

2.4.2 The backbone network

YOLOv5 adopts CSPDarknet53 as the backbone network; the backbone network consists of Focus layer, CSPNet framework and Spatial Pyramid Pooling (SPP) module. The Focus layer is a method for data enhancement on the data side. When dealing with larger feature maps, YOLOv5 can first split and splice a feature map, then pass concatenating layers to stack images so that feature representations at different levels can then be extracted through convolutional layers.

The CSPNet framework forms the backbone network and enhances the feature fusion ability of feature maps with different dimensions through residual connections, which is the basis of back propagation in the network[12]. The SPP module performs maximum pooling in four different dimensions: 1 × 1, 5 × 5, 9 × 9, and 13 × 13, to strengthen the network's receptive ability of pictures and differentiate feature information.

2.4.3 The Neck network

This fuses the texture information and position information in the feature map to strengthen the ability of information fusion on multi-scale objects, the neck network of YOLOv5 adopts the fusion structure of PAFPN [12]. The FPN structure further enhances the features of different dimensions in the network through Up-sampling, Graph fusion ability and multi-size object detection ability. The PAN framework can bring the information of the shallow layer to the bottom layer through short-circuit links, which improves the detection results of disturbing objects

2.4.4 The Output

The output consists of the NMS module and the loss function, the original YOLOv5 used CIoU loss function in the output. It overcomes the problem where IoU is not steerable in special cases and improves the detection effect when the prediction frames overlap[11]. Weighted NMS is used to consolidate the detection performance in multi-objective environment, thus obtaining the optimal detection framework.

2.5 Conclusion

The literature review mentioned in your question highlights the wide range of technological features and mechanical architecture designs available for unmanned aerial vehicles (UAVs). While many of these features can be physically added to the flight system, researchers have also focused on developing novel drones with increased functionality and performance.

One popular approach to improving UAV performance is to modify the selected control techniques. By doing so, researchers have been able to improve the stability and maneuverability of the mechanical systems, resulting in better overall performance. Another trend in the literature is the development of novel drone designs, such as tiltrotors or tilt-wings[3]. These designs involve structural modifications to traditional quadrotors that allow for increased versatility and functionality in outdoor applications. For example, tiltrotors can transition from vertical takeoff to forward flight, while tilt-wings combine the benefits of fixed-wing aircraft and quadrotors.

Overall, the literature suggests that the development of novel UAV designs is becoming increasingly important, as researchers look to improve the performance and versatility of these systems. Whether through control technique modifications or structural design changes, the goal is to create UAVs that can perform a wide range of tasks with greater efficiency and effectiveness.

CHAPTER 3
METHODOLOGY

3.1 Introduction

Building a dynamic unmanned aerial vehicle (UAV) requires the integration of various complex electronic devices. In the implementation described in your question, several intelligent electronic devices were used, including brushless DC motors, the Ardupilot Mega control board (APM-2.8), ESCs (electronic speed controllers), and a 2200 mAh Lithium Polymer battery[7]. This chapter will discuss each of these components and their behavior in detail, as well as the development of a telemetry system for real-time communication with the drone.

Brushless DC motors are widely used in UAVs due to their high efficiency, reliability, and low maintenance requirements. These motors use electronic commutation to control the speed and direction of rotation, and they are typically controlled by ESCs[5]. ESCs are devices that regulate the power supply to the motor, allowing for precise control of speed and direction.

The Ardupilot Mega control board is a popular open-source autopilot system used in UAVs. It is equipped with a range of sensors, including accelerometers, gyroscopes, and barometers, which provide information on the drone's orientation, altitude, and speed. The APM-2.8 is compatible with a range of software options, including Mission Planner and APM Planner, which allow users to configure and monitor the drone's behavior.

The 2200 mAh Lithium Polymer battery is a lightweight and high-capacity power source commonly used in UAVs. These batteries are preferred over other types of batteries due to their high energy density, low self-discharge rate, and ability to handle high discharge rates.

Finally, the telemetry system allows for real-time communication between the ground control station and the drone. This system typically includes a transmitter on the drone and a receiver on the ground, allowing users to monitor the drone's behavior, receive status updates, and adjust settings in real time. The integration of these intelligent electronic devices is critical for building a dynamic UAV. These components allow for precise control of the drone's behavior, while the telemetry system provides real-time feedback and control for increased safety and efficiency.

3.2 Components

In order to develop this project, we have used Brushless DC motors, Electronic Speed Controllers (ESC), Ardupilot Mega control board(APM-2.8), 2200mAh Li-Po battery, Flysky Radio, G module, propellers, drone frame and also the Deep Learning framework(YOLO V5) which is used for live analysis is introduced in this section.

3.2.1 Brushless DC motor

We have used A2212/13T motor for the propeller. The A2212/13T is a 3.9 ounce, 1000KV, 450 watts out runner brushless motor. It's used for sport planes weighing 709 to 1550 gram.

Fig. 3.1: Brushless DC motor.

Table 3.1: A2212/13T motor parameters.

Model	A2212
KV	1000
Max Efficiency	80%
Max Efficiency Current	4-10A (>75%)
Current Capacity	12A/ 60s
No Load Current	10V/0.5A
Number of Cells	2-3 Li-Poly
Motor Size	27.5x38mm/1.08"x1.5"
Shaft Diameter	3.17mm/0.12"

3.2.2 ESC (Electronic Speed Controller)

An electronic speed controller or ESC is a device installed to a remote controlled electrical model to vary its motor's speed and direction. It needs to plug into the receiver's throttle control channel.

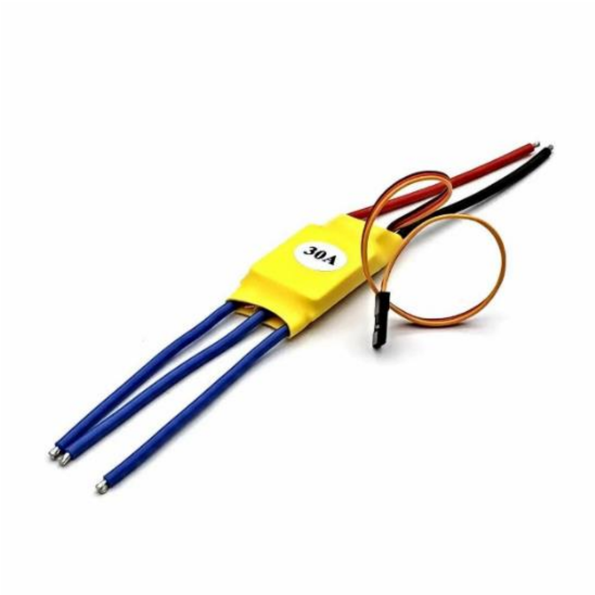

Fig. 3.2: Electronic speed controller.

Table 3.2: Electronic speed controller parameters.

Output:	Continuous 30A, Burst 40A up to 10 Secs.
Input Voltage	2-3 cells lithium battery or 5-9 cells NiCd/NIMh battery.
BEC	2A / 5V (Linear mode).
Max Speed	210,000rpm for 2 Poles BLM, 70,000rpm for 6 poles BLM, 35,000rpm for 12 poles BrushLess Motor
Size	45mm (L) * 24mm (W) * 11mm (H)
Weight	25g

3.2.3 Ardupilot Mega control board(APM-2.8)

The **APM 2.8 Multicopter Flight Controller** is a complete open source autopilot system. It allows the user to turn any fixed, rotary-wing. In addition, it turns multirotor vehicles (even cars and boats) into a fully autonomous vehicle. meanwhile, it is capable of performing programmed GPS missions with waypoints.

Fig. 3.3: Ardupilot Mega control board(APM-2.8).

Table 3.3: Ardupilot Mega control board(APM-2.8) Parameters.

Model	APM 2.8
Power supply	LP2985-3.3.
Port	MUX (UART0, UART2, mnnI2, and OSD are optional, OSD is the defaulted output).
Input Voltage (V)	12~16 VDC
Sensors	3-Axis Gyro-meter Accelerometer High-performance Barometer
Processor	ATMEGA2560 and ATMEGA32U-2
Dimensions (mm) LxWxH	70 x 45 x 15
Weight (gm)	82

3.2.4 Lithium Polymer battery

"LiPo" is short for lithium polymer, which describes the type of electrolyte used in LiPo batteries. Although the development of LiPo batteries started in the 1970s, it is only in the recent year that they have become widely used in mainstream applications. The compact and lightweight design of LiPo batteries have made them a viable alternative to a fuel power source for unmanned aerial vehicles(Drone).

Fig. 3.4: Lithium Polymer battery.

Table 3.4: Lithium Polymer battery parameters.

Battery Parameter	ZOP Power 11.1V 2200mAh 60C 3S Lipo Battery
Capacity	2200mAh
Size	23*34*105mm
Plug	XT60 Plug
Continuous Discharge Rate	60C
Weight	178g

3.2.5 Flysky Radio

The Flysky radio system is a popular radio system used in unmanned aerial vehicles (UAVs). This radio system is designed to provide a high-quality, jamming-free long-range radio transmission. The system uses a high-gain, multi-directional antenna that covers the entire frequency band, ensuring a reliable signal transmission.

One of the key features of the Flysky radio system is its high sensitivity receiver. The receiver is designed to be very sensitive to the signal transmitted by the transmitter, which helps to reduce the risk of signal interference or loss. This high sensitivity also means that the radio system is capable of transmitting over long distances, making it suitable for UAVs that need to fly far from their operators.

Another important feature of the Flysky radio system is the use of unique IDs for each transmitter. When a transmitter is bound with a receiver, the receiver saves the unique ID of the transmitter. This means that the receiver will only accept data from the bound transmitter, and will reject any other signals. This greatly increases interference immunity and safety, as it helps to prevent other users from accidentally or intentionally interfering with the UAV's signal.

This radio system uses low power electronic components and sensitive receiver chip. The RF modulation uses intermittent signal thus reducing even more power consumption.

Fig. 3.5: Flysky Radio.

Table 3.5: Flysky Radio Parameters.

Model Name	Flysky FS-i6
Channels	6 Channels
Model Type	Gliders/Heli/Airplane
RF Range	2.40-2.48GHz
Bandwidth	500KHz
RF Power	Less Than 20dBm 2.4ghz System: AFHDS 2A and AFHDS
Sensitivity	1024
ANT length	26mm*2(dual antenna)
Weight	392g
Power	6V 1.5AA*4
Display mode	Transflective STN positive type, 128*64 dot matrixVA73*39mm, white backlight.
Size	174x89x190mm

3.2.6 GPS Module

Global Positioning System(GPS) is used to determine the position of the drone relative to a network of orbiting satellites

Fig. 3.6: GPS Module.

3.2.7 Drone Frame

This Q450 Quadcopter Frame is made from Glass Fiber which makes it tough and durable. They have the arms of ultra-durable Polyamide-Nylon which are the stronger moulded arms having a very good thickness so no more arm breakage at the motor mounts on a hard landing. The arms have support ridges on them, which improves stability and provides faster forward flight.

Fig. 3.7: Drone Frame.

3.2.8 Raspberry Pi

The Raspberry Pi 3 Model B+ is a popular single-board computer released in March 2018 as an update to the Raspberry Pi 3 Model B. It offers several improvements over its predecessor, including a faster processor, improved networking capabilities, and enhanced thermal management.

Overall, the Raspberry Pi 3 Model B+ is a versatile and capable platform for a wide range of computing applications, including home automation, media centers, robotics, and educational projects. Its small size, low cost, and extensive community support make it a popular choice among hobbyists, students, and professionals alike.

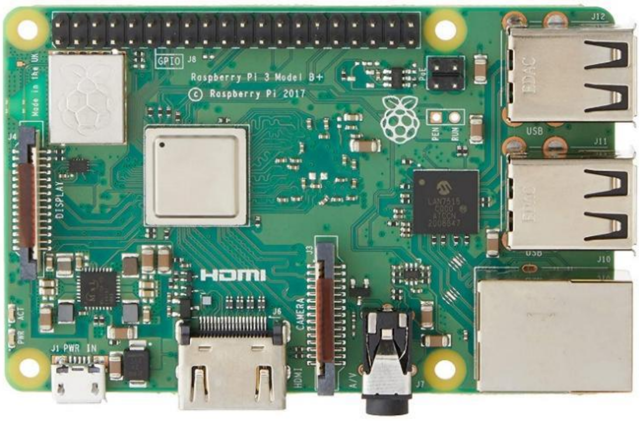

Fig. 3.8: Raspberry Pi 3 Model B+.

Table 3.6: Raspberry Pi Parameters.

Model	Raspberry Pi 3 Model B+
CPU type/Speed	ARN Cortex-A53 1.4 GHz
RAM size	1 GB LPDDR2
Integrated Wi-Fi	2.4Ghz and 5Ghz
Bluetooth	4.2 BLE
USB	4 x USB 2.0
HDMI	1 x full size
Video Decode	H.264(1080p30)
Video Encode	H.264(1080p30)
OpenGL ES	1.1,2.0 graphics

3.2.9 PiCamera

Picamera is a Python library designed for working with Raspberry Pi cameras. It provides an easy-to-use interface for accessing the camera module on a Raspberry Pi and capturing images or video footage. Pi camera supports a range of camera modes, resolutions, and frame rates, allowing users to capture high-quality images and video footage in a variety of settings. It also includes features for adjusting camera settings such as brightness, contrast, and exposure, as well as advanced options such as burst mode and time-lapse photography.

The Pi Camera module is a powerful tool for capturing images and video with a Raspberry Pi. One of the advantages of the Pi Camera is its ability to be used for real-time image processing and analysis using Python, making it an ideal tool for robotics, computer vision, and machine learning applications.

The Pi Camera module can be easily attached to the Raspberry Pi's CSI (Camera Serial Interface) port using a 15-pin ribbon cable[13]. Once connected, the Pi Camera can be accessed using a simple Python interface, allowing users to easily capture images and video footage with the camera.

In addition to basic capture functionality, the Pi Camera also supports advanced features such as image stabilization, high-dynamic range (HDR) imaging, and low-light performance. These features make it possible to capture high-quality images and video footage in a wide range of lighting conditions and environments.

Furthermore, the Pi Camera module can be used in conjunction with other Raspberry Pi accessories such as the Sense HAT, allowing for even more advanced image processing and analysis capabilities[11]. This makes the Pi Camera a highly versatile and powerful tool for working with Raspberry Pi cameras.

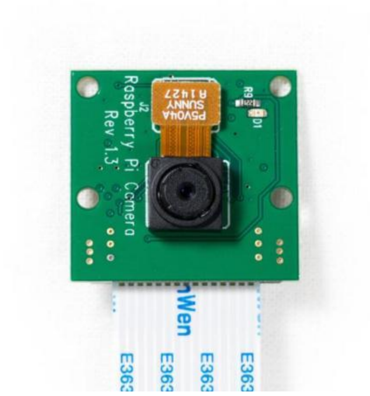

Fig. 3.9: PiCamera.

3.3 Development and Construction

Construct the Drone body and extend all positive and negative terminals from panel Now connect ESCs and Battery to the panel, another terminal of ESCs are connected to Motors.

ESCs has 3 cables

- 2 are for power supply
- 1 is for Data transfer(middle)

All these 3 cables are connected to motor cables

The process described involves calibrating and connecting various components of a drone to enable it to function properly.

First, the Electronic Speed Controllers (ESCs) need to be calibrated by using the Flysky Radio to set their speed. This is important to ensure that the motors are running at the correct speed and can help prevent issues such as motor overheating or failure. Once calibrated, the propellers can be attached to the motors.

Next, all four ESCs and motors are connected to the Ardupilot. Calibration of each individual motor and ESC is done by using the Flysky Radio, which allows for precise adjustments to be made. Once all of the components are calibrated, they are connected to the Ardupilot to work simultaneously.

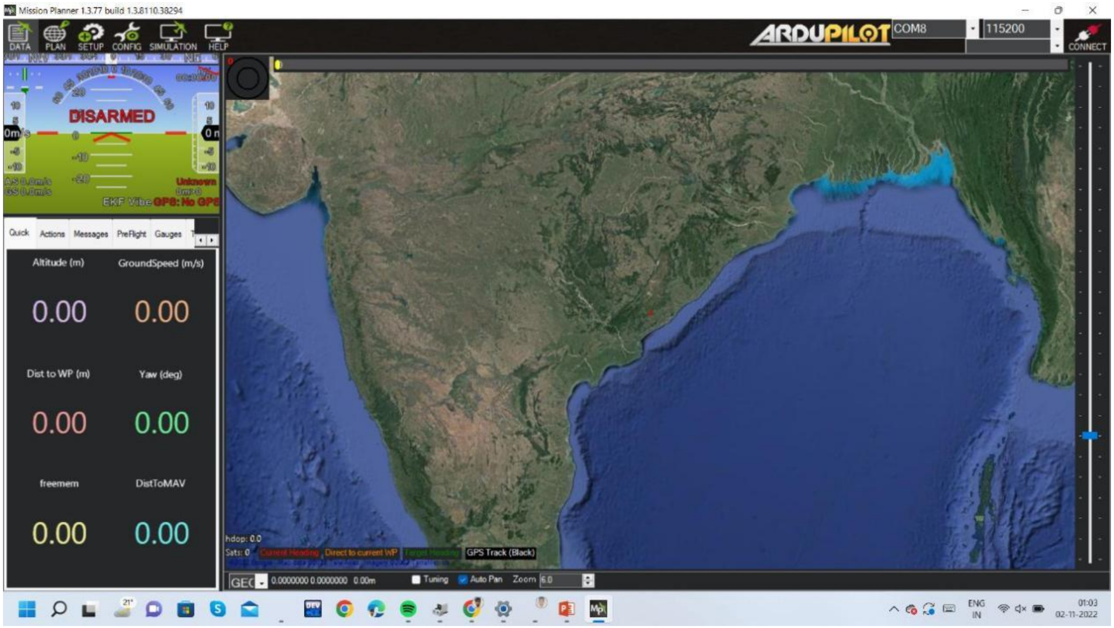

Fig. 3.10: Mission Planner Software.

Calibration of the Ardupilot is then done using either Mission Planner or APM Planner, which are software programs that allow for configuration and monitoring of the Ardupilot. A GPS module is connected to the Ardupilot to enable the drone to determine its live location, which is important for various applications such as surveying or mapping.

The Ardupilot has an inbuilt gyro which helps the drone with stabilization and way-point based navigation. This means that the drone can maintain its orientation and flight path even in windy conditions or when flying long distances.

To connect the Ardupilot to the Flysky Radio, a Flysky Receiver (FS-iA6B) is connected to the input of the Ardupilot. This allows the Ardupilot to receive data from the Flysky Radio, which is used to control the drone's flight.

An active internet connection is needed to run Mission Planner, which is used to configure the Ardupilot. The connection is made using a Type-B cable, which is a standard USB cable. APM 2.8 firmware is uploaded to Mission Planner, which enables it to fetch data packets from the Ardupilot. These data packets contain information such as GPS coordinates, battery voltage, and motor speeds, which are used to control the drone's flight and monitor its status.

After fetching the data, we need to Load the firm ware into the AMP board and calibrate the Mandatory Hardware.

The mandatory hardware consists of the following:

1. Frame type
2. Initial parameter setup
3. Accel Calibration
4. Compass
5. Radio Calibration
6. Servo output
7. ESC Calibration
8. Flight Modes
9. Fail Safe
10. HW ID
11. ADSB

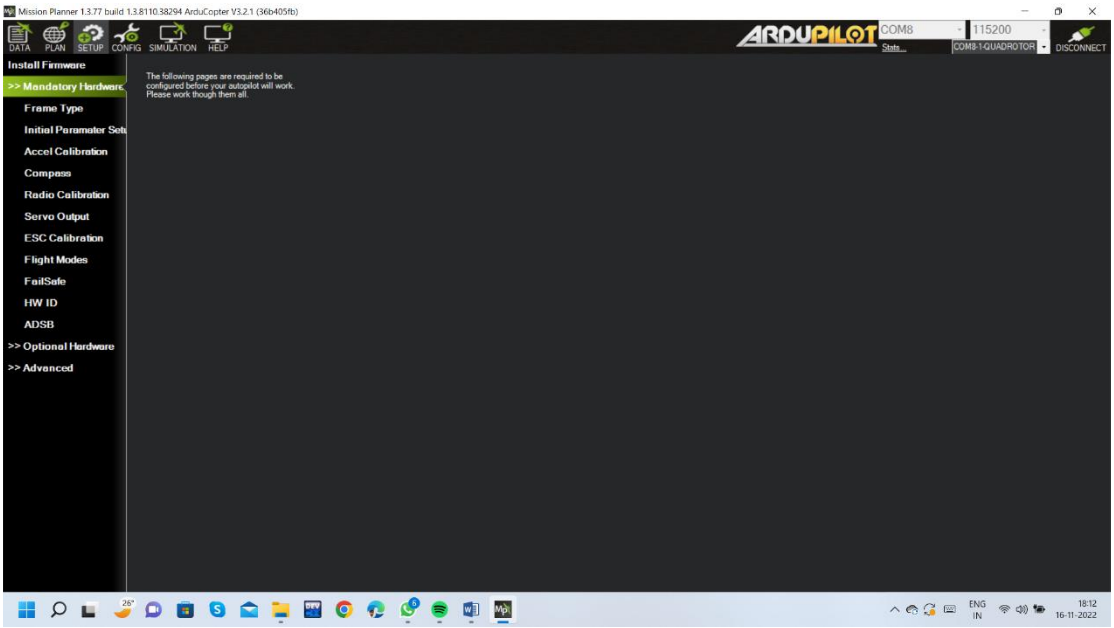

Fig. 3.11: Mandatory Hardware.

3.3.1 Frame type

Check whether the Frame type is correct or not. If it is wrong, we need to boot the APM board and we need to Load the firm ware again.

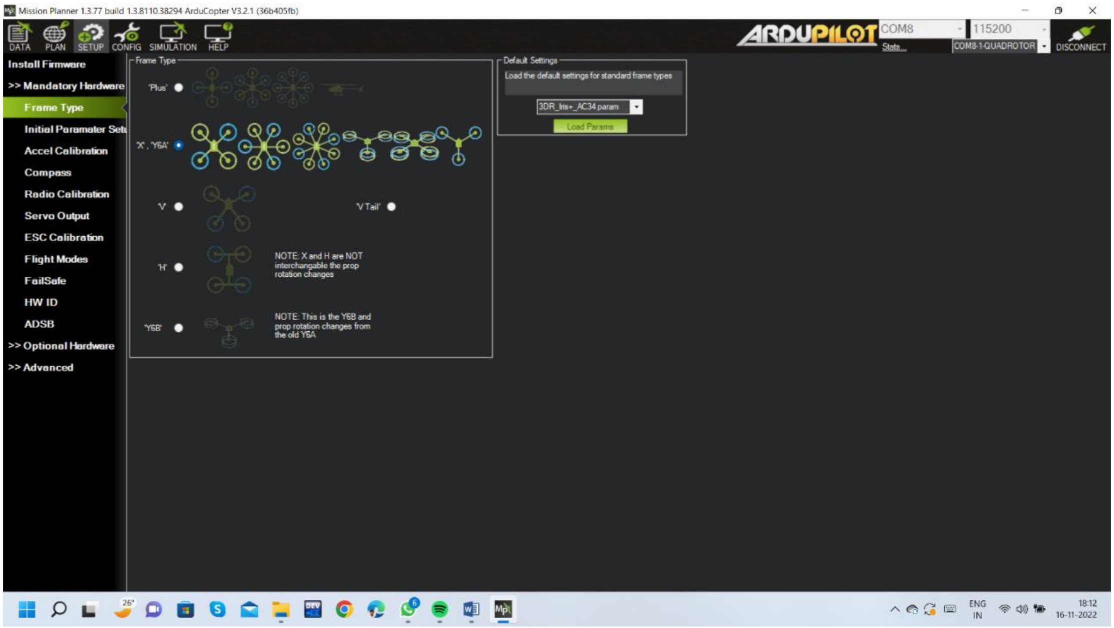

Fig. 3.12: Frame Type.

3.3.2 Accel Calibration

This article shows how to perform basic accelerometer calibration (using Mission Planner). The accelerometers in the autopilot must be calibrated to correct for them bias offsets in all three axes, as well as any off-axis variations. Bias offsets in all three axes, as well as any off-axis variations.

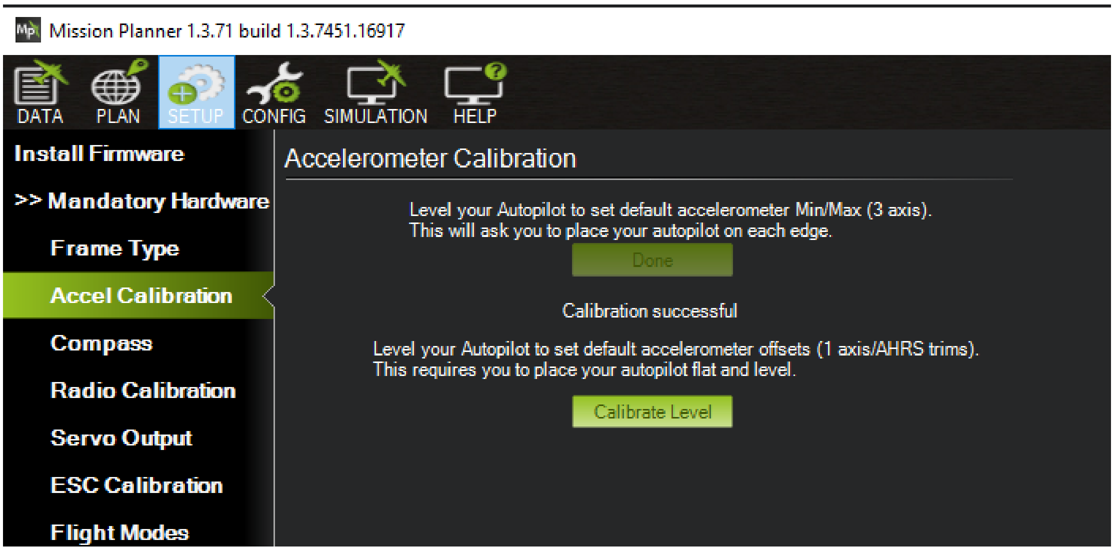

Fig. 3.13: Accel Calibration.

3.3.3 Compass Calibration

Select Live Calibration to begin calibration. APM Planner will start a timer. During these next 60 seconds, hold your vehicle in the air and rotate it slowly so that each side (front, back, left, right, top and bottom) points down towards the earth for a few seconds in turn. When the calibration period ends, APM Planner will display the resulting offsets. For APM, all three values should be between -150 and 150. For PX4 and Pix hawk, values may be greater than 150 and less than -150.

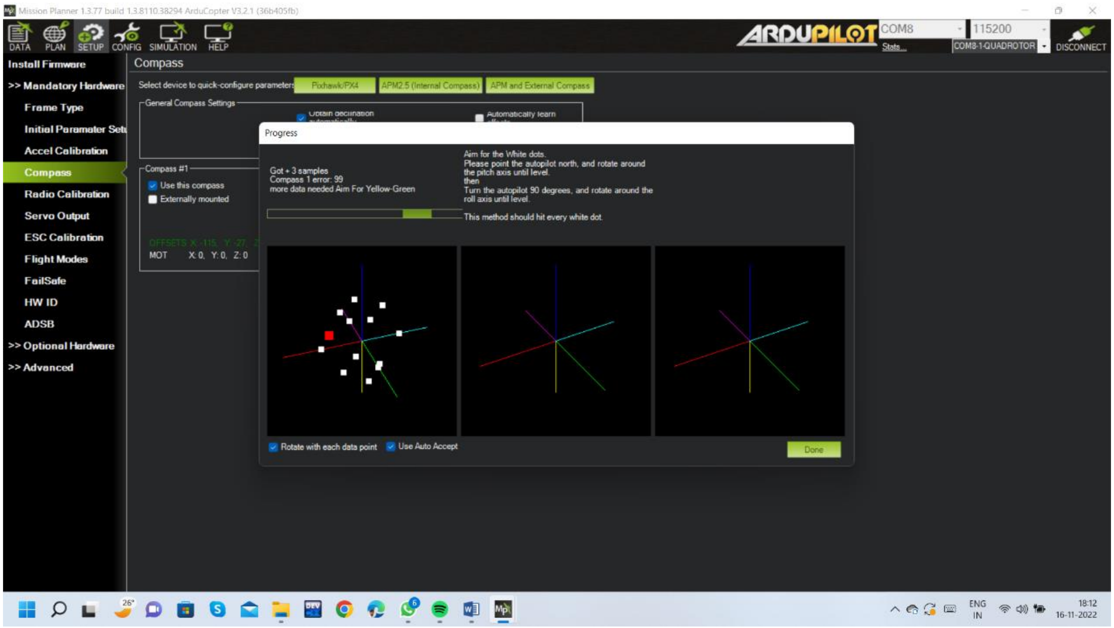

Fig. 3.14: Compass Calibration.

3.3.4 Radio Calibration

The first step is to turn on the transmitter and verify that it is in airplane mode. Airplane mode is required regardless of the type of platform being piloted, as it ensures that the transmitter's signals do not interfere with any other devices.

Next, make sure that all trims are centered. Trims are small adjustments that can be made to the control surfaces of the aircraft to help it fly straight and level. Centering them ensures that the aircraft starts from a neutral position.

For Mode 1 transmitters, the left stick controls pitch (up and down movement) and yaw (left and right movement), while the right stick controls throttle (up and down movement) and roll (left and right movement).

For Mode 2 transmitters, the left stick controls throttle and yaw, while the right stick controls pitch and roll.

Regardless of the type of transmitter, the three-position switch should be attached to channel 5 and will control flight modes. Flight modes refer to different settings that affect the behavior of the aircraft. For example, a beginner mode might limit the speed and altitude of the aircraft to make it easier to control, while a sport mode might allow for more aggressive maneuvers.

By attaching the three-position switch to channel 5, the pilot can easily switch between different flight modes during flight. It's important to understand the different flight modes and their effects on the aircraft before taking off.

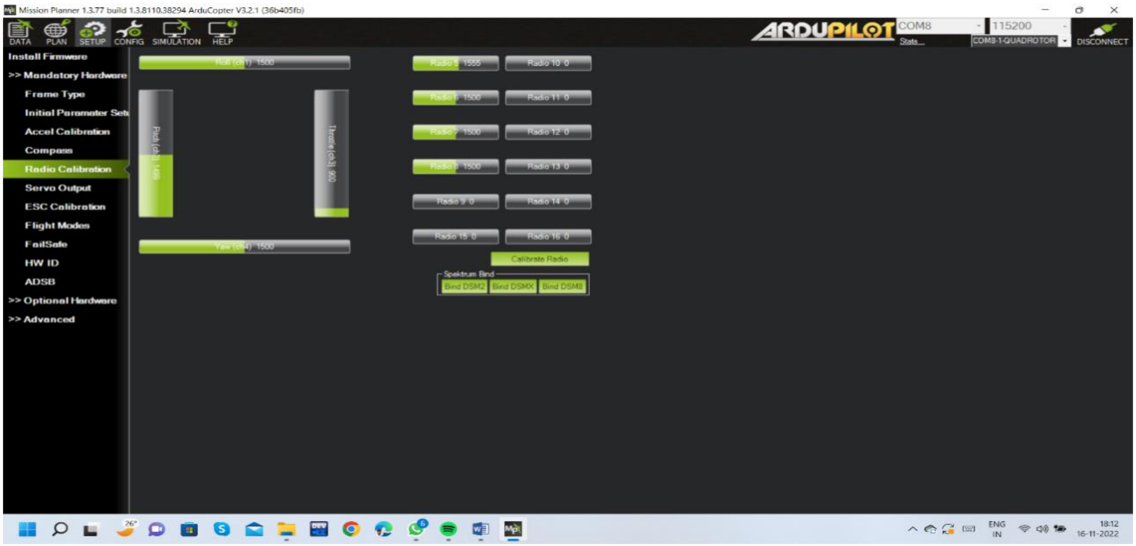

Fig. 3.15: Radio Calibration.

3.3.5 Flight Modes

To enable simple mode for a selected flight mode, you will typically need to access the settings or configuration menu of your flight control system. Once you have located the menu, find the flight mode you want to enable simple mode for and look for a checkbox or option labeled "simple mode" next to it. Check this box to enable simple mode for that flight mode.

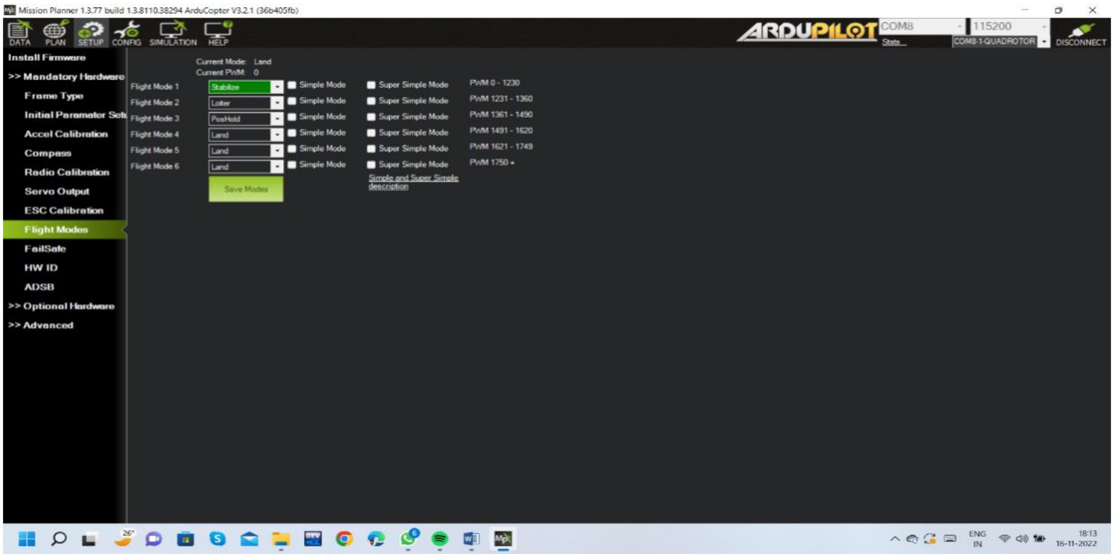

Fig. 3.16: Flight Mode.

3.4 YOLO v5 Implementation

YOLO (You Only Look Once) is a popular object detection algorithm used in computer vision and image processing applications. YOLO v5 is the latest version of the YOLO algorithm, developed by Ultralytics, that achieves state-of-the-art performance on object detection benchmarks while being significantly faster and more efficient than previous versions.

YOLO v5 is a single-stage object detection model, meaning it performs object detection and classification in a single forward pass through the neural network. This allows YOLO v5 to process images quickly and efficiently, making it well-suited for real-time applications such as autonomous vehicles, robotics, and surveillance systems.

The YOLO v5 architecture consists of a backbone network, a neck network, and a head network. The backbone network is responsible for extracting features from the input image, while the neck network fuses the features from the backbone network into a high-dimensional representation. The head network performs object detection and classification, predicting the location, size, and class of objects in the image.

One of the key innovations of YOLO v5 is the use of a scaled-YOLOv4 architecture, which includes a large number of convolutional layers with progressively increasing receptive fields[9]. This enables YOLO v5 to detect objects at multiple scales and resolutions, improving its accuracy and ability to detect objects of different sizes and shapes.

In addition, YOLO v5 introduces a number of optimizations to improve its speed and efficiency. These include using a single anchor box per grid cell, using smaller input image sizes, and reducing the number of convolutional filters in the network. YOLO v5 is a powerful and efficient object detection algorithm that offers state-of-the-art performance on a range of benchmarks and is well-suited for real-time applications. Its simplicity and speed make it a popular choice for many computer vision tasks, and it continues to be actively developed and refined by the research community.

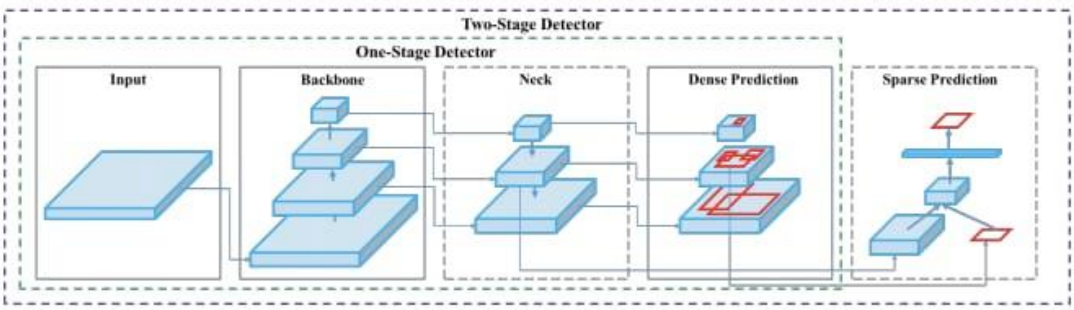

Fig. 3.17: YOLO v5 Two-Stage Detector.

3.5 YOLO v7 Implementation

YoloV7 (You Only Look Once version 7) is an object detection algorithm that is based on deep learning. It is an upgraded version of YOLOv5, which was released in 2020. The YoloV7 model is designed to detect and classify objects in images and videos in real-time, with high accuracy and speed.

The YoloV7 model is trained on a large data set of annotated images, using a neural network architecture that consists of convolutional layers, max-pooling layers, and fully connected layers[7]. The model can detect multiple objects in an image simultaneously and label them with their respective class.

One of the key features of YoloV7 is its speed and efficiency. It is designed to run on a variety of hardware platforms, including CPUs, GPUs, and mobile devices. YoloV7 is also optimized for real-time object detection, making it useful for applications such as autonomous driving, surveillance, and robotics.

Overall, YoloV7 is a powerful tool for object detection, with state-of-the-art performance and speed. It has numerous applications in a variety of industries, and it continues to be a popular choice among researchers and practitioners in the field of computer vision.

3.6 Connection of Pi Cam

To connect a Raspberry Pi camera module to your Raspberry Pi, you need to ensure that the camera module is compatible with your specific Raspberry Pi model. Most Raspberry Pi models are compatible with the camera module, but it's important to double-check to avoid any compatibility issues.

Once you've confirmed compatibility, you'll need to locate the camera connector on your Raspberry Pi. This connector is a ribbon connector that's typically located near the HDMI port. The camera connector needs to be opened before you can insert the camera module ribbon cable.

To open the camera connector, gently pull up on the tabs on either side of the connector. Once it's open, insert the camera module ribbon cable into the connector, making sure that it's firmly and straight. The ribbon cable needs to be inserted with the contacts facing away from the HDMI port.

Once the ribbon cable is inserted, close the camera connector by gently pushing down on the tabs until they click into place. It's important to ensure that the connector is closed properly, as an improperly closed connector could cause the camera module to not work correctly.

After you've connected the camera module to your Raspberry Pi, you'll need to power on your Raspberry Pi and log in to the terminal. You can test the camera module by running a command to capture an image and save it to the current directory. One such command is “raspistill -o image.jpg”, which will capture an image and save it to the current directory as "image.jpg". If the camera module is working correctly, you should see a preview of the image on the screen.

Finally, it's important to note that some Raspberry Pi models may require you to enable the camera module in the Raspberry Pi configuration settings before you can use it. To do this, you can run the command “sudo raspi-config” in the terminal, select "Interfacing Options", and enable the camera module. Once enabled, you should be able to use the camera module in your programming projects.

Fig. 3.18: Connection of Pi Cam.

3.7 Code Snippets

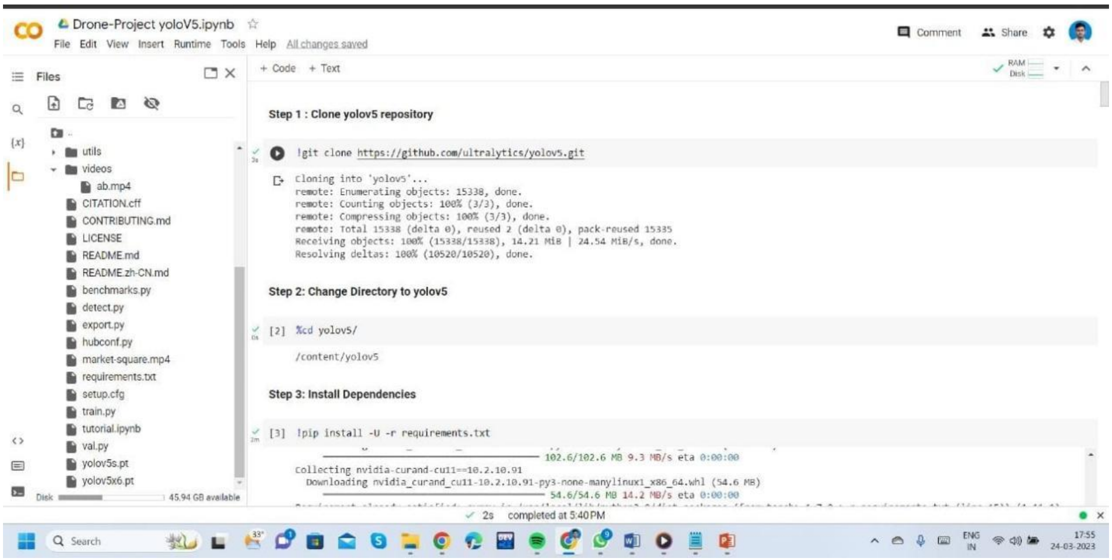

Fig. 3.19: Code Snippet 1**.**

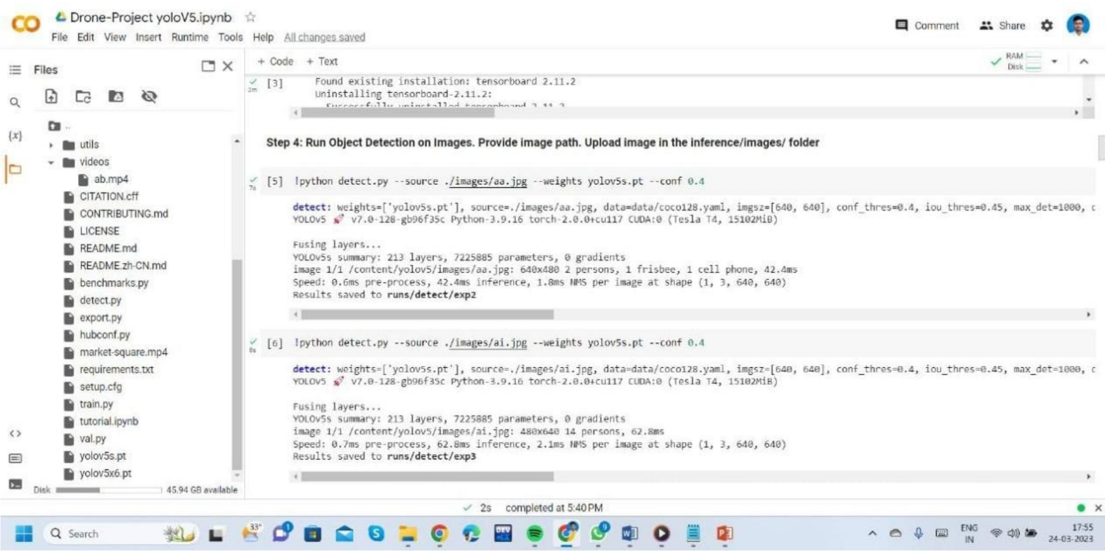

Fig. 3.20: Code Snippet 2.

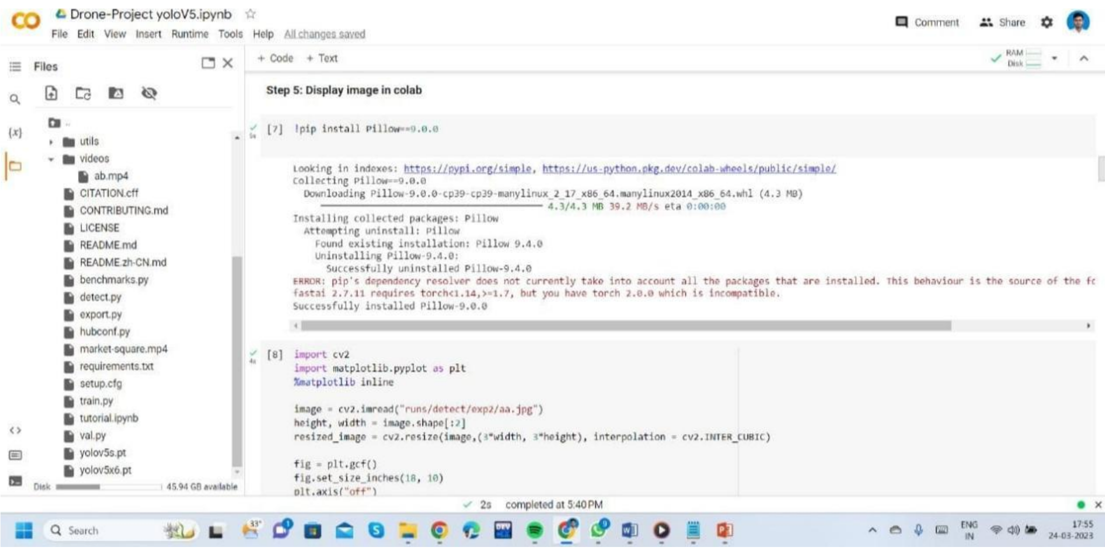

Fig. 3.21: Code Snippet 3.

To run YOLOv5 object detection on an image, you need to start by cloning the YOLOv5 repository from GitHub. Then, change your working directory to the cloned yolov5 directory and install the required dependencies. After that, you can use the detect.py script to detect objects in the image by specifying the YOLOv5 weights file, the image size, the confidence threshold, and the image path. Finally, you can display the resulting image with detected objects in Colab using the Image function. It's important to note that these steps assume you are using Google Colab. If you are running YOLOv5 on your local machine, you may need to adjust the steps accordingly.

After successful installation of YOLOv5 in Colab now we can access any image or video for object detection and analysis of data

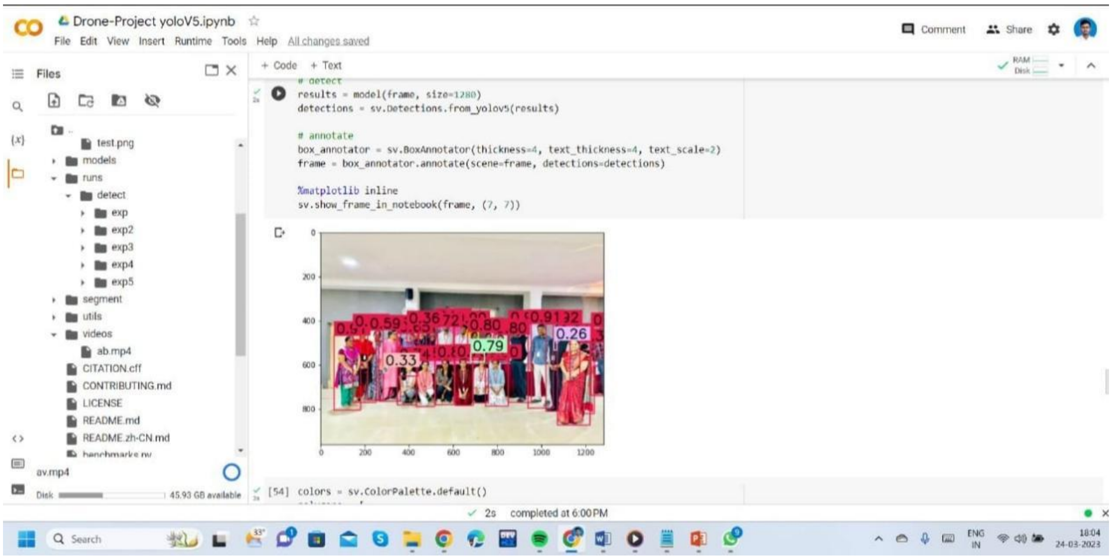

Fig. 3.22: Code Snippet 4.

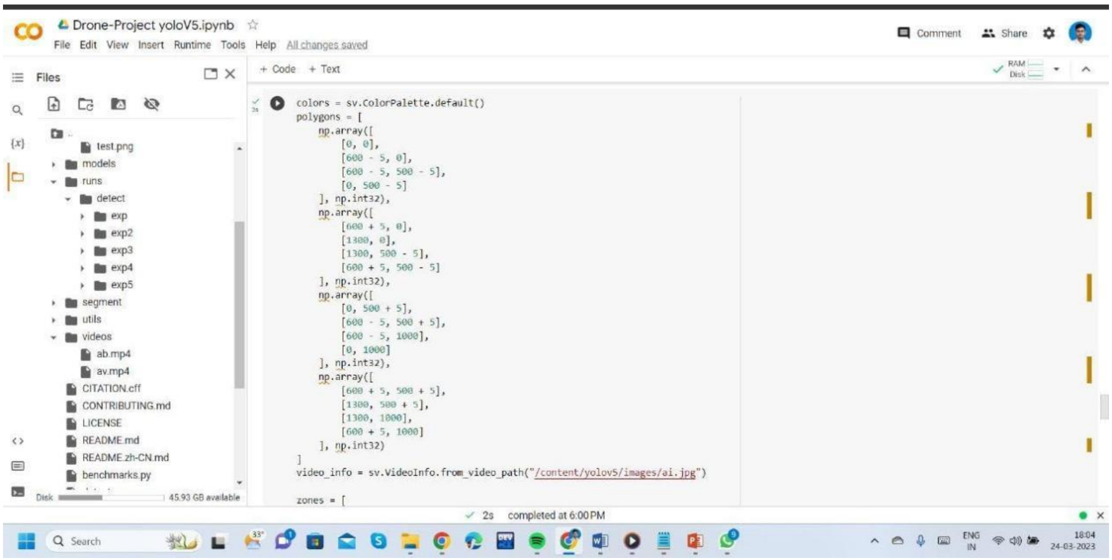

Fig. 3.23: Code Snippet 5.

Rectangle classification refers to the task of identifying objects in an image and drawing a rectangle around each object to classify it.

The YOLOv5 object detection model uses a deep neural network to detect objects in an image and classify them into predefined categories. When an object is detected, the model draws a rectangle around it to indicate its location in the image. The rectangle is defined by the coordinates of the object's top-left and bottom-right corners.

To classify the object within the rectangle, the YOLOv5 model uses the predicted probabilities for each category[8]. The model assigns the object to the category with the highest probability.Rectangle classification in YOLOv5 can be used in a variety of applications, such as detecting and classifying objects in real-time video streams or identifying objects in satellite or drone imagery.

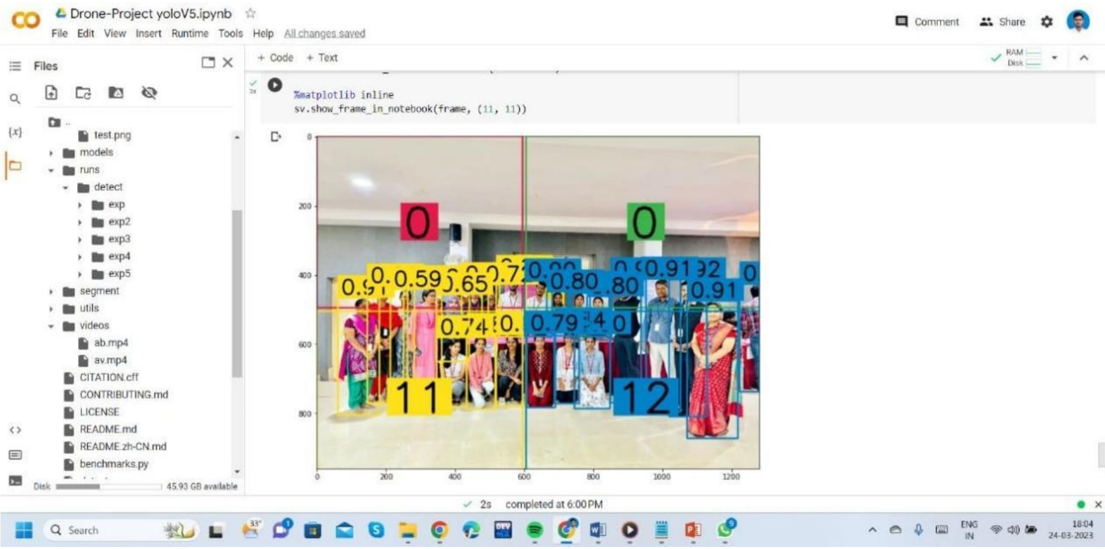

Fig. 3.24: Code Snippet 6.

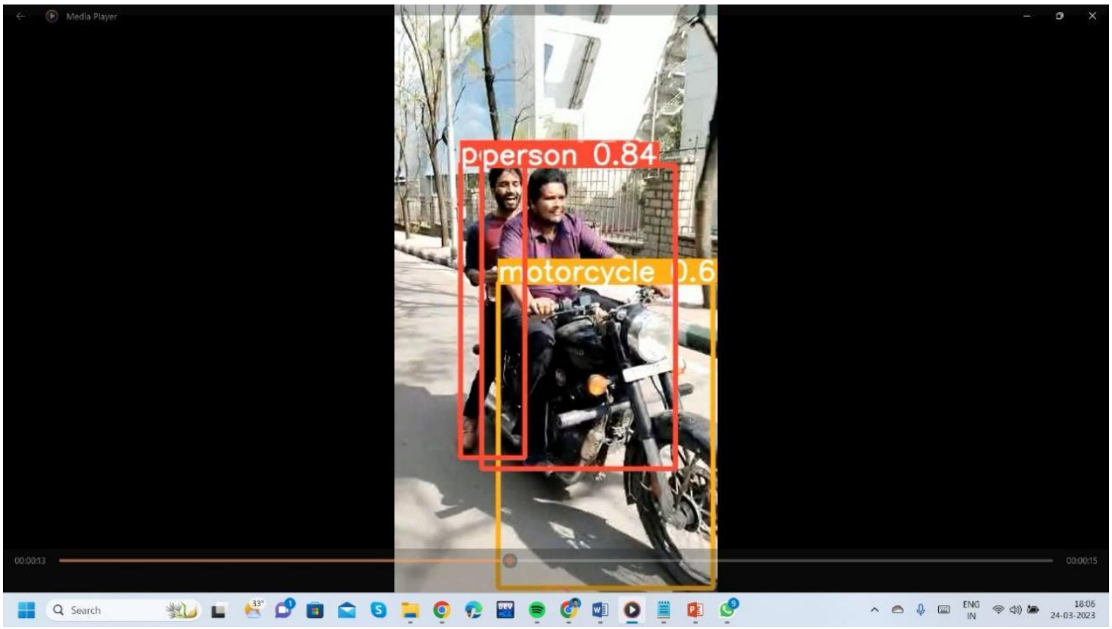

Fig. 3.25: Code Snippet 7.

3.8 IPv4 Port forwarding

IPv4 port forwarding is a technique used to allow external devices or networks to communicate with services running on devices within a private network. This is important because many networks today are configured with a router that acts as a gateway between the private network and the internet. Without port forwarding, external devices would not be able to directly access services running on devices within the private network.

To understand how port forwarding works, it's important to understand how network communication happens. In most cases, when a device on the internet wants to communicate with a device on a private network, it sends a request to the public IP address of the network (i.e. the IP address assigned to the router by the ISP). The router receives this request and needs to decide what to do with it. By default, the router will typically discard any incoming traffic that doesn't match an existing connection[9]. However, if a port forwarding rule has been set up, the router will forward incoming traffic on a specific port to a specific device on the private network.

For example, suppose you want to allow external devices to access a web server running on a device in your private network[12]. By default, web traffic uses port 80 (TCP), so you would need to set up a port forwarding rule that maps incoming traffic on port 80 to the IP address of the device running the web server. When an external device sends a request to your public IP address on port 80, the router will forward that traffic to the device running the web server, allowing the external device to communicate with the web server.

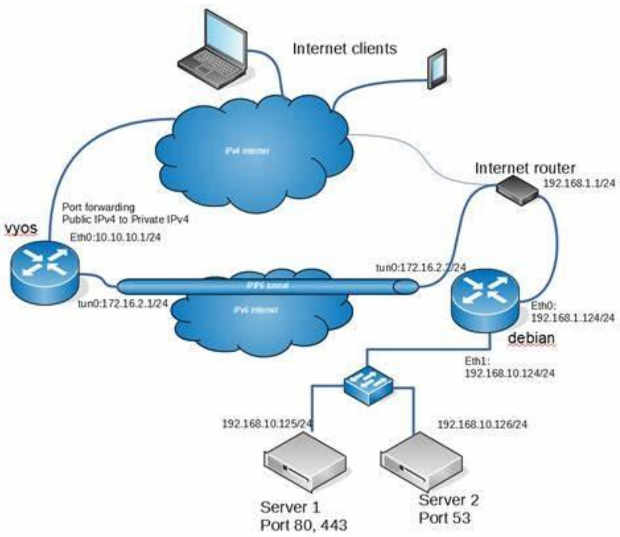

Fig 3.26: IPv4 port forwarding.

It's important to note that port forwarding can introduce security risks, since it allows external devices to directly access services running on devices within the private network. It's recommended that you only set up port forwarding for services that are necessary and that you take steps to secure those services (e.g. by using strong passwords, keeping software up to date, and configuring firewalls).

3.8.1 Remote access to devices and services

Many devices and services on a private network are not designed to be accessible from outside the network. For example, a file server may be set up to only allow access from devices on the same network. By using port forwarding, you can make the file server accessible from outside the network, such as from a remote location or while traveling. This can be useful for accessing files, photos, or other data stored on the file server. Similarly, if you have a web server running on your network, port forwarding can allow you to access the website from anywhere in the world.

3.8.2 Hosting services

If you have a service that you want to make available to others on the internet, such as a game server or a web application, you can use port forwarding to allow external devices to connect to the service[13]. By forwarding the appropriate ports, you can make the service accessible from anywhere in the world, as long as the external device knows the IP address of your router.

3.8.3 Peer-to-peer networking

Many peer-to-peer applications, such as BitTorrent and Skype, require incoming connections to function properly. This means that if you are behind a router, other devices may not be able to connect to you directly. By using port forwarding, you can make your device accessible to others on the internet, allowing them to connect directly to you. This can improve performance and make it easier to share files or communicate with others.

3.8.4 Internet of Things (IoT) devices

Many IoT devices, such as smart home devices and security cameras, require access to the internet to function properly. For example, a smart thermostat may need to communicate with a remote server to get weather information or to adjust the temperature based on your schedule. By using port forwarding, you can allow the device to communicate with the remote server, even if the device is behind a router[11]. This can be especially useful if you are experiencing connectivity issues with your IoT devices.

In summary, port forwarding is a powerful tool that can be used to enable remote access, host services, improve peer-to-peer networking, and support IoT devices. However, it's important to use port forwarding carefully and securely, since it can also introduce security risks if not configured correctly.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Introduction

In any development project, measurement is a critical component in ensuring that the project is successful. In the context of the drone development project, precise measurement was performed to ensure that the drone was developed to meet the required specifications. This included measuring the dimensions and weight of the drone and its various components, such as the frame, motors, propellers, and electronic components.

Once the drone was developed, it was tested for its various applications. These applications included delivering lightweight products, surveillance, and monitoring of various environments. For instance, the drone could be used for surveillance and monitoring of a college campus to identify potential safety risks, monitor activity, and make informed decisions about resource allocation and campus planning.

To analyze the live video captured by the drone during surveillance and monitoring, a deep learning framework was used. The deep learning framework helped to analyze the video footage in real-time, identifying and classifying various objects within the drone's field of view, such as vehicles, pedestrians, and other objects. The deep learning framework used in the project was able to accurately classify these objects, which helped in analyzing the live video footage.

The precise measurement of the drone, testing of its various applications, and analysis of live video footage using a deep learning framework were critical components of the drone development project. They helped to ensure that the drone was developed to meet the required specifications, and that it was able to perform its intended applications accurately and effectively.

4.2 Measurements

In the measurement process for the developed drone, the weight of the drone was measured as 1 kg, including all the payloads such as the electronic speed controller (ESC), battery, controller, and motors. The weight measurement is a crucial factor to consider in drone development because it affects the drone's maneuverability, stability, and overall performance.

To ensure that the drone is capable of achieving its intended flight characteristics, it is important to determine the amount of thrust that it can generate. In this case, it was determined that each brushless motor with a 10 X 8 propeller can produce 400g of thrust. Therefore, with four propellers, the drone can generate a total thrust of almost 1.6 kg (4 * 0.4 kg).

Knowing the thrust capacity of the drone is important as it determines the drone's ability to achieve lift-off, hover in place, and perform various maneuvers. In this case, the measured thrust of 1.6 kg is more than the weight of the drone, which means that the drone is capable of achieving lift-off and hovering in place. However, it is important to note that other factors such as air resistance, wind conditions, and the drone's center of gravity can also affect its flight characteristics. Therefore, the thrust measurement is just one aspect of ensuring that the drone is capable of performing as intended. Lift equation tells us,

$$\text{Thrust} \geq \text{Weight (Condition)} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

So our drone satisfies this equation as we can get 1.6 kg of thrust and weight of the drone is 1 kg.

Table 4.1: Measurements of the drone.

Weight	1kg
Length	0.9m
Max thrust	1.6kg
Max extra payload	600g

4.3 Application of the developed drone

Application of the drone we have developed has covered a vast area of usage. Main applications of this flying machine is given below:

- Live Video Analysis using Deep Learning framework
- Counting of different categories in image/video
- Improves Surveillance in remote areas
- Emergency first aid delivery
- Shipping and product delivery
- Agricultural usage
- Military purpose

4.4 Results

Result Analysis After configuring all the parts, assembling as required, configuring Software, finally we obtained our drone. We need to test the Acceleration Calibration every time when we change the ground surface area.

Tuning and calibration of the proportional–integral–derivative(PID) controller were done to achieve stabilization on each axis. Now the quad copter that will try stable its position according to preferred altitude. However, we have found a lot of unwanted vibration that causes a small oscillation while flying. This vibration is large at low speed and vibration is low at high speed.

The drone provides a rare view of the campus to get complete information in and out with an analysis report. As drone is a movable aerial vehicle with integrated camera, can reach blind spots easily and can improve surveillance.

Fig. 4.1:Quad copter Drone.

In the case of campus surveillance, the YOLOv5 framework can be used to classify different types of objects within the drone's field of view, such as vehicles and pedestrians. The algorithm works by analyzing the visual features of each object and comparing them to a database of known object types, allowing it to accurately identify and classify each object within the image or video.

Once the objects have been classified, the algorithm can then provide a count of each category, such as the number of vehicles (including 2 wheelers and 4 wheelers) and pedestrians present within the drone's field of view.

By integrating a Raspberry Pi module and Pi camera to a drone, campus security and management teams can capture real-time video footage of the campus and its surroundings.

This information can be used for various purposes, including monitoring activity on campus, identifying potential safety risks or areas of congestion, and making more informed decisions about resource allocation and campus planning.

Fig. 4.2: Connection of Pi camera.

Integrating a Raspberry Pi module and Pi camera to a drone can enable live streaming of video footage and the storage of this footage on the Raspberry Pi module's storage. With the right software and configuration, this setup can be a powerful tool for capturing high-quality footage during drone flights.

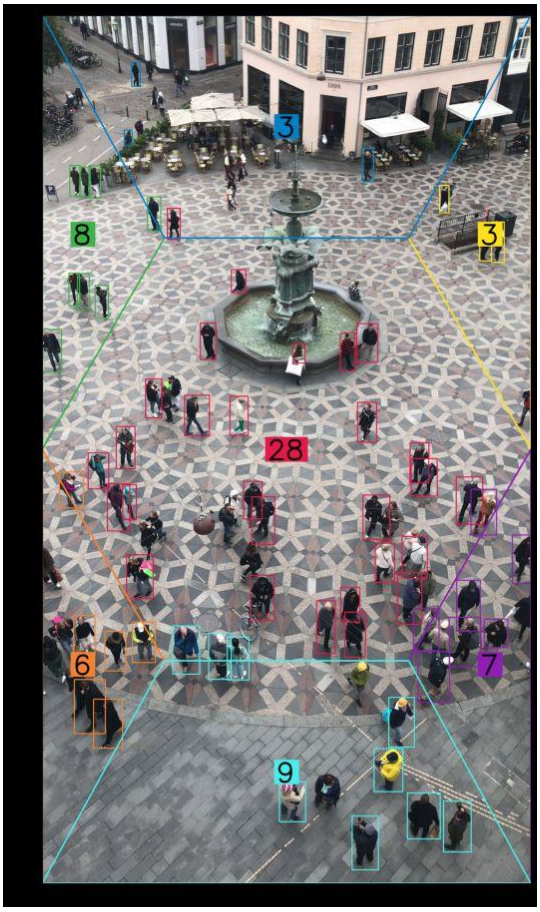

Fig. 4.3: Hexagon classification analysis.

Fig. 4.4: Rectangle classification analysis.

Fig. 4.5: Flying of Drone.

CHAPTER 5
CONCLUSION

5.1 Conclusion

The main objective of a recent project was to develop a lightweight drone that can be used for various purposes, including delivering lightweight products. To control the drone, the project used a 2.4 GHz radio frequency transmitter, a receiver, a micro-controller, an electronic speed controller, brushless DC motor, propellers, and a drone frame. The drone's roll, pitch, and yaw were controlled using a proportional-integral controller, which demonstrated good performance. Live GPS tracking was also incorporated into the project.

One potential application of this drone is in campus surveillance. Using the YOLOv5 framework, the drone can classify different types of objects within its field of view, such as vehicles and pedestrians. The YOLOv5 algorithm analyzes the visual features of each object and compares them to a database of known object types, allowing it to accurately identify and classify each object within the image or video.

After the YOLOv5 algorithm classifies the objects within the drone's field of view, it can provide a count of each category. For instance, it can count the number of vehicles, including both two-wheelers and four-wheelers, and the number of pedestrians present in the drone's field of view. This count can provide valuable insights into campus activity and help the security and management teams to monitor activity on campus.

The information obtained from object classification and counting can be used to identify potential safety risks, such as congested areas on campus, or suspicious activity in restricted areas. The campus security team can then take appropriate action to mitigate these risks and ensure the safety of students, faculty, and staff.

In addition, the information obtained from drone surveillance can be used to make more informed decisions about resource allocation and campus planning. For example, if the drone detects a high number of pedestrians in a particular area of campus, the campus management team can decide to increase the number of pedestrian crossings or widen the sidewalks in that area to make it safer and more comfortable for pedestrians.

Overall, the use of deep learning algorithms like YOLOv5 in conjunction with drone technology represents a powerful new tool for campus surveillance and analysis. It has the potential to greatly enhance campus safety and security, as well as provide valuable insights for campus planning and management.

5.2 Limitations

Though we were trying to make it modest, we have some limitations.

- The power issues got priority. Out prototype can fly up to 25-30 minutes with fully charged battery. However, we can overcome such issues by using more powerful batteries and motors but that will increase the cost approximately 50% of the overall cost.
- Highest roll angle of the aircraft is 45º. If more than 45º rotation occurs, then it lost control.
- Since our radio controller's range is approximately 1 km so we cannot operate this vehicle beyond this range.
- Due to less storage capacity in Raspberry Pi we can only save or capture the data limitedly.
- If the frame rate of the camera is low, it provides noisy data (image/video) which leads to poor analysis of data

CHAPTER 6
USER MANUAL

6.1 Hardware

1. Arrange the frame in quad copter position.

2. Fix the panel to the frame.

3. Connect motors with ESC’s (2 corner cables are for current and middle one is for data transmission).

4. Repeat the same with all four motors.

5. Now attach the motors to the frame and connect the ESC’s to panel.

6. Place the ardupilot on top of the frame. Then connect the GPS module to it.

7. Put the battery in middle of the frame and connect to the panel.

8. Connect the camera to the Raspberry pi and attach them to the drone.

9. Finally fix the propellers to the motors (2 are clockwise and 2 are anticlockwise directions)

6.2 Software

1. Install mission planner in your laptop or desktop.

2. Connect the drone(ardupilot) to the computer using a USB cabel.

3. Transfer the Data by clicking on "Connect".

4. Check the confidence rate for GPS signal.

5. Go to setup and install the firmware

6. Go to mandatory hardware and calibrate the following:

    1. Frame type
    2. Initial parameter setup
    3. Accel Calibration
    4. Compass
    5. Radio Calibration
    6. Servo output
    7. ESC Calibration
    8. Flight Modes
    9. Fail Safe

7. Follow Chapter 3.3 for detailed calibration steps.

8. Install the Raspberry Pi OS into a micro SD card.

9. Connect the camera to the raspberry pi by enabling the camera in the interface option.

10. Open terminal and install all the required dependencies

11. For cloning Raspberry Pi Camera Stream Open up terminal and clone the Camera Stream repo: cd /home/pi

12. git clone https://github.com/EbenKouao/pi-camera-stream-flask.git

13. Launch Web Stream and Create an Autostart of the main.py script is recommended to keep the stream running on bootup.

14. sudo python3 /home/pi/pi-camera-stream-flask/main.py

15. Now Autostart your Pi Stream. A good idea is to make the the camera stream auto start at bootup of your pi.

16. You will now not need to re-run the script every time you want to create the stream.

17. You can do this by going editing the /etc/profile to: sudo nano /etc/profile

18. sudo python3 /home/pi/pi-camera-stream-flask/main.py

19. This would cause the following terminal command to auto-start each time the Raspberry Pi boots up. This in effect creates a headless setup - which would be accessed via SSH. Note: make sure SSH is enabled.

20. Open terminal and run this command-python camera.py

21. Copy and open the link in web browser

6.3 Readme

1. There are two throttles in Flysky radio left side throttle is used for up and down and right side throttle is used for left, right, front and back.

2. To start the drone place the left side throttle towards right side bottom corner for 5 seconds and to stop the drone place the left side throttle towards left side bottom corner for 5 seconds.

3. Place the drone at flat surface for comfortable take off.

4. Charge the battery before flight, we can check battery status in Flysky radio.

5. Avoid flying drone in rainy and windy days it may effect the components.

6. Gently rise the left throttle to take off the drone

7. Use the right side throttle to control the drone to move front, back, right and left.

8. Use both throttles to rotate the drone.

9. Prefer automatic landing rather than landing manually, sometimes manual landing may lead to damage of components.

10. If motor are not calibrated then off the battery and keep full speed to radio then after calibration turn down the radio.

11. If any of one of the motors is not working try to calibrate them individually. If its not working it means the component has damaged, replace the component with same version of component(refer component parameter table).

12. Due to vibrations in drone some screws get loose try to check and tight them after every flight.

CHAPTER 7

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