CHAPTER 1
INTRODUCTION

1.1 Problem Context

Our project aims to establish a robust swarm connection between drones tailored for agricultural purposes. By leveraging swarm intelligence, these drones will collaborate autonomously, facilitating seamless data collection, analysis, and real-time decision-making. This technology aims to revolutionize precision agriculture by providing farmers with invaluable insights into crop health, soil conditions, and irrigation needs on a scale previously unattainable. By harnessing the collective power of these interconnected drones, we seek to empower farmers with efficient, data-driven solutions to enhance yields, reduce resource wastage, and promote sustainable farming practices.

1.2 Aim

The aim of this research project is to develop and implement a novel approach to controlling multiple drones through a single remote control, utilizing Bluetooth communication technology. This innovation aims to simplify user interfaces, enhance user experience, and reduce costs associated with drone systems, particularly in agricultural applications. By leveraging the collective capabilities of drones within a swarm, the aim is to enhance payload capacity and efficiency, ultimately improving the effectiveness of tasks such as aerial displays, surveillance, and delivery services.

1.3 Objectives

1.3.1 Develop and integrate Bluetooth communication technology to enable seamless intercommunication between multiple drones within a swarm, allowing them to collaborate effectively on tasks. To achieve the objective of incorporating Bluetooth communication technology for seamless inter-drone communication within a swarm, significant research and development efforts will concentrate on devising and implementing robust communication protocols and hardware solutions. This endeavour entails the integration of Bluetooth modules into the drones' onboard systems, such as Arduino and flight controllers, to establish dependable and low-latency communication links. Advanced algorithms will be devised to facilitate efficient data exchange and coordination among drones, empowering them to collaborate effectively on various tasks. Special attention will be given to ensuring scalability and adaptability to diverse drone configurations and environmental conditions, allowing drones within the swarm to exchange information and synchronize their actions in real-time. This comprehensive approach aims to enhance the communication capabilities of swarm drones, enabling them to operate harmoniously and achieve collective objectives with precision and efficiency.

1.3.2 Implement a centralized control mechanism through a single remote control, simplifying user interfaces and streamlining operations for users, thereby enhancing user experience. To achieve the objective of establishing a centralized control mechanism via a single remote control, efforts will prioritize the creation of user-friendly interfaces and streamlined operations. This entails crafting intuitive control software enabling users to command and oversee the entire drone swarm from a unified interface. Incorporating features like automated task allocation, real-time feedback, and status updates will simplify the user experience and bolster situational awareness. By consolidating control mechanisms, users can concentrate on higher-level decision-making tasks instead of micromanaging individual drones, ultimately enhancing efficiency and productivity. The emphasis lies in developing a centralized control system that empowers users to effortlessly oversee and orchestrate the actions of the entire drone fleet, facilitating seamless operation and optimizing the utilization of resources.

1.3.3 Investigate and optimize the coordinated lifting capabilities of multiple drones within a swarm, aiming to enhance payload capacity and efficiency for tasks requiring heavier equipment or larger payloads. To address the objective of examining and refining the synchronized lifting abilities of numerous drones in a swarm, research endeavours will centre on augmenting payload capacity and efficiency for tasks necessitating heavier loads or larger payloads. This endeavour will encompass investigating the dynamics of collaborative lifting manoeuvres and devising algorithms to enhance the equitable distribution of weight among drones. Parameters like battery longevity, power consumption, and flight steadiness will be taken into account to ensure the secure and efficient execution of lifting operations. Through the optimization of synchronized lifting capabilities, the drone swarm will be equipped to undertake a broader array of tasks, ranging from aerial exhibitions to surveillance missions, with heightened effectiveness and dependability. This comprehensive approach aims to enhance the versatility and operational prowess of swarm drones, enabling them to tackle diverse challenges and fulfil various mission objectives with precision and efficiency.

1.3.4 Evaluate the cost-effectiveness of utilizing multiple smaller drones versus a single larger drone for agricultural applications, considering factors such as affordability, efficiency, and scalability. To address the fourth objective of assessing the cost-effectiveness of employing multiple smaller drones versus a singular larger drone for agricultural purposes, a thorough comparative analysis will be undertaken. This entails evaluating the initial capital investments, ongoing operational costs, and maintenance demands over time associated with both strategies. Additionally, factors like task efficiency, scalability, and suitability for various agricultural settings will be examined to ascertain the most economically viable option. By quantifying the cost-effectiveness of each approach, informed decisions can be made concerning the adoption of drone swarm technology in agricultural contexts. This comprehensive evaluation aims to provide valuable insights into the financial implications of different drone deployment strategies, aiding stakeholders in optimizing resource allocation and maximizing returns on investment in agricultural drone applications.

1.3.5 Assess the time efficiency of utilizing multiple drones for tasks such as crop spraying or monitoring, compared to traditional methods, and identify areas for optimization and improvement. To address the objective of evaluating the time efficiency of employing multiple drones for activities like crop spraying or monitoring, meticulous experimentation and data gathering will be undertaken. This endeavour will entail contrasting the time needed to accomplish designated tasks utilizing drone swarms against conventional methods like manual labour or machinery. Key efficiency metrics such as coverage area, task completion duration, and resource utilization will be scrutinized to pinpoint opportunities for enhancement and refinement. By quantifying the time efficiency enhancements facilitated by drone swarm utilization, valuable insights can be gleaned into the prospective advantages and constraints of this technology across diverse agricultural contexts. This rigorous assessment aims to provide a comprehensive understanding of the time-related benefits derived from deploying drone swarms, informing decision-making processes and fostering the optimal integration of this innovative technology within agricultural operations.

