MINOR PROJECT REPORT

On

"Autonomous Agricultural Drone"

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Technology (B.Tech)

In the department of

Computer Science and Engineering

Submitted by:

Sunanda Jana (UG/02/BTCSE/2020/002)

Under the Guidance of

Debdutta Pal
Associate Professor
Computer Science and Engineering

School of Engineering and Technology
ADAMAS University, Kolkata, West Bengal

Jul 2023 – Dec 2023

CERTIFICATE

award This is to certify that the project report entitled ***"*Autonomous Agricultural Drone*"***, submitted to the School of Engineering and Technology (SOET), **ADAMAS UNIVERSITY, KOLKATA** in partial fulfilment for the completion of **Semester – 7th** of the degree of **Bachelor of Technology** in the department of **Computer Science and Engineering**, is a record of Bonafede work carried out by **Sunanda Jana**, UG/02/BTCSE/2020/002.**,** under our guidance.

All help received by us from various sources have been duly acknowledged.

No part of this report has been submitted elsewhere for of any other degree.

Debdutta Pal

(Professor)

Sayantan Singha Roy / Aninda Kundu

(Project Coordinator)

Dr. Sajal Saha

(HOD CSE)

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mentioning of the people whose constant guidance and encouragement made it possible. We take pleasure in presenting before you, our project, which is the result of a studied blend of both research and knowledge.

We express our earnest gratitude to our **Debdutta Pal (Assistant Professor)**, **Department of CSE**, for their constant support, encouragement and guidance. We are grateful for their cooperation and valuable suggestions.

Finally, we express our gratitude to all other members who are involved either directly or indirectly for the completion of this project.

DECLARATION

We, the undersigned, declare that the project entitled '**Autonomous Agricultural Drone**', being submitted in partial fulfillment for the award of Bachelor of Engineering Degree in Computer Science and Engineering, affiliated to ADAMAS University, is the work carried out by us.

Sunanda Jana
(UG/02/BTCSE/2020/002)

ABSTRACT

Autonomous agricultural drones that are equipped with cameras and telemetry modules have revolutionized precision farming. These drones have cutting-edge capabilities for disease detection, crop monitoring, and efficient pesticide application. These drones capture exact photos of crops using high-resolution cameras, allowing in-the-moment analysis of pest infestations, plant health, and growth patterns. The drones and ground control systems can seamlessly exchange data and plan missions thanks to the usage of telemetry modules.

Advanced algorithms and data analytics tools can be used to analyze the data gathered by the cameras and telemetry modules, giving important insights into crop health, disease trends, and yield forecasts. Informed decisions and focused interventions can then be carried out by farmers for improved crop management.

These autonomous agricultural drones have enormous potential benefits, but there are still issues that need to be resolved regarding precision navigation, obstacle avoidance, and battery life optimization. They can increase crop health, lower the need for pesticides, and boost overall farm productivity. For farmers to integrate technology effectively, user-friendly interfaces and training programs will be essential.

Agricultural drones that can fly themselves and are fitted with cameras and telemetry modules have a lot of potential for precision farming. These drones help to promote sustainable agricultural practices and guarantee food security by monitoring crops in real-time, identifying diseases, and applying pesticides effectively. The capabilities and broad use of these autonomous systems in the agriculture sector will be further enhanced by ongoing technological and scientific breakthroughs.

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CHAPTER 1
INTRODUCTION

1.1 Drone

An aircraft that functions without a human pilot on board is referred to as an unmanned aerial vehicle (UAV). It is widely used in many industries, including agriculture, surveying, mapping, delivery services, photography, and surveillance. There are many distinct types of drones, such as multirotor drones, winged drones, and hybrid drones with various functional qualities.

Frames, motors, propellers, flying controls, batteries, sensors, and cameras are some of the parts that make up a drone. Lift and propulsion are provided by the motor and engine, while the frame functions as the primary structural element. As the brain, flight control processes input and modifies motor speed to maintain stability and control. The drone is run by batteries, and sensors and cameras handle tasks including data collecting, obstacle avoidance, navigation, and placement.

Fig 1.1: Image of Drone

Drones have autonomous capabilities, navigation, flight control systems, and control inputs. Control input for altitude, direction, speed, and other flying parameters is provided by aircraft or autonomous systems. The drone is stabilized, and its intended flying characteristics are maintained via a flight control system that consists of sensors and flight controls. Using a GPS receiver and additional sensors, navigation and placement enable the drone to stay in one place, follow a course, or navigate on its own. Drones are used in many different sectors. They provide distinct viewpoints and images to films, real estate, tourism, and event coverage in aerial photography and videography. The drone's capacity to swiftly and precisely build 3D models and high-resolution maps is beneficial for jobs including mapping and surveying. Drones in agriculture aid in precision farming, focused sowing, crop monitoring, and resource efficiency as well as production gains. Drones assist with infrastructure inspections, search and rescue operations, environmental monitoring, and even parcel delivery. Drones are incredibly useful instruments in the business because of their efficiency and adaptability. It makes it possible to access difficult-to-reach places, delivers real-time data collecting, boosts security, and is an affordable option. We may anticipate more creative uses and extensive drone uses in the future as drone technology develops and laws change.

1.2 Application of Drones

Unmanned aerial vehicles, or UAVs, are another name for drones, and they are used in many different sectors. The pliable aircraft possess the capacity to operate independently or under remote control, and their small dimensions, exceptional agility, and sophisticated sensors make them indispensable tools in several domains. Below is a comprehensive overview of some important drone packages:

1. The field of airborne photography and filmmaking has been transformed by drones fitted with high-decision cameras. For filmmaking, real estate marketing and advertising, tourist merchandising, event coverage, and creative endeavors, they offer a wholly original viewpoint and produce stunning images. Drones make it possible for filmmakers and photographers to take amazing aerial shots and photos that would have been difficult or expensive to obtain otherwise.

Fig 1.2: Picture was taken from Drone.

2. Mapping, Surveying, and 3D Modeling: Drones have made significant advancements in these fields. Drones can quickly and safely cover large regions while taking high-resolution photos and gathering data for specific maps, topographic surveys, and three-dimensional

models. The fields that benefit most from this era's advancements include land surveying, infrastructure management, city planning, and mapping.

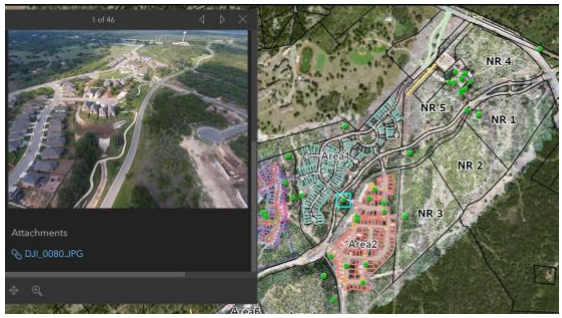

Fig 1.3: Drone mapping

3. Agriculture and Crop tracking: The use of drones in agriculture for crop health evaluation, precision farming, and crop monitoring is growing. Equipped with an array of sensors, including thermal or multispectral cameras, drones are able to gather data on crop health, pinpoint diseased or strained areas, expose irrigation systems, and assess fertilizer efficacy. With the use of this record, farmers may make informed decisions that maximize crop yields, reduce assistance waste, and apply focused treatments for plants that are healthier and more productive.

Fig 1.4: Drone in Agricultural Field

4. Drones are a critical component of search and rescue operations, particularly in hazardous or challenging terrain. Drones using infrared sensors, thermal imaging, and high-decision cameras can quickly cover broad areas in search of survivors or missing persons. They provide rescue squads with aerial viewpoints and real-time video feeds, which improves their ability to map operations and increases the likelihood of success.

5. Drones are an invaluable resource for environmental studies, following the natural world, and conservation initiatives. They may be used to monitor animal populations, assess habitat conditions, find and stop illegal activities like poaching and deforestation, and gather data on the quality of the air and water. Drones offer a valuable and non-intrusive method for monitoring and safeguarding biodiversity and ecosystems.

6. Drones are being used more and more for infrastructure assessments, which include buildings, pipelines, electricity lines, and bridges. They may get access to difficult-to-reach areas, take high-definition photos or videos, and deliver real-time information on structural integrity, damage assessment, and maintenance requirements. Drone inspections lower costs and improve universal infrastructure management since they are safer, more effective, and far less disruptive than traditional guide inspections.

7. Emergency management and catastrophe response: Drones are essential to these processes. In the appraisal of injury, they could swiftly identify, and map impacted regions, boundaries or perceived threats, and available resources. Drones equipped with thermal imaging cameras can assist in finding survivors, and when it comes to critical circumstances, their capacity to transmit real-time video feeds to command centers allows for better decision-making and resource allocation.

Fig 1.5: Drone delivering emergency medical.

8. Drones have gained popularity in recent years for the transportation industry. Drones are being investigated by companies such as Amazon and other logistics suppliers for ultimate-mile delivery. Especially in remote locations or during emergencies when traditional

transportation may be challenging, cargo drones provide the potential for faster and more flexible transit choices.

Fig 1.6: Drone delivery service

1.3 Different Types of Drones

1. **Multirotor Drones**: Drones with several rotors are the most ubiquitous and easily identifiable kind. It has several rotors, usually between four and eight, symmetrically organized. The drone's movement may be raised and manipulated by the rotors in different directions and at different speeds. Multirotor drones are perfect for tasks requiring stability and agility since they are incredibly maneuverable and can hover in the area. Multirotor drones are perfect for tasks requiring stability and agility since they are incredibly maneuverable and can hover in the area. They're typically used in aerial pictures, videography, inspections, and recreational flying.

Fig1.7: Image of a multi-rotor drone

2. **Fixed-Wing Drones:** Fixed-wing drones have a design just like traditional aero planes, with a hard and fast wing and a propulsion device that generates ahead thrust. It relies on aerodynamic carry to live in the air and requires continuous forward motion to keep carrying. Fixed-wing drones are recognized for their efficiency and long flight endurance, permitting them to cover massive regions in a single flight. It could fly at better speeds and take care of windy situations higher than multirotor drones. Constant-wing drones are commonly utilized in mapping, surveying, surveillance, and lengthy-range missions.

Fig 1.8: Image of Fixed-Wing Drone

3. **Hybrid Drones:** Hybrid drones combine the capabilities of each multirotor and fixed-wing design, supplying the benefits of each kind. It could take off and land vertically like multirotor drones, however, additionally transition into fixed-wing flight for improved variety and performance. Hybrid drones are versatile and appropriate for programs that require both vertical takeoff and landing abilities and longer flight periods. It is regularly utilized in obligations along with large-scale mapping, aerial inspections, and surveillance.

Fig 1.9: Image of Hybrid Drone

4. **Single-Rotor Helicopters:** Single-rotor helicopters, additionally called single-rotor drones, have a layout much like traditional helicopters. It functions as one massive rotor on top and a smaller tail rotor to counteract torque. Single-rotor drones offer more balance and payload ability in comparison to multirotor drones however require greater skill to operate. It is normally used in expert programs including aerial photography, videography, industrial inspections, and seek and rescue operations. Because of its ability to carry heavier payloads and preserve stability in hard situations, it may be favored for specialized missions.

Fig 1.10: Image of Single-Rotor Helicopter

5. **Nano and Micro Drones:** Nano and micro drones are the smallest and lightest types of drones, frequently weighing less than 250 grams. They're compact in size, typically palm-sized or smaller, and designed for indoor or near-quarters flying. Nano drones are popular for recreational use, while micro drones discover packages in research, education, and swarm-primarily based operations. Despite their small length, they could nonetheless bring lightweight cameras and sensors, making them appropriate for shooting specific perspectives in tight areas.

Fig 1.11: Image of Nano Drone

CHAPTER 2
LITERATURE REVIEW

Agricultural drones have emerged as a promising technology in modern farming practices, offering potential benefits such as crop monitoring, precision spraying, mapping, and data collection. This literature review explores the perspectives and findings from several research papers focused on agricultural drones, covering various aspects including platforms, control systems, applications, and their impact on precision agriculture.

- "Unmanned Aerial Vehicles in Agriculture: A Review of Perspective of Platform, Control, and Applications" by Jeongeun Kim et al. (2019): The paper provides an extensive review of agricultural drones, discussing different types of platforms, control mechanisms, and applications in farming. It emphasizes the need for reliable flight control systems and highlights the potential of drones in crop monitoring, yield estimation, and pest management [1].

- "Drones for Smart Agriculture: A Technical Report" by D.R. Kurkute et al. (2018): This technical report focuses on the application of drones in smart agriculture. It discusses the use of drones for crop health monitoring, fertilizer and pesticide spraying, and data analytics. The authors provide insights into the challenges and future prospects of drone technology in agriculture [2].

- "Implementation of Drone Technology for Farm Monitoring and Pesticide Spraying" by Abdul Hafeez et al.: The paper explores the implementation of drone technology for farm monitoring and pesticide spraying. It discusses the benefits of using drones for crop health assessment, weed detection, and targeted pesticide application. The authors highlight the potential cost and time savings associated with drone-based spraying systems [3].

- "Mapping and 3D Modelling using Quadrotor Drone and GIS Software" by Widodo Budiharto et al. (2021): This study focuses on mapping and 3D modelling using quadrotor drones and GIS software. It presents the workflow of capturing aerial imagery, processing data, and generating accurate 3D models of agricultural areas. The authors highlight the potential of drones in precision agriculture and land management [4].

- "Drones in Agriculture: A Review and Bibliometric Analysis" by Abderrahman Rejeb et al.: The paper provides a comprehensive review and bibliometric analysis of drones in agriculture. It covers various aspects such as applications, benefits, challenges, and future trends. The authors analyze the existing literature and identify research gaps and emerging research directions in the field [5].

- "Review on Application of Drone Systems in Precision Agriculture" by Umamaheswara Rao Mogili et al.: This review paper focuses on the application of drone systems in precision agriculture. It discusses the use of drones for crop monitoring, irrigation management, disease detection, and yield estimation. The authors emphasize the role of drones in optimizing resource utilization and improving farm productivity [6].

- "Design and Development of an Autonomous Hexacopter for Agricultural Applications" by Kumar et al. (2016): This paper presents the design and development of an autonomous hexacopter specifically tailored for agricultural applications. It discusses the system architecture, sensor integration, and autonomous flight control algorithms. The authors emphasize the potential of the hexacopter for tasks such as crop monitoring and spraying [10].

- "Design and Implementation of an Autonomous Agricultural Drone" by Kołodziejczyk et al. (2016): The paper focuses on the design and implementation of an autonomous agricultural drone. It discusses the drone's hardware and software components, including flight control, navigation, and payload integration. The authors highlight the importance of autonomy for efficient and precise agricultural operations [11].

- "Agricultural Drone for Crop Protection and Pest Control" by Ayyoubzadeh et al. (2016): This paper explores the use of agricultural drones for crop protection and pest control. It discusses the integration of different technologies, such as multispectral imaging and precision spraying systems, to effectively monitor and manage crop health. The authors highlight the potential of drones in reducing pesticide usage and improving crop yield [12].

- "Design and Construction of a Low-cost Agricultural Drone for Crop Monitoring" by Jadhav et al. (2021): This paper focuses on the design and construction of a low-cost agricultural drone for crop monitoring. It discusses the selection of components, flight control systems, and image processing algorithms. The authors highlight the affordability and accessibility of drones for small-scale farmers [14].
- "Development of an Autonomous Crop Surveillance Drone for Precision Agriculture" by Kolluru et al. (2022): The paper presents the development of an autonomous crop surveillance drone for precision agriculture. It discusses the integration of advanced sensing and imaging technologies, as well as the autonomous navigation system. The authors emphasize the drone's potential in collecting data for yield estimation and crop management [15].

- "Development of an Autonomous Multi-rotor Drone for Precision Agriculture" by Patil et al. (2020): The paper focuses on the development of an autonomous multi-rotor drone specifically designed for precision agriculture. It discusses the integration of sensors, image processing algorithms, and autonomous navigation. The authors highlight the drone's potential in providing real-time information for crop health assessment and decision-making [17].

CHAPTER 3
MOTIVATION AND PROBLEM STATEMENT

3.1 Motivation

Developing an autonomous agricultural drone with a camera offer numerous compelling motivations. Here are some key reasons why pursuing such a project can be highly beneficial:

- **Enhanced Efficiency:** By integrating autonomous capabilities and a camera, the agricultural drone can efficiently survey large areas of farmland. It can capture high-resolution images or videos, allowing farmers to assess crop health and make informed decisions quickly. This reduces the time and effort required for manual inspections, leading to increased operational efficiency.
- **Precision Agriculture:** Equipped with a camera, the autonomous agricultural drone enables precision agriculture techniques. Farmers can analyze the captured visual data to identify specific areas that require attention, such as pest infestations, nutrient deficiencies, or irrigation issues. This precise targeting optimizes resource allocation, minimizes wastage, and improves overall crop productivity.
- **Early Detection of Crop Issues:** The camera-equipped drone can detect crop issues in their early stages, enabling proactive measures. By capturing images from above, the drone can identify subtle changes in vegetation patterns, color variations, or stress indicators. Early detection allows farmers to take prompt action, preventing further damage and yield loss.
- **Crop Monitoring and Mapping**: An autonomous drone with a camera can regularly survey farmland, capturing images or videos for crop monitoring. These visuals can be processed to create accurate crop maps, providing insights into crop health, growth rates, and spatial variations. Farmers can leverage this information for effective decision-making, including irrigation planning, fertilizer application, and yield estimation.
- **Cost-Effectiveness:** Implementing an autonomous agricultural drone with a camera offers cost-effective solutions for farm management. Drones can cover larger areas more quickly and at a lower cost compared to traditional methods. They reduce the need for manual labour and expensive equipment, resulting in operational cost savings. Targeted interventions also minimize the use of chemicals and inputs, optimizing resource utilization.

- **Environmental Sustainability:** The use of an autonomous agricultural drone promotes sustainable farming practices. Precise data collection enables farmers to optimize resource usage, reducing environmental impact. Early detection of crop issues allows for targeted treatments, minimizing the need for widespread pesticide application. This promotes environmentally friendly farming practices and reduces chemical usage.
- **Technological Advancement:** Developing an autonomous agricultural drone with a camera contributes to technological progress. It pushes the boundaries of automation, computer vision, and artificial intelligence in agriculture. This project encourages innovation, collaboration, and the adoption of advanced technologies in the farming sector.

In conclusion, the motivation to develop an autonomous agricultural drone with a camera lies in its potential to enhance efficiency, enable precision agriculture, detect crop issues early, provide detailed crop monitoring, offer cost-effective solutions, promote environmental sustainability, and contribute to technological advancement. By harnessing the capabilities of drones and cameras, farmers can make data-driven decisions, optimize farm management practices, and ultimately improve crop yield and quality.

3.2 Problem Statement

Traditional farming methods lack real-time data and precision, resulting in suboptimal decision-making, inefficient resource allocation, and potential yield losses. Limited access to detailed information on soil conditions, moisture levels, and crop health hampers precision agriculture practices. There is a need for a small, smart agricultural drone with advanced sensors, imaging technologies, and data analytics capabilities to address these challenges. The drone would enable real-time crop monitoring, accurate data collection, and analysis for precise decision-making. By providing farmers with vital information on crop health, soil conditions, and environmental factors, the drone would empower them to optimize resource allocation, implement targeted interventions, and improve overall productivity and sustainability. Technical challenges include sensor integration, data processing, autonomous navigation, and communication with a ground control system. Developing a small, smart agricultural drone with user-friendly interfaces is crucial for effective utilization by farmers. This innovation has the potential to revolutionize the agricultural industry, promoting sustainable farming practices and efficient resource management.

CHAPTER 4
HEXACOPTER

4.1 Introduction

A hexacopter is a type of drone that functions with six rotors organized in a symmetrical configuration. it's far a famous and versatile desire amongst drone lovers and experts because of its better stability, payload potential, and maneuverability in comparison to quadcopters (four rotors) and different smaller drones. The term "hexa" refers to six, reflecting the six motor and rotor assemblies that propel and manipulate the drone.

Fig 4.1: Image of Hexacopter

4.1.1 Configuration and layout:

- Hexacopters feature a symmetrical association of six rotors, flippantly spaced round a crucial frame.
- The rotors are commonly installed on personal motor arms extending outward from the main frame, ensuring equal distribution of lift.
- The relevant frame frequently homes the flight controller, electricity distribution board, and different digital components.

Hexacopters can range in length, from compact purchaser-grade fashions to large expert-grade drones with extended motor hands for expanded stability and payload capacity.

4.1.2 Flight traits:

- Hexacopters provide advanced stability and control compared to quadcopters and smaller drones.
- The six rotors generate a more balanced carry distribution, ensuing in smoother and greater solid flight performance.
- This stability is beneficial for responsibilities that require maneuvering and constant aerial pictures, such as professional images, videography, and cinematic programs.
- Hexacopters are also known for their agile flight skills, allowing for actions, brief turns, and rotations.

4.1.3 Payload capacity and camera Stabilization:

- Hexacopters have a higher payload capacity in comparison to smaller drones, thanks to the additional rotors and larger body size.
- They can deliver heavier cameras and systems, together with expert-grade DSLR cameras or specialized sensors for mapping, surveying, and inspections.
- To ensure strong and shake-free pictures, many hexacopters come equipped with superior digital camera stabilization structures, including 3-axis gimbals.
- These gimbals actively counteract undesirable movement, imparting easy and expert-quality aerial pictures.

4.1.4 Applications

- Hexacopters locate programs across numerous industries and sectors.
- In aerial pictures and videography, they are used for shooting beautiful aerial shots, cinematic sequences, and panoramic views.
- Professional filmmakers regularly depend upon hexacopters for aerial cinematography in films, documentaries, and commercials.
- Hexacopters are also applied in industries together with infrastructure inspection, agriculture, search and rescue, environmental monitoring, and surveillance.
- Their balance, payload potential, and manoeuvrability cause them to have valuable gear for collecting facts, carrying out inspections, and tracking big areas.

4.1.5 Protection and Redundancy:

- Hexacopters offer improved safety and redundancy as compared to quadcopters.

- The additional rotors provide redundancy in case of a motor or rotor failure, permitting the drone to retain flying and land adequately.
- This redundancy feature enhances flight safety and reliability, mainly in crucial operations or whilst carrying luxurious gadgets.

4.1.6 Law and Licensing:

- It is critical to notice that running a hexacopter or any drone is a problem to local policies and airspace restrictions.
- Pilots may additionally need to obtain suitable licenses or certifications, adhere to flight restrictions, and comply with safety tips set with the aid of the aviation government.

4.2 Components

The hexacopter is made up of many key components that work together to ensure its flight and performance. Here are the main components of the hexacopter:

4.2.1 Frame:

The frame acts as the basic structure of the hexacopter that holds everything together. They are usually made of heavy and durable materials such as carbon fiber or aluminum alloy frame.

It provides ports for motors, fans, electronics and charging.

The frame used in this project is mentioned below:

- Model Name - Tarot FY680
- size: 680mm
- Weight: 600g
- Height from ground to lower rods: 180mm
- Height from ground to top: 220mm.
- Propeller size: 10~13-inch carbon fibre propeller
- Motor: 620~980KV 2212~4006 brushless motor
- Battery specifications: 11.1~14.8V 3000~5000mAh
- Brushless ESC: 20~30A

Fig 4.2: Tarot FY680 Frame

4.2.2 Flight Controller:

- The flight controller is the central processing unit of the hexacopter, liable for stability, management, and navigation.
- It includes a microcontroller with an integrated gyroscope, accelerometer, and sometimes a magnetometer.
- The flight controller receives data from those sensors to decide the hexacopter's orientation, movement, and environmental situations.
- Primarily based on this information, it calculates and adjusts the motor speeds via the ESCs to preserve balance and manage the hexacopter's flight.
- Advanced flight controllers may additionally consist of additional features like GPS navigation, altitude hold, and independent flight modes.

The Flight Controller used in this project is mentioned below:

- Model Name: Radiolink Pixhawk 4
- Advanced 32-bit CortexM4 ARM high-performance processor, and 32-bit STM32STMF100 failsafe co-processor.
- Multiple flight mode switches freely, Helicopter, Fixed-wing, Multi-rotor, Model Car.
- All interfaces are fully tested and accurately detected by an automatic detection system, avoiding bad interfaces leading to flight control installation unsuccessfully.
- Support DSM Spektrum receiver.
- Multi-sound buzzer interface support.
- Multiple flight modes, support for self-stability, height-set, hover, sports, freestyle,

circling, following, return, guidance, automatic, and all-powerful.

- Abundant connectivity options for additional peripherals (GPS, I2C, SPI).
- 14 PWM / servo outputs (8 with failsafe and manual override, 6 auxiliary, high-power compatible).
- Providing a multi-sound buzzer interface.
- Sensors: MS5611 barometer senso, IST8310 is a three-axis digital gyroscope, E-compass triaxial accelerometer: IST8310, MPU6000 is a six-axis accelerometer (gyro).

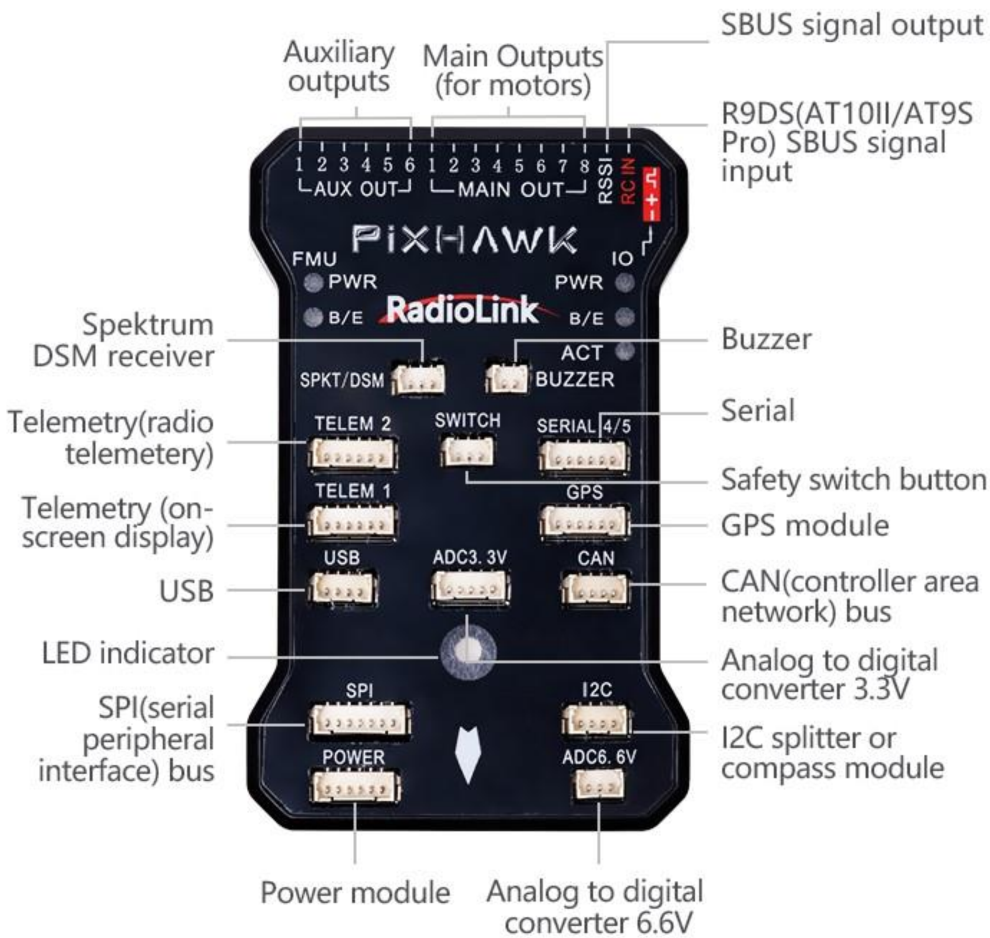

Fig 4.3: Radiolink Pixhawk Flight Controller

4.2.3 Motors and Propellers:

Hexacopter has six brushless motors, one for each rotor. These motors generate the power needed to lift and propel the hexacopter. Motors are generally rated according to their size, power and maximum RPM (revolutions per minute). Each motor is connected to a propeller that turns the rotational motion into thrust. Propellers vary in size and pitch, which affects the performance, payload and characteristics of the hexacopter.

The motors used in the project are mentioned below:

- Model Name: Flyrobo 750kv BLDC Motor
- Size: 50*10mm
- Weight: 80g
- Shaft Size: 4mm
- ESC: 20-40A
- Thrust: upto 1.5KG with 4S Li-po Battery

Fig 4.4: 750KV BLDC Motor

The propellers used in the project are mentioned below:

- Model Name - Xbotics 1355 Carbon Fiber Propeller
- Length: 13inch

- Pitch: 5.5inch
- Weight: 15g
- Shaft Diameter: 4mm
- Cover Plate Hole Centers: 12mm

Fig 4.5: Carbon Fiber Propeller

4.2.4 Radio Transmitter and Receiver

The radio transmitter is a hand controller used by the pilot to wirelessly send control commands to the hexacopter. Transmitter works on a special radio and sends the signal to the receiver mounted on the hexacopter. The receiver decodes these signals and sends them to the flight controller, which converts them into engine control signals. The Transmitter-Receiver System allows the pilot to control hexacopter movements such as throttle, yaw and roll.

The Transmitter used in the project is mentioned below:

- Model Name: FlySky FS-i6
- Channel: 6
- Frequency: 2.408 - 2.475GHz
- Bands: 135
- Bandwidth: 500 KHz
- RF power: <20dBM
- Protocol: AFHDS 2A
- Modulation Type: GFSK
- Power Input: 6V DC

Fig 4.6: Flysky FS-i6 Transmitter

The Transmitter used in the project is mentioned below:

- Model Name: Flysky FS-iA6B
- PWM Channel: 6
- Protocol: AFHDS 2A
- Range: 500-1500m
- Data Port: PWM, PPM, i.bus, s.bus
- RSSI: Supported

Fig 4.7: Flysky FS-iA6B Receiver

4.2.5 Electronic Speed Controllers (ESC):

ESCs are critical components that control the speed and rotation of the motor. They receive signals from the flight controller and adjust the power supplied to each engine. ESCs provide synchronous and precise motion control, allowing the hexacopter to operate smoothly and maintain stability. ESC also provides features such as motor braking and battery voltage monitoring for safety and efficiency.

The ESC used in the project is mentioned below:

- Model Name: ReadytoSky 40A ESC
- Constant Current: 40A
- Burst Current: 60A.
- Battery: 2-6S
- Firmware: Hobbywing Xrotor 40A

Fig 4.8: ESC

4.2.6 GPS:

- **Accurate Positioning:** Drone GPS modules provide precise location data by receiving signals from GPS satellites.
- **Navigation Capabilities**: With a GPS module, drones can navigate along pre-programmed waypoints and follow specific flight paths.
- **Autonomous Flight:** GPS modules enable drones to perform autonomous flights, executing missions without manual piloting.
- **Return-to-Home:** GPS modules allow drones to automatically return to their takeoff location if the signal is lost or on low battery.
- **Geofencing:** GPS modules enable geofencing, creating virtual boundaries to restrict the drone's flight within designated areas.
- **Integration:** GPS modules integrate with the drone's flight controller, providing positioning data for enhanced flight control.
- **Enhanced Safety:** GPS modules contribute to safe drone operations by providing accurate positioning and navigation information.

The GPS used in the project is mentioned below:

- Model Name: Radiolink SE100
- GPS decoder chip: Radiolink M8N GPS, with u-blox UBX-M8030(M8)
- 72 Channels
- Geomagnetic: HMC5983 from Honeywell
- Antenna: 2.5dbI high gain and selectivity ceramic antenna
- Max height: 50000m
- Max update rate: up to 10Hz
- Positional Accuracy: 50-centimetre precision when working with concurrent GNSS.
- Voltage 5VDC+-5%
- Current 50~55mA

Fig 4.9: Radiolink SE100 GPS Module

CHAPTER 5
TELEMETRY AND GROUND STATION

5.1 Telemetry Module

Telemetry plays a very important role in Drone. It is helpful in order to control the drone autonomously and collect important flight data. Different Telemetry module uses different protocols for communication.

Fig 5.1: Telemetry Module

Telemetry within the context of drones refers to the gathering, transmission, and reception of real-time facts between the unmanned aerial automobile (UAV) and the ground control station (GCS). It permits operators to display the drone's status, performance, and environmental conditions for the duration of the flight. right here are distinct insights into telemetry:

Numerous communique protocols are used for transmitting telemetry facts, along with MAV Link, which is a lightweight messaging protocol widely used in the drone enterprise. MAV Link permits efficient statistics alternate and helps an extensive variety of facts, along with flight manage commands, sensor data, and gadget status.

- **Telemetry records content material:** The telemetry statistics transmitted from the drone to the GCS includes critical flight parameters like GPS coordinates, altitude, speed, roll, pitch, yaw, battery voltage, modern-day intake, signal energy, temperature, and more. The data

- **Data collection**: Telemetry module gathers information from diverse sensors and onboard additives of the drone, which includes GPS, altimeters, gyroscopes, accelerometers, compasses, battery monitors, and greater. these sensors offer critical information about the drone's position, altitude, velocity, orientation, battery stage, sensor readings, and other flight parameters.
- **Data Transmission:** Telemetry records are transmitted wirelessly from the drone to the ground station in real time. Its miles are commonly completed using radio frequency (RF) communique, consisting of the famous 2.4 GHz or 5.8 GHz frequency bands. The data are modulated and transmitted through radio transmitters and receivers, making sure of a solid and dependable connection between the drone and the GCS.
- **Telemetry Protocols:** It is constantly up to date and offers operators real-time facts about the drone's reputation.
- **Ground Control Station display:** The GCS software program offers the received telemetry statistics in a user-pleasant interface. It gives operators visualizations, graphs, and numerical values, allowing them to monitor the drone's flight parameters and make knowledgeable decisions based totally on the data supplied.
- **Indicators and Notifications:** Telemetry structures can generate indicators and notifications based totally on predefined thresholds or unusual situations. as an example, low battery voltage, GPS sign loss, or exceeding specific altitude limits can cause alerts at the GCS, enabling operators to take important moves or modify the drone's flight parameters.
- **Telemetry Logging:** Telemetry systems frequently offer the capability to log and file the obtained facts throughout the flight. This facts logging permits operators to research flight performance, troubleshoot issues, and behavior post-flight evaluation for optimization and development.
- **Variety and Reliability:** The variety of telemetry transmission relies upon on numerous elements, such as the communication protocol, antenna fine, power output, and capability obstacles inside the signal route. it's miles vital to hold a reliable connection between the drone and the GCS in the operational variety to ensure continuous telemetry conversation.

- Telemetry plays a critical position in drone operations by offering operators with real-time facts approximately the drone's flight parameters, performance, and environmental situations. It enhances situational recognition, permits efficient manipulation, and facilitates the safe and effective execution of drone missions.

5.2 Ground Control Station

A ground control station (GCS) is a system or software used to remotely monitor, control, and communicate with an unmanned aerial vehicle (UAV) or unmanned aerial vehicle (UAV). It works as the central command centre for drone operations, providing operators with real-time information and control capabilities.

- **Hardware and Software components**: A GCS typically consists of hardware and software components. A device may contain a computer or special controller and input devices such as joysticks, switches, and buttons. The software is the interface on the computer or controller that allows the operator to communicate with the drone and receive telemetry data.
- **Telemetry and data display:** GCS receives telemetry data from the drone, including position, altitude, speed, battery status, sensor readings, and other flight parameters. This information is presented in a user-friendly interface, often displayed as graphs, charts, maps, or numerical values, providing real-time information about the drone's status and performance.
- **Mission Planning and Execution:** GCS enables operators to plan, design and execute unmanned aircraft. Operators can determine waypoints, determine flight parameters, determine flight paths, and action plans related to the mission. GCS enables drones to perform autonomous missions by following pre-programmed commands.

Fig 5.2: Ground Control Station

- **Flight control and navigation:** Operators can control drone flight using GCS. It can take off, land and take manual control if necessary. GCS provides drone control input by adjusting position, altitude and direction. It also facilitates waypoint navigation by ensuring that the drone follows a specified flight path.
- **Load control:** Most GCS systems allow operators to control unmanned load carriers or sensors. This includes adjusting camera settings, initiating image or video capture, and managing other payload operations based on mission requirements.
- **Safety Features**: GCS systems often include safety features to ensure the operation of unmanned drones. This can include geofencing, which creates a virtual boundary to restrict drones from flying in a designated area. It can also provide alerts and warnings for critical events such as low battery, loss of signal, or exceeding the altitude limit.
- **Telemetry Logging and Analysis:** GCS systems often have the ability to log telemetry data received from the drone. These logs can be used for post-mission analysis, troubleshooting, and performance evaluation. Operators can review flight data to identify problems or anomalies and improve future missions.
- **Integration and compatibility**: The GCS system is designed to be compatible with various drones and autopilot systems. It can integrate with various drone platforms and communication protocols, providing seamless communication and control between GCS and drones.

- **Remote Monitoring and Surveillance**: GCS systems often incorporate video streaming capabilities, allowing operators to view live video feeds from the drone's onboard camera or other payload sensors. This enables real-time monitoring and surveillance, making it useful for applications such as aerial inspections, search and rescue operations, and security monitoring.
- **Advanced Mission Planning:** Some GCS systems provide advanced mission planning features, including complex waypoint navigation, automated survey patterns, and multi-drone coordination. Operators can create intricate flight paths, define specific actions at each waypoint, and orchestrate collaborative missions involving multiple drones for enhanced efficiency and coverage.
- **Data Analysis and Visualization:** GCS software often includes tools for data analysis and visualization. Operators can review flight data, sensor readings, and mission results, helping them assess performance, identify trends, and extract valuable insights. This data analysis capability aids in optimizing drone operations and decision-making for future missions.

For this project, we have chosen Qgroundcontrol Software as our Ground control Station. It is an open-source software with many advantages. It is available for all platforms and supports PX4 and Mav link.

Fig 5.3: Qgroundcontol

CHAPTER 6
BLOCK DIAGRAM AND WORKING PRINCIPLE

6.1 Block Diagram

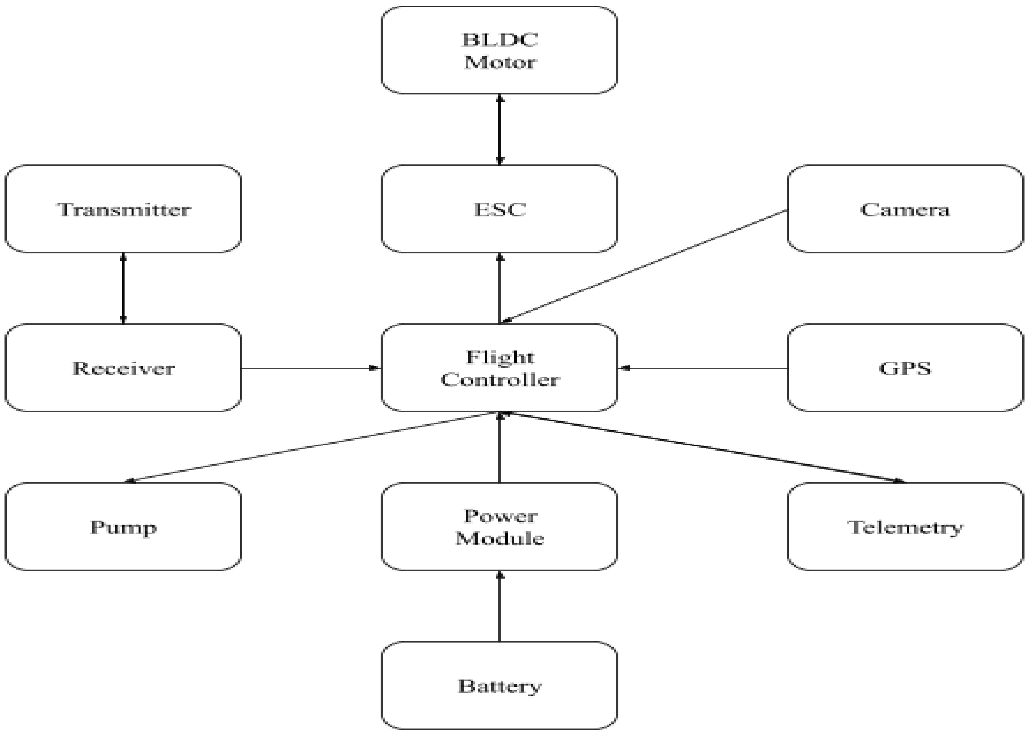

Fig 6.1: Block Diagram of Drone

6.2 Working Principle

- Flight Controller is the heart and brain of the drone. In our project, we used a Radiolink Pixhawk flight controller. All the processing is done inside the PX4. It has all the necessary sensors build-in like an accelerometer, gyro, and barometer. These sensors help to maintain a stable flight in mid-air.
- Flight Controller receives signals from the receiver. The pilot controls the drone manually with the help of a transmitter. The receiver gets those signals and sends them to the controller.

- PX4 then process the control signals and controls the motor with the help of ESC. The flight controller communicates with the ESC mounted on the drone's motor. Based on the received control signals, the flight controller adjusts the power and speed of each motor by sending commands to their respective ESCs. These controls allow the drone to change altitude, move forward or backwards, and rotate.
- GPS module provides the exact position of the drone to the controller. The module determines the drone's latitude, longitude, and altitude by using signals from several satellites. In order to locate the drone and follow pre-established flight routes or waypoints, the flight controller continually receives this data.
- The drone's battery voltage is monitored by the power module. It continually transmits voltage data to the flight controller, enabling it to keep track of the battery's condition and predict how much longer the flight will go. The flight controller initiates a failsafe mechanism, such as starting a return to home or landing procedure, if the voltage falls below a safe level, to ensure the drone is operated safely.
- Camera provides the live footage of the field.
- Telemetry Module is connected to the ground station. From there we can plan a mission for the drone and upload it without being directly connected to the drone.
- When the pump trigger is pulled from the transmitter, the pump starts.

CHAPTER 7
SET UP AND CONFIGURATION

7.1 Mission Planner

Mission Planner is a ground control station software used for autonomous mission planning and control of drones. It allows users to plan missions by defining waypoints and flight parameters on a map interface. During the mission, real-time telemetry data is displayed, including the drone's position, altitude, speed, and battery status. Setup > Optional Hardware Planner also supports geofencing, payload control, and data analysis. It is compatible with various drone platforms and autopilot systems, making it a valuable tool for mission management and control.

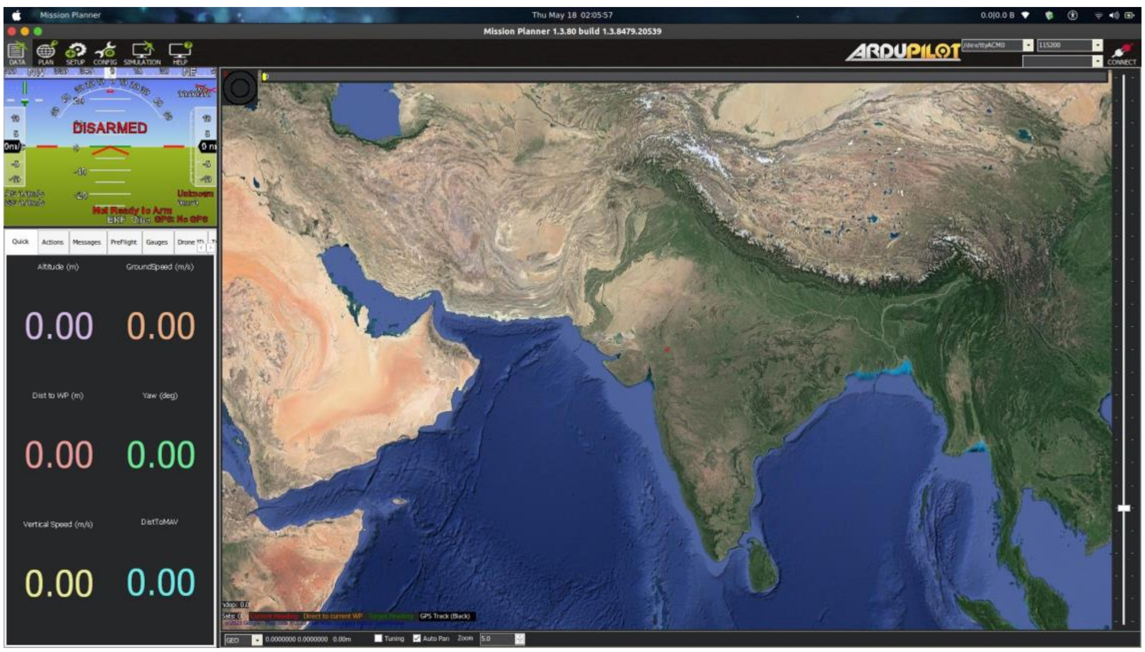

Fig 7.1: Mission Planner Software

- **Mission Planning:** Mission Planner provides a user-friendly interface that allows operators to plan and design autonomous missions for their drones. It offers various tools for defining waypoints, setting flight parameters, and configuring mission-specific actions.

- **Waypoint Navigation:** Users can define waypoints on a map, specifying the drone's desired path, altitude, and speed. Mission Planner calculates the mission route based on these waypoints, allowing the drone to autonomously navigate along the planned path.
- **Mission Monitoring:** During the mission, operators can monitor the drone's real-time telemetry data, including its position, altitude, speed, battery status, and sensor readings. This information helps ensure the mission's progress and allows for immediate action if any issues arise.
- **Payload Control:** Mission Planner enables control over the drone's payload, such as cameras or sensors. It allows operators to adjust camera settings, trigger image capture, or control other payload operations based on mission requirements.
- **Geofencing and Safety Features:** Mission Planner supports geofencing, allowing operators to define virtual boundaries for the drone's flight area. It helps prevent the drone from entering restricted or no-fly zones, enhancing flight safety and regulatory compliance.
- **Data Analysis:** After completing a mission, Mission Planner provides tools for analyzing and reviewing mission data. Operators can review flight logs, analyze sensor data, and evaluate mission performance for future optimizations.
- **Firmware and Parameter Configuration:** Mission Planner facilitates the management of firmware updates for the drone and its components. It also allows operators to configure various parameters, such as flight modes, control settings, and advanced features specific to the drone's platform.
- **Compatibility and Integration:** Mission Planner supports a wide range of popular drone platforms and autopilot systems, including ArduPilot and Pixhawk. It provides a versatile platform for managing different drone models and configurations.

7.2 Initial Setup

One of the biggest advantages of using Mission Planner is that it is open Source. So it is a great option for students to test and build a drone with this platform. Another major advantage is that it supports Pixhawk. So, it's easy to program the Flight Controller with the Mission Planner. For that reason, we have used Mission Planner to program our Dorne.

- **Step 1:** First it is required to install the proper firmware to the flight controller. Most of the time Pixhawk comes with pre-loaded firmware. But it is good practice to install the latest firmware whenever we start to build any drone. Here also we have installed the latest firmware available through Mission Planner. To do this first, connect the Radiolink Pixhawk flight controller with the PC with the provided Micro USB cable.

- **Step 2:** Now select the **setup** option. Then go to **Install Firmware** and select the hexacopter with the version **Copter V4.3.6 official**. This will install the firmware in Pixhawk. Do not click **Connect** button before installation.

Fig 7.2: Image of installing firmware

- **Step 3:** Now click **Connect** button. It will take around 30-45 Seconds to connect.
- **Step 4:** Now it is ready for Calibration. Go to **Setup** > **Mandatory Hardware.** Here first we must do Accel Calibration. Click on the Accel Calibration and follow the on-screen instructions.
- **Step 5:** Next we must calibrate Compass. To do that we have to get a proper GPS signal. So, it is recommended to perform the task in the open field. Same as Accel Calibration, Click Compass Calibration. Then select Live calibration. Now move and rotate the drone until it's complete. When it's done Pixhawk will give a signal.
- **Step 6:** Now calibrate the Radio.
- **Step 7:** Lastly, we have to assign the Failsafe triggers according to our requirements.

7.3 Telemetry Setup:

- **Step 1:** With the help of Telemetry, we can get the flight information. Also, we can calibrate the drone without connecting it directly to our PC. First, connect the Ground Module to the PC. Go to Setup> Optional Hardware.

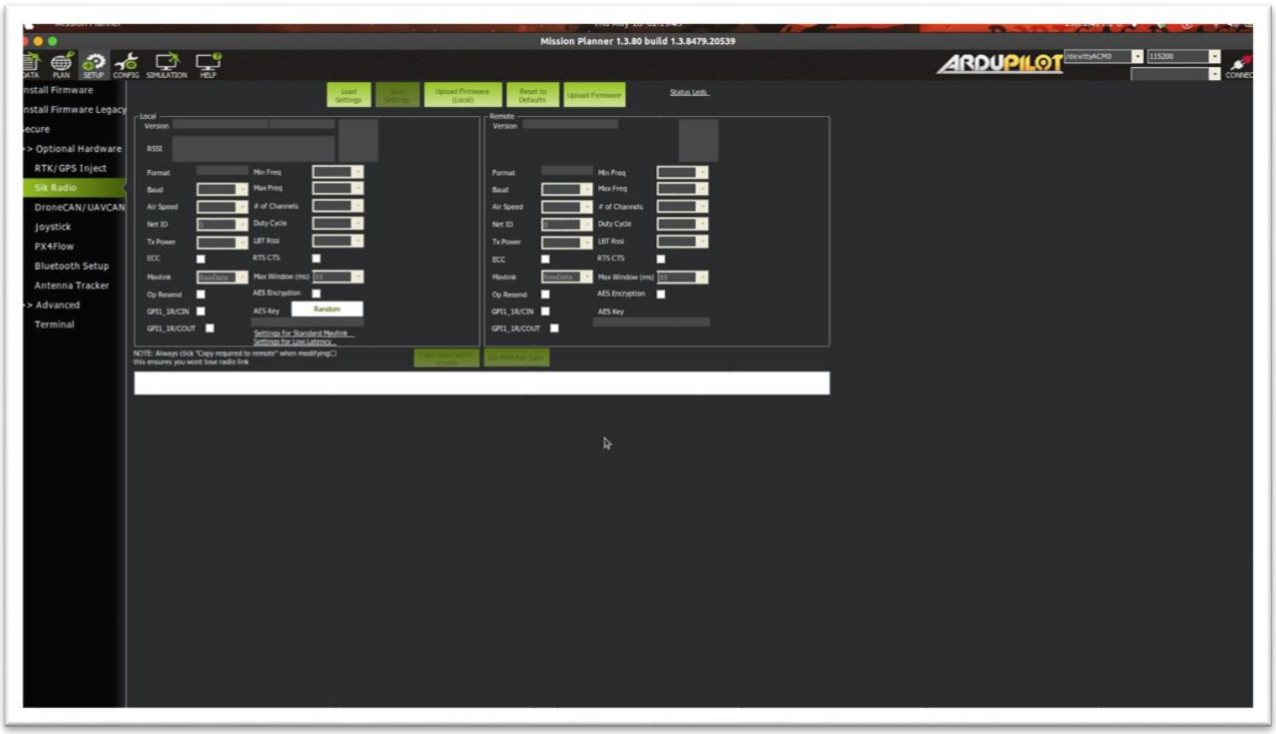

Fig 7.3: Telemetry Setup

- **Step 2:** Select Sik Radio.
- **Step 3:** Click Load Settings. It will load the ground module to the Mission Planner.
- **Step 4:** All the cells will populate with values.
- **Step 5:** After making the necessary changes, click save settings.

CHAPTER 8

REAL WORLD TESTING

8.1 Introduction

Testing a drone using Mission Planner and QGroundControl is essential for assessing its usefulness and performance. Assuring a secure and effective flight experience, it enables the evaluation of flight stability, responsiveness, altitude hold accuracy, adherence to flight modes, and the validation of programmed features. The information acquired and observations made during testing allow for the enhancement of the hexacopter's operation and design.

The software tools for ground control stations used to test and monitor drones include Mission Planner and QGroundControl. They offer a thorough interface that allows for real-time telemetry data streaming, flight parameter tuning, and mission planning when interacting with the Pixhawk Radiolink flight controller and a telemetry module. These software programmes provide a wealth of functionality, including data logging, sensor calibration, waypoint navigation, and flight mode selection, allowing users to assess and improve the hexacopter's performance. They also offer a user-friendly interface for keeping an eye on important flight metrics and performing post-flight analysis for performance assessment and problem-solving.

8.2 Pre-testing Preparation

Ensuring a suitable outdoor testing area away from obstacles and populated areas is crucial in pre-testing preparations for a drone. It minimizes the risk of accidents or collisions with structures, vehicles, or people, promoting safety during the testing phase. An open and unobstructed area provides ample space for maneuvering and evaluating the drone's flight capabilities, allowing for better control and reducing the likelihood of interference or accidents.

Then We make sure the drone is entirely put together and all parts are firmly fastened. Before each flight, Give the drone a visual inspection before each flight to ensure that all propellers are installed, fastened, and free of any loose or damaged blades. then look to see whether the frame, arms, or landing gear exhibits any signs of instability or cracks. Ensure that all wiring connections, including those for the motors, electronic speed controllers, and flight controller are secure and free from exposed wires and loose connections.

It's crucial to double-check the physical connections and power sources to make sure the Pixhawk Radiolink flight controller and telemetry module have correct connectivity and power. Make sure that every cable is firmly attached to the appropriate ports on the telemetry module and flight controller. Additionally, make sure that the voltage range indicated by the manufacturer is adhered to and that the power supply for the telemetry module and flight controller is steady. For dependable connectivity and precise telemetry data transmission during the drone testing process, proper connection and power supply are crucial.

8.3 Powering on and Connecting

Power on the hexacopter and the ground control station computer then connect the telemetry module to the computer using a USB cable and launch Mission Planner or QGroundControl on the computer.

8.4 Establishing Communication

We choose the proper COM port for the telemetry module connection in Mission Planner or QGroundControl. Following that, click the "Connect" option to create a link between the flight controller and the ground control station.

8.5 Verifying Telemetry Connection

Examine the telemetry status on the ground control station interface to verify the connection's success. It displays essential telemetry data and indicates a stable connection.

8.6 Pre-Flight Checks:

To make sure the drone is ready and safe for flight, pre-flight inspection is crucial. Propellers should be inspected for damage or imbalance, motors should be checked for proper operation and secure attachment, the flight battery's charge level and integrity should be evaluated, and safety features like emergency stop switches or fail-safe mechanisms should be tested as well. This thorough examination aids in finding any potential problems or anomalies that can jeopardies the hexacopter's performance or present dangers while in flight.

8.7 Configuring Flight Parameters:

Find the relevant tab or menu option in the software interface to access the "Parameters" section of Mission Planner or QGroundControl. It is often located under the "Config/Tuning" tab in Mission Planner. It may be accessible in QGroundControl by choosing the "Vehicle Setup" tab. Once in the "Parameters" area, you can edit the parameter values or enable/disable certain features as necessary to tailor the flight settings to your unique needs.

We access the appropriate settings in Mission Planner or QGroundControl to set up the necessary parameters for our drone test scenario. Adapt flight modes, such as manual control, altitude hold, or autonomous flying, to our unique needs. Optimize the drone's stability and responsiveness by fine-tuning stabilization benefits. To provide safe activities in the event of signal loss or other critical circumstances, configure failsafe behavior. Also, set up any other options necessary for our test scenarios, such as camera triggers, waypoint navigation, or sophisticated flight features.

8.8 Flight Testing

In order to upload the mission to the drone, first we must check if the drone is flying correctly or not. So first we must control it manually. So, arm the drone first and increase the throttle gradually until its lifts off the ground. Then check if the drone is stable or not. Fly the drone in Stabilize mode.

If everything works perfectly, then we are ready to u [load the mission onto our drone. First, we need to arm the hexacopter from our Qgroundcontrol app. If it's armed and doesn't show any error, then it's time to plan the mission. After planning and setting up the mission, upload the mission to Hexacopter.

8.9 Monitoring and Data Analysis

After launching the mission, it is important to monitor the mission and observe all the parameters for future reference. Although the hexacopter has its own fail-safe it is important to observe the parameters.

After the mission is over, a log file will be generated, so we can read that log file for any type of flight information.

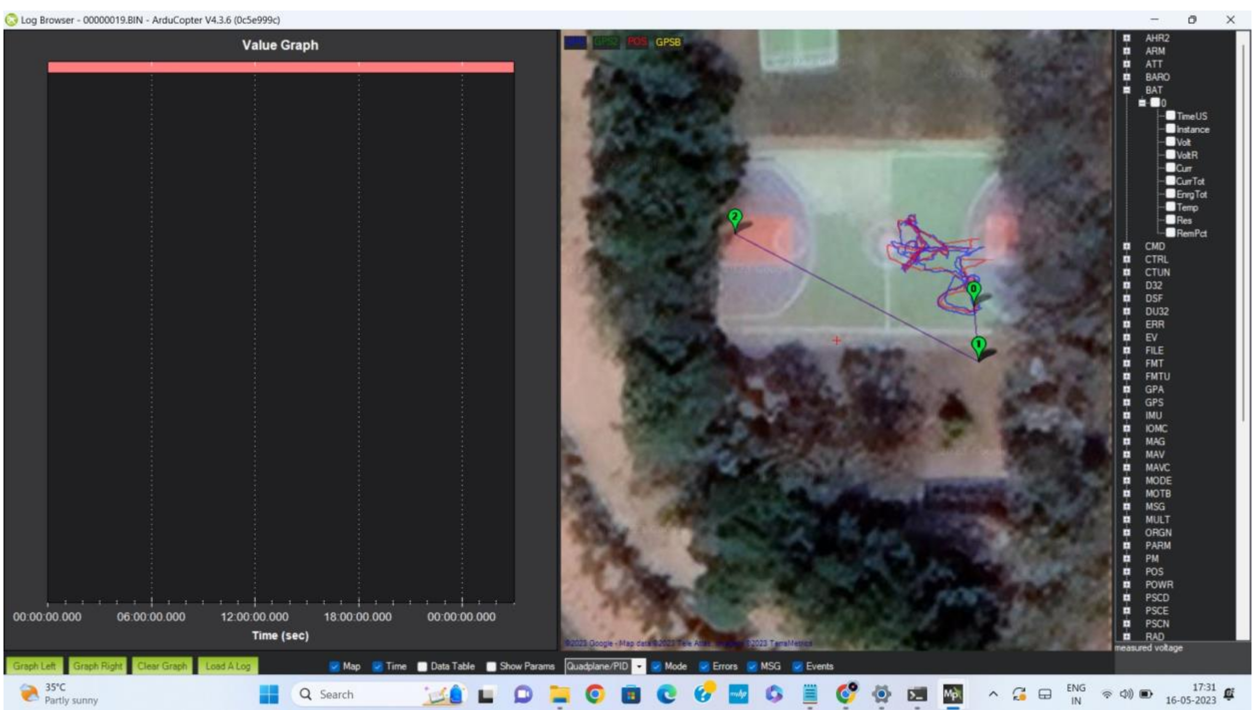

Fig 8.1: Flight log of the Drone

FUTURE SCOPE

- **Real-time Data Monitoring and Analysis:** Telemetry systems integrated into the drone allow for the collection and transmission of real-time data on crop health, environmental conditions, and drone status. This data can be analyzed to gain insights into crop growth patterns, disease detection, and overall farm management.
- **Advanced Imaging and Crop Analysis:** The camera onboard the drone captures high-resolution images or videos of the fields, enabling detailed crop analysis. Image processing algorithms can be employed to detect plant diseases, monitor growth stages, assess nutrient deficiencies, and identify areas requiring targeted interventions.
- **Autonomous Navigation and Precision Farming:** Telemetry systems, in conjunction with GPS technology, enable the drone to navigate autonomously and follow predefined flight paths. This allows for precise and efficient coverage of the agricultural area, ensuring uniform data collection and targeted interventions.
- **Integration with Geographic Information Systems (GIS):** Combining telemetry data, camera imagery, and GIS technology allows for accurate mapping of crop health indicators, soil characteristics, and other relevant parameters. This integration provides farmers with valuable geospatial insights for better decision-making and resource allocation.
- **Enhanced Pest and Weed Management:** By combining telemetry data and camera imagery, the drone can assist in identifying and monitoring pest and weed infestations. This information helps farmers implement timely and targeted control measures, reducing the need for indiscriminate pesticide use.
- **Water and Resource Management:** Telemetry systems can monitor soil moisture levels and provide data on irrigation requirements. Combined with camera imagery, the drone project can aid in optimizing water usage, improving irrigation efficiency, and reducing water wastage.
- **Remote Monitoring and Control:** The telemetry system enables remote monitoring and control of the drone's operations, allowing farmers to access real-time data and adjust flight parameters or mission plans as needed. This remote capability enhances operational flexibility and enables quick response to changing farm conditions.

- **Integration with Farm Management Software:** The telemetry data and camera imagery can be seamlessly integrated with farm management software systems, providing a comprehensive overview of the farm's operations. This integration streamlines data analysis, record-keeping, and decision-making processes for improved farm management.
- **Scalability and Adaptability:** The future scope of the project involves designing the drone system to be scalable and adaptable to different farm sizes and crop types. This ensures that the benefits of smart agriculture can be realized across various agricultural contexts.
- **Constant Technological Development:** With continuous improvements being made to communication networks, image processing algorithms, and sensor technologies, the area of smart agricultural drones is developing quickly. In order to improve the drone's capabilities, the future scope calls for staying up to date with these developments and adding new features and functions.

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Paper/Submission ID	1179171
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Submission Date	2023-12-08 10:05:44
Total Pages	53
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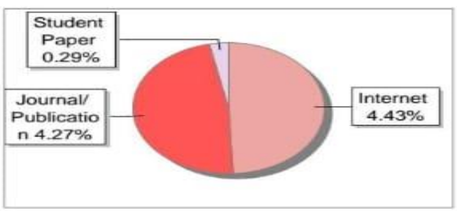

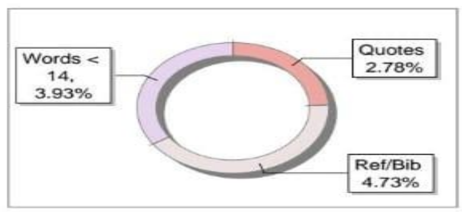

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