1.4 Scope

The research will primarily focus on the development and testing of a Bluetooth communication-based control system tailored for multiple drones, with a specific emphasis on its suitability for agricultural operations. Implementation endeavours will centre on seamlessly integrating Bluetooth modules with Arduino and flight controllers, facilitating effective communication among the drones. Both hardware and software components will be comprehensively addressed, encompassing the design of user interfaces, refinement of control algorithms, and meticulous evaluation of system performance. Field trials and real-world testing will constitute the evaluation phase, wherein collaboration with agricultural stakeholders will be pivotal in gauging the system's practicality, affordability, and its potential to enhance agricultural productivity. Moreover, the research will extend its scope beyond agriculture to explore the scalability and versatility of the developed technology across various industries and applications. Surveillance, delivery services, and aerial displays are among the areas of interest, as investigating their suitability for the proposed Bluetooth communication-based control system could amplify its impact and relevance across diverse domains. Through this multifaceted approach, the research aims to not only address agricultural needs but also to unlock broader applications, thereby maximizing the technology's societal benefits.

1.5 Novelty

1.5.1 Swarm-connected drones enhance resource efficiency by sharing workloads, optimizing battery life, and extending mission durations effectively. The integration of swarm-connected drones heralds a paradigm shift in resource efficiency, as tasks are distributed across the swarm to optimize battery usage and extend mission durations. By fostering collaborative efforts, the workload is shared among drones, alleviating individual strain and maximizing operational time. This approach not only optimizes resource utilization but also enhances overall efficiency, paving the way for extended mission durations. Swarm technology emerges as a transformative force in unmanned aerial vehicle (UAV) operations, revolutionizing the traditional approach by leveraging collective intelligence to achieve unprecedented levels of efficiency and productivity. With its capacity to harness the collective power of multiple drones, swarm technology represents a significant advancement in aerial operations, offering unparalleled capabilities in various applications, from surveillance and reconnaissance to search and rescue missions.

1.5.2 Swarm technology enhances system reliability through redundancy. If one drone fails, the swarm can adapt and continue its mission. Swarm technology strengthens system reliability through the utilization of redundancy. Should a single drone encounter failure, the swarm promptly adjusts, guaranteeing uninterrupted mission progression. This redundancy strategy serves to minimize interruptions, mitigate risks, and fortify the overall resilience of the system. Through the dynamic redistribution of tasks among operational drones, swarm-connected systems secure mission accomplishment, even amidst individual component malfunctions. This trait renders them exceptionally dependable in critical operations, as they exhibit a capacity to maintain functionality and effectiveness despite adverse circumstances. Swarm technology's adeptness at leveraging redundancy not only ensures mission continuity but also instils confidence in the system's ability to withstand unforeseen challenges, further solidifying its role as a cornerstone technology in various applications, ranging from disaster response to surveillance missions.

1.5.3 Swarm drones achieve synchronized and coordinated actions among the drones to perform complex tasks that would be challenging for individual drones. Swarm drones exhibit proficiency in synchronized and coordinated actions, enabling them to tackle complex tasks that exceed the capabilities of solitary drones. Leveraging sophisticated communication and collaboration methods, the swarm orchestrates collective movements with meticulous precision and effectiveness. This synchronized approach streamlines task completion, enhances productivity, and unlocks new possibilities for innovative applications like search and rescue missions, surveillance operations, and agricultural tasks. The synchronized actions of swarm drones enable them to navigate complex environments and execute multifaceted missions with heightened efficiency and accuracy. This coordinated approach optimizes task performance and broadens the scope of possibilities for drone applications across various sectors, underscoring the transformative potential of swarm technology in enhancing operational capabilities and achieving impactful outcomes.

1.5.4 By utilizing multiple small drones instead of relying on a few larger, more expensive ones, swarm drone systems can be more cost-effective. Employing numerous small drones instead of a handful of larger ones presents notable cost-effectiveness within swarm drone systems. The decentralized layout of smaller drones diminishes the susceptibility to substantial losses resulting from individual malfunctions, thus boosting overall reliability while requiring a reduced investment. Furthermore, smaller drones typically incur lower costs for procurement, upkeep, and replacement, rendering swarm technology an economically advantageous option for diverse applications like surveillance, delivery services, and agricultural operations. This approach underscores the financial viability of utilizing multiple smaller drones, as it not only mitigates the impact of potential failures but also optimizes resource allocation and operational efficiency. With its affordability and resilience, swarm technology emerges as a pragmatic solution for organizations seeking cost-effective alternatives to traditional drone deployments across various sectors.

CHAPTER 2

LITERATURE SURVEY

[1] Drones have become essential tools in urban environments, offering various benefits but also raising concerns about safety and efficiency. This paper focuses on 4D path planning for drone operations, proposing a swarm-based approach within the 'AirMatrix' framework. It addresses path planning for individual drones and conflict resolution among them. The multi-path planning level aims to generate diverse flight paths for each drone, enhancing flight request acceptance rates. The clustering improved ant colony optimization (CIACO) algorithm is employed, integrating clustering with a crowding mechanism to improve global and local search capabilities. At the task scheduling level, conflicts between drones are managed considering time intervals and potential collisions. A three-layer fitness function maximizes permitted flights while ensuring safety. A genetic algorithm (GA)-based task scheduling algorithm is developed to complement the model. Simulation results demonstrate the efficacy of the swarm-based algorithms in generating safe and efficient 4D flight paths for drones in urban airspace. By integrating swarm intelligence and addressing path planning and conflict resolution, this paper provides a comprehensive solution for optimizing drone operations. Through this approach, stakeholders can manage urban airspace complexity, integrating drones into daily life and commercial activities while prioritizing safety and efficiency.

[2] The advent of the Internet of Drones (IoD) signifies a significant leap forward, enabling drones to collaboratively navigate confined airspaces for various Industry 4.0 applications. However, challenges persist in ensuring energy efficiency and seamless data sharing among drones, crucial for executing complex tasks efficiently in real-time. Of particular concern is maintaining information security, especially in the face of malicious actors like Byzantine drones that can disrupt swarm coordination, leading to unpredictable outcomes. Introducing Blockchain technology holds promise in addressing these challenges, yet its application in swarm drone collaboration remains in its infancy. Hence, there's a pressing need for an innovative blockchain-based approach to effectively manage multi-drone collaboration during swarm operations. This approach employs Blockchain as a secure communication conduit within drone swarms, enhancing consensus achievement security while optimizing energy efficiency and connectivity for environmental exploration tasks. By fortifying consensus security and improving connectivity and energy efficiency, this methodology streamlines operational processes and strengthens the resilience of multi-drone applications in Industry 4.0.

In essence, integrating Blockchain into swarm drone collaboration signifies a paradigm shift, promising enhanced security and efficiency in task execution, and heralding a new era of innovation in addressing real-world challenges.

[3] The widespread presence of drones and drone swarms has sparked significant concerns regarding public safety and national security. This paper addresses the urgent need for effective countermeasures against potential misuse of these unmanned aerial vehicles. While strategies exist to counter small drone groups, dealing with large-scale swarms poses a formidable challenge, primarily due to limited detection technologies. The paper proposes a swift counter approach aimed at promptly disrupting swarm coordination by fragmenting them into disconnected segments. By isolating crucial nodes within the swarm, the proposed genetic algorithm and particle swarm optimization algorithm expedite the disintegration process. Extensive simulation studies demonstrate the superior effectiveness of both algorithms in dividing drone swarms, disrupting coordination and clustering. Comparative experiments confirm the accuracy and efficiency of the proposed algorithms. Through rigorous analysis, the paper emphasizes the resilience and reliability of these algorithms in dismantling drone swarms effectively. Overall, the proposed approach provides a promising solution to the escalating threat posed by drone swarms, especially in large-scale deployments. Leveraging advanced optimization techniques, the approach enhances public safety and national security by promptly disrupting swarm coordination. The comprehensive evaluation presented underscores the efficacy and feasibility of the proposed algorithms in mitigating the threat of drone swarms.

[4] The primary aim is to support military operations, notably through the implementation of a Drone Swarm Surveillance system for patrolling and surveillance in restricted areas. Virtual Reality (VR) technology plays a pivotal role in simulating real-life scenarios, enabling users to create lifelike simulations and execute necessary actions. In defence monitoring and surveillance, VR allows military personnel to conduct patrols in rugged terrain without endangering themselves. Each drone captures real-time images upon receiving commands, facilitating surveillance of criminal activities stored locally. Image Processing techniques automate analysis tasks, improving efficiency in threat identification. The Monitoring system organizes drone movement, optimizing area coverage and coordination. Path planning is enhanced by a comprehensive Waypoint System, enabling precise navigation. By integrating VR and advanced surveillance, this initiative enhances military operations' effectiveness while reducing risks to personnel in challenging environments. Automated image acquisition,

processing, and coordinated drone movements provide a robust solution for monitoring and maintaining security in restricted areas.

[5] This paper introduces a new framework for building Swarm-based Drone-as-a-Service (SDaaS) systems tailored for delivery purposes. It outlines two composition approaches, sequential and parallel, designed to accommodate various behaviors observed in drone swarms. The framework considers constraints such as recharging time and battery limitations to ensure timely delivery fulfillment. To address these challenges, SDaaS composition algorithms based on a modified A* algorithm is incorporated. Additionally, a cooperative behavior model is integrated to minimize recharging and waiting times during delivery operations. Experimental results validate the effectiveness and efficiency of the proposed approach, highlighting its potential to enhance delivery services through swarm-based drone deployment. Drones, autonomously operated unmanned aircraft, have become increasingly accessible, enabling diverse applications including disaster management, crowd control, and agriculture. The rise of drone delivery services, exemplified by Amazon's use of quadcopters for rapid package delivery and Google's project Wing, reflects growing industry interest. Drone delivery offers convenience and environmental benefits by providing faster delivery with reduced energy consumption, addressing both functional and non-functional properties comprehensively.

[6] Advancements in drone technology have popularized unmanned aerial vehicles (UAVs) across various sectors, notably in reconnaissance missions aimed at locating missing persons and objects over extensive areas. However, conventional systems often rely on single UAVs, conducting object detection post-flight or manually due to computational limitations. Addressing these challenges, this paper introduces a novel reconnaissance drone system employing multiple UAVs, each equipped with real-time object detection capabilities. The system transmits detection results to a ground control system (GCS) for image stitching. Utilizing filter pruning, the paper reduces parameters in the YOLOv5 model by 40%, achieving a frame rate of approximately 11.73 FPS on the Jetson Xavier NX. Moreover, the proposed image stitching technique efficiently matches features, enhancing real-time object detection over large areas in field tests. This innovative approach enhances reconnaissance operations by reducing response times, increasing coverage, and enabling timely decision-making. The lightweight YOLOv5 model and optimized image stitching further augment the system's effectiveness, promising to revolutionize reconnaissance missions by enabling rapid and precise object detection, thereby improving situational awareness and response capabilities.

CHAPTER 3

SYSTEM DESIGN

3.1 System Model

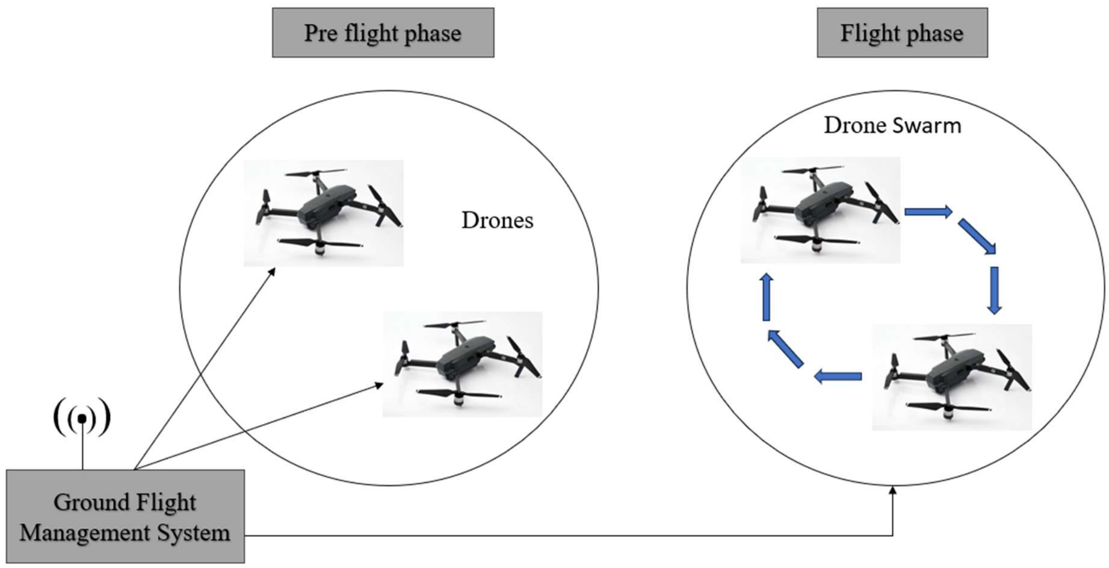

Fig 3.1. Visual representation of the swarm drones

Ground Flight Management System: As Shown in the fig 3.1**,** in swarm technology ground management systems play a critical role in coordinating the actions of multiple drones. These systems serve as the central command and control hubs, enabling operators to monitor, control, and communicate with the drones effectively. Here are some key aspects of ground management systems in swarm technology. Here, Ground Flight Management System is FLYSKY FS-i6 2.4G 6CH AFHDS RC Transmitter.

Pre-flight phase: In pre-flight phase Both drones are built individually and tested payload of each drone individually by flying them in air.

Flight phase: In Flight phase both drones are combined using Swarm technology and communication is established between drones using Bluetooth module and finally tested the payload of combined drones in Flight phase.

3.2 Activity Diagram

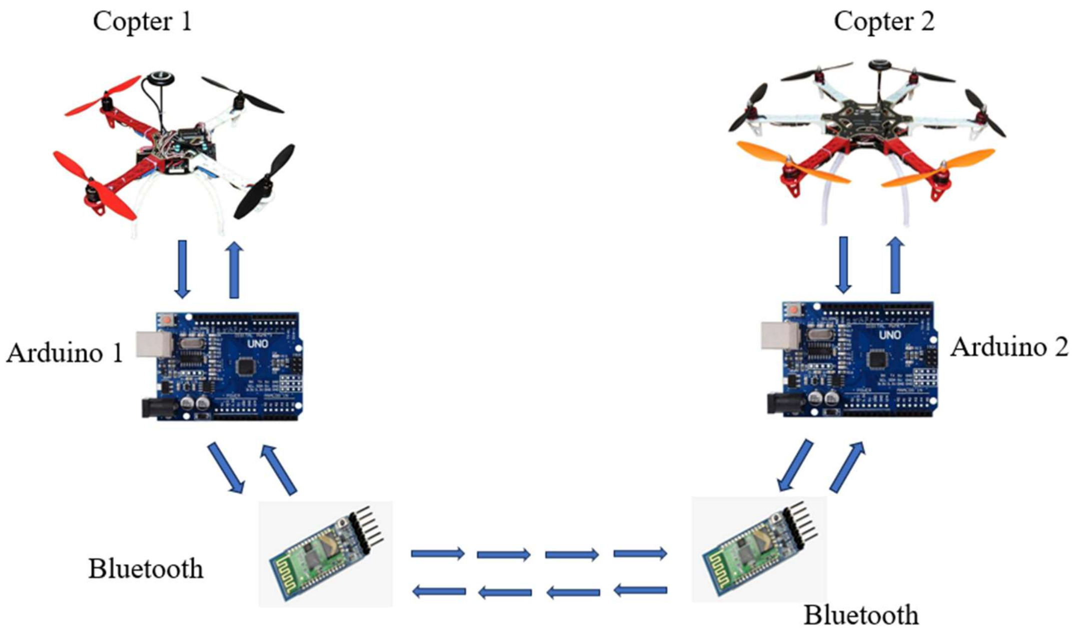

Fig 3.2. Block diagram of communication between drones

Figure 3.2 illustrates the establishment of communication between drones utilizing Bluetooth technology. Through careful adjustment of the distance between the drones within the Bluetooth range, effective communication can be ensured. Initially, when a signal is transmitted by the remote control, it is received by the receiver on the drone. This received signal is then stored within the onboard Arduino microcontroller. Subsequently, the signal is transmitted to another drone via Bluetooth. Upon reception by the Bluetooth module of the second drone, the transmitted signal is forwarded to its Arduino for further processing. The Arduino then undertakes the task of analysing the received signal. Once processed, the signal is relayed to the flight controller. It is at this stage that the action corresponding to the received signal is triggered in the second drone. The ability to adjust the distance between the drones within the Bluetooth range is crucial for ensuring uninterrupted communication. This practice ensures that the signal remains strong and stable, minimizing the risk of interference or disruption. The Arduino serves as the intermediary in this communication framework, playing a pivotal role in both storing and processing the transmitted signal. Its capability to interpret signals accurately ensures that commands from the remote control are effectively communicated to the receiving drone, facilitating smooth execution of tasks. In summary, the communication system depicted in Figure 3.2 allows drones to exchange commands and data wirelessly, thanks to the integration of Bluetooth technology and Arduino microcontrollers.

This setup opens up possibilities for collaborative operations among drones, enabling them to work together seamlessly in various applications such as aerial photography, surveillance, and search and rescue missions.

3.3 Software

ArduPilot, an open-source autopilot software suite, stands as the foundational framework for governing drones, UAVs, and robotic vehicles, offering a comprehensive array of functionalities. It furnishes users with precise navigation, stabilization, and mission planning capabilities, tailored to accommodate the diverse demands of unmanned systems. Developed collaboratively by a global community, ArduPilot distinguishes itself through its adaptability and extensibility, facilitating the seamless execution of intricate tasks. The Mission Planner user interface, showcased in Fig 3.3, serves as a prime example of ArduPilot's versatility. Whether catering to hobbyists, researchers, or commercial enterprises, its flexibility and expansive feature set position it as the preferred choice in autonomous vehicle control. ArduPilot functions as a driving force behind the development and deployment of reliable, autonomous unmanned vehicle systems, advocating peace and prosperity. Although ArduPilot does not engage in hardware manufacturing, its firmware remains compatible with a wide spectrum of platforms, enabling control over various unmanned vehicles. When coupled with ground control software, vehicles equipped with ArduPilot firmware gain access to advanced features, including real-time communication with operators. Additionally, a vibrant online community provides dedicated support to users, nurturing a collaborative environment conducive to growth and innovation. Since its inception in 2009, ArduPilot has evolved into a sophisticated and dependable open-source autopilot software system. Developed by professionals, academics, and enthusiasts worldwide, it offers comprehensive control capabilities for a myriad of vehicle systems. With installations surpassing 1,000,000 vehicles globally, ArduPilot is relied upon for its advanced data-logging, analysis, and simulation tools. Its open-source nature ensures ongoing development, with stringent release processes guaranteeing stability and reliability. The expansive ecosystem of sensors, companion computers, and communication systems further augments ArduPilot's versatility. Its transparent code allows for thorough auditing to adhere to security standards, contributing to its widespread adoption within the autonomous systems industry. Notably, ArduPilot serves as a pivotal testing and development platform for esteemed institutions and corporations worldwide, including NASA, Intel, and Insitu/Boeing. In essence, ArduPilot's evolution into a cornerstone of unmanned vehicle technology underscores its dedication to innovation and excellence, empowering users worldwide with trusted and adaptable autopilot solutions.

Here are some key points about Ardupilot software

1.Open Source: Ardupilot, being an open-source endeavour, allows its source code to be freely accessed, altered, and shared under the General Public License (GPL).

2.Supported Platforms: Ardupilot runs on a variety of hardware platforms, including Arduino-based boards like the APM (ArduPilot Mega), as well as more powerful processors like those found in Pixhawk and Cube autopilot hardware.

3.Features: Ardupilot offers a wide range of features, including autonomous navigation, stabilization, mission planning, telemetry, and support for various sensors such as GPS, accelerometers, gyroscopes, and magnetometers.

4.Modes: It supports different flight modes, such as Manual, Stabilize, AltHold, Loiter, Auto, and others, which provide different levels of control and automation.

5.Community: The Ardupilot community, consisting of developers, contributors, and users, actively collaborates to enhance the software, introduce fresh features.

6.Customization: Users can customize and extend Ardupilot's functionality by modifying its source code or integrating additional hardware and software components.

7.Compatibility: Ardupilot is compatible with various ground control station (GCS) software, such as Mission Planner, QGroundControl, and MAVProxy, which allow users to interact with and monitor their vehicles during flight.

8.Applications: Ardupilot is used in a wide range of applications, including aerial photography and videography, agricultural monitoring, search and rescue operations, environmental research, and military reconnaissance.

Fig 3.3. User Interface of mission planner software

CHAPTER 4

METHODOLOGY

4.1 Design Methodology and Components

The implementation of one critical low-level behaviour is the foundation of the methodology for controlling many drones from a single remote. Every drone has an adjustable parameter that the user may change to set how far apart each drone must stay from other drones.

4.2 Components of Quadcopter and Hexacopter

Frames: The frame, crafted from carbon fibre for its blend of strength and lightness, serves as the fundamental framework for both Quadcopters and Hexacopters, delivering essential stability and structural support to the drone's components. Its design can vary, with layouts like the X and Y6 configurations tailored to enhance stability and manoeuvrability during flight. Acting as the backbone of the drone, the frame ensures the maintenance of shape and integrity throughout operation. This foundational structure plays a critical role in optimizing the overall performance of the drone, providing a robust platform for the integration of propulsion systems, electronics, and payload. By virtue of its material properties and design considerations, the frame contributes significantly to the durability, agility, and reliability of the drone, enabling it to navigate diverse environments and execute complex aerial tasks with precision and confidence.

Fig 4.2.1. Quadcopter frame

Fig 4.2.2. Hexacopter frame

Motors: The motors possess a Motor kV rating of 1000, denoting their rotational speed per volt input. Integral to the drone's functionality, they are pivotal in generating lift and facilitating precise manoeuvring. Typically, brushless DC motors are utilized, exemplified by those featuring a 1000Kv rating. These motors excel in converting electrical energy into mechanical motion, serving as the driving force behind the rotors and enabling the drone to execute flight manoeuvres with precision and stability. Their efficient operation ensures optimal utilization of power resources, contributing to prolonged flight times and enhanced overall performance. With their high-performance characteristics and reliable functionality, these motors stand as essential components within the drone's propulsion system, embodying advanced engineering principles to deliver consistent and responsive flight control in diverse operating conditions.

Fig 4.2.3. Brushless Motors

Propellers: Propellers serve as indispensable elements comprised of blades radiating outward from a central hub, inducing rotation upon activation. Affixed directly onto the motors, they play a pivotal role in generating the requisite thrust for propelling the drone through the atmosphere. Typically ranging from 8 to 10 inches in size and commonly featuring a two-blade configuration, these propellers are meticulously designed to harmonize with the drone's operational requirements. Their dimensions and structure are thoughtfully chosen to enhance the drone's aerodynamic efficiency, enabling seamless lift and manoeuvring throughout flight. Careful consideration is given to their design to optimize performance, ensuring that each propeller contributes to the overall stability and control of the drone. Thus, propellers stand as essential components in the intricate orchestration of drone mechanics, embodying precision engineering to enable smooth and reliable flight operations in various environmental conditions.

Fig 4.2.4. Propellers

ESC (Electronic Speed Controller): Electronic Speed Controllers (ESCs) are specialized components designed to precisely regulate the speed of electric motors. Operating based on signals from the flight controller, ESCs typically have current ratings between 20 to 30 amperes (A). Crucial for drone propulsion, they maintain stability and agility by finely adjusting motor speed. Integrated seamlessly with the flight controller, ESCs ensure optimal performance and enable pilots to execute precise manoeuvres confidently. In essence, ESCs are essential elements of drone technology, embodying reliability and efficiency in managing propulsion systems.

Fig 4.2.5. Electronic Speed Controllers

Battery: The Li-po battery, an abbreviation for Lithium Polymer, emerges as a rechargeable power solution deployed across various domains, including quadcopters. It boasts a solid polymer electrolyte and integrates lithium within one of its electrodes. Serving as the primary power reservoir for quadcopters, these batteries furnish the essential electrical energy required for both propulsion and onboard systems.

Fig 4.2.6. 2200 Mah Battery

Fig 4.2.7. 4200 Mah Battery

Examples of commonly utilized LiPo batteries in quadcopters encompass configurations like 3S-2200mAh and 4S-3000mAh, offering diverse capacities and voltage levels tailored to specific performance demands. These batteries play a pivotal role in sustaining prolonged flight durations and supporting the execution of complex aerial manoeuvres. Through their advanced chemistry and tailored configurations, LiPo batteries epitomize a vital component in the operational framework of quadcopters, ensuring reliable power delivery and enabling enhanced flight performance across various mission profiles and environmental conditions.

APM 2.8 Flight Controller: The APM 2.8 flight controller stands out as a highly acclaimed open-source autopilot system specifically designed for unmanned aerial vehicles (UAVs). It seamlessly incorporates a variety of sensors in conjunction with advanced GPS technology to ensure accurate navigation, enabling a wide spectrum of flight modes to be easily accessed and utilized. Recognized for its unparalleled versatility and dependable performance, this controller equips users with the ability to execute intricate aerial manoeuvres and navigate with pinpoint precision, solidifying its status as a favoured option among both drone enthusiasts and seasoned professionals. Its reputation for reliability and adaptability underscores its widespread adoption within the drone community, where it continues to play a pivotal role in enhancing the capabilities and functionality of unmanned aerial systems for various applications. The APM 2.8 flight controller is a widely used open-source autopilot system designed for controlling multirotor drones, fixed-wing aircraft, helicopters, and other unmanned aerial vehicles (UAVs). It is part of the ArduPilot project, which aims to provide reliable, flexible, and affordable autopilot systems for hobbyists, enthusiasts, researchers, and commercial users.

Key features of the APM 2.8 flight controller include:

1.Microcontroller: The APM 2.8 is powered by an ATmega2560 microcontroller, which is based on the Arduino platform. This microcontroller provides the processing power necessary for running the autopilot software and controlling the vehicle.

2.Sensors: The flight controller is equipped with a suite of sensors, including a 3-axis gyroscope, accelerometer, and magnetometer. These sensors provide essential data about the vehicle's orientation, acceleration, and heading, allowing the autopilot to stabilize and control the vehicle.

3.GPS Module: The APM 2.8 typically comes with a GPS module, which provides accurate positioning information to the autopilot system. This enables features such as autonomous navigation, waypoint following, and return-to-home functionality.

4.Barometer: A barometer is included to measure atmospheric pressure, which is used to estimate altitude above sea level. This altitude information is crucial for altitude hold, altitude hold, and other altitude-related flight modes.

5.Ports and Connections: The APM 2.8 features a variety of ports and connectors for interfacing with other components, including motor outputs for controlling motors, servo outputs for controlling servos, analog and digital inputs for connecting sensors and switches, and telemetry ports for communication with ground control stations and telemetry modules.

6.Onboard Data Logging: The flight controller has onboard data logging capabilities, allowing it to record flight data such as GPS position, altitude, attitude, motor outputs, and sensor readings. This data can be analysed after the flight for performance evaluation and troubleshooting.

7.Compatibility: The APM 2.8 is compatible with a wide range of airframes and configurations, including quadcopters, hexacopters, octocopters, fixed-wing aircraft, and more. It is also compatible with various ground control software platforms, including Mission Planner and QGroundControl, which provide a user-friendly interface for configuring the autopilot, planning missions, and monitoring flight performance.

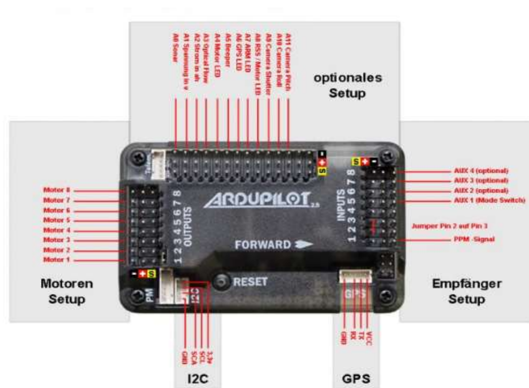

Fig 4.2.8. APM 2.8 flight controller

Overall, the APM 2.8 flight controller stands as a versatile and dependable autopilot system, well-suited for diverse UAV applications, spanning from recreational flying to professional aerial tasks like photography and surveying. Its popularity stems from its open-source design, comprehensive features, and robust community backing, appealing to drone enthusiasts and developers globally.

FS-iA6B Receiver: The Flysky FS-iA6B Receiver, renowned as a 6-channel receiver extensively utilized in radio-controlled (RC) aircraft, functions within the 2.4GHz frequency range and integrates seamlessly with Flysky's transmitter systems. Its six channels provide meticulous control over multiple aspects of the RC model, encompassing throttle, aileron, elevator, rudder, gear, and auxiliary functions.

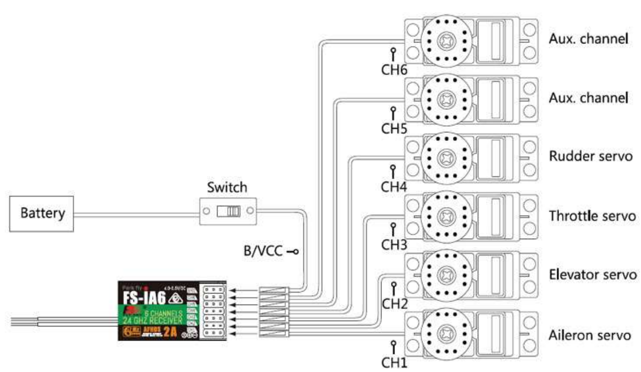

Fig 4.2.9. Fly sky Receiver FS-iA6B and its channels

This receiver garners popularity among RC enthusiasts due to its compatibility, dependability, and adaptability, allowing users to fine-tune their aircraft's performance according to specific preferences and needs with remarkable ease and accuracy. Its widespread adoption within the RC community underscores its reputation for reliability and versatility, serving as a cornerstone component in enhancing the overall functionality and manoeuvrability of RC aircraft. The FS-iA6B receiver is a popular radio receiver module designed for use with Flysky transmitters, particularly those in the FS-i6 series. It is commonly used in radio-controlled (RC) vehicles and aircraft, such as drones, airplanes, helicopters, cars, and boats.

Key features of the FS-iA6B receiver include:

1.Six Channels: The FS-iA6B receiver supports up to 6 channels, allowing it to receive control signals for various functions and components of an RC vehicle or aircraft. Channels can be assigned to control throttle, steering, pitch, roll, yaw, and other customizable functions.

2.Frequency(2.4GH): Like Flysky transmitters, the FS-iA6B receiver operates on the 2.4GHz frequency band, providing stable and reliable communication with minimal interference. This frequency band also offers a relatively long range, allowing for control over considerable distances.

3.i-BUS Support: The FS-iA6B receiver features i-BUS support, which allows for more channels to be transmitted over a single signal wire. This feature enables the receiver to transmit up to 18 channels when used with compatible transmitters and flight controllers. In addition to i-BUS, the FS-iA6B receiver provides both PWM (Pulse Width Modulation) and PPM (Pulse Position Modulation) output options, allowing compatibility with a wide range of flight controllers and autopilot systems.

4.Dual Antennas: The receiver is equipped with two antennas, which enhance signal reception and improve overall communication reliability, particularly in environments with obstacles or interference.

5.Fail-Safe Function: The FS-iA6B receiver includes a fail-safe function, which activates if the signal is lost between the transmitter and receiver. Users can program the fail-safe settings to ensure that the vehicle or aircraft returns to a safe state, such as cutting throttle or maintaining a level flight attitude.

6.Compact Design: The receiver features a compact and lightweight design, making it easy to install and suitable for use in various types of RC vehicles and aircraft.

7.Compatibility: The FS-iA6B receiver is compatible with a wide range of Flysky transmitters and flight controllers, as well as other brands that support the i-BUS, PWM, or PPM communication protocols.

Overall, the FS-iA6B receiver offers reliable performance, versatility, and compatibility, making it a popular choice among RC enthusiasts for controlling a variety of vehicles and aircraft. Its advanced features, including i-BUS support and fail-safe functionality, contribute to a safe and enjoyable RC experience.

FS-i6 Remote Control Transmitter: The FS-i6 Remote Control Transmitter enjoys widespread adoption within the radio-controlled hobbyist sphere, serving as a go-to option for managing a variety of vehicles like drones, airplanes, and cars. Highlighted attributes of the FS-i6 encompass its utilization of a 2.4GHz frequency band, provision of 6 channels for versatile control, ergonomic design promoting comfortable handling, an LCD display for intuitive navigation, and customizable settings to suit individual preferences.

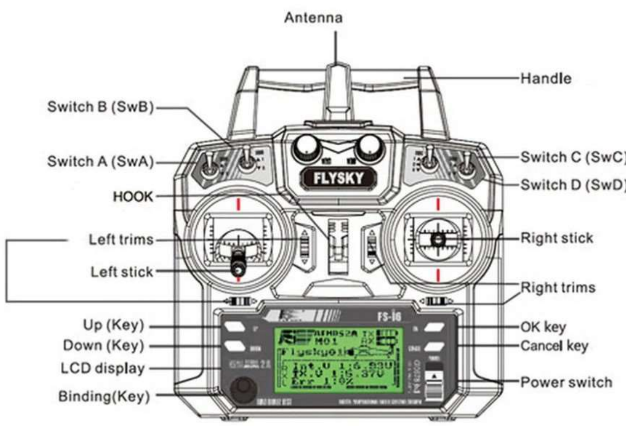

Fig 4.2.10. FS-i6 Remote Control Transmitter

On the other hand, Mission Planner represents an open-source software application tailored explicitly for ArduPilot-based autopilots. Its principal role revolves around the crucial task of firmware flashing into the flight controller, a pivotal step essential for configuring and updating autonomous vehicles. By offering user-friendly interfaces and comprehensive functionalities, Mission Planner empowers hobbyists and professionals alike to efficiently manage and optimize the performance of their autonomous vehicles, ensuring seamless integration and enhanced operational capabilities within the drone ecosystem.

The FS-i6 remote control transmitter, crafted by Fly-sky, is a sought-after radio transmitter tailored for managing radio-controlled (RC) vehicles and aircraft like drones, airplanes, helicopters, cars, and boats. With a host of features, it caters to the needs of both novice and seasoned RC enthusiasts.

Key features of the FS-i6 remote control transmitter include:

1.Channels: The FS-i6 supports up to 6 channels, allowing users to control various functions and components of their RC vehicle or aircraft. Channels can be assigned to control throttle, steering, pitch, roll, yaw, and other customizable functions.

2.Frequency(2.4GHz): The transmitter operates on the 2.4GHz frequency band, providing stable and reliable control with minimal interference. This frequency band also offers a relatively long range, allowing users to control their vehicles from a considerable distance.

3.LCD Display: The FS-i6 is equipped with a backlit LCD display, which provides real-time feedback on important parameters such as signal strength, battery voltage, trim settings, and channel assignments. The display is easy to read, even in bright sunlight or low-light conditions.

4.Model Memory: The transmitter features model memory, allowing users to store settings and configurations for multiple RC vehicles or aircraft. This enables quick and easy switching between different models without the need for reprogramming.

5.Dual Rate and Exponential: The FS-i6 offers dual rate and exponential adjustments, allowing users to fine-tune the responsiveness and sensitivity of their controls. This feature is particularly useful for adjusting the handling characteristics of aircraft and vehicles to suit different flying or driving styles.

6.Fail-Safe Function: The transmitter includes a fail-safe function, which automatically activates if the signal is lost between the transmitter and receiver. Users can program the fail-safe settings to ensure that the vehicle or aircraft returns to a safe state, such as cutting throttle or maintaining a level flight attitude.

7.Transmitter Modes: The FS-i6 supports multiple transmitter modes, including Mode 1 (throttle on the right) and Mode 2 (throttle on the left), allowing users to choose the configuration that best suits their preferences and flying style.

8.Compatibility: The FS-i6 transmitter is compatible with a wide range of receivers, servos, and other RC components, making it a versatile choice for use with various types of RC vehicles and aircraft.

Overall, the FS-i6 remote control transmitter offers a combination of features, reliability, and affordability, making it a popular choice among RC enthusiasts of all skill levels. Whether flying drones, piloting airplanes, or driving RC cars, the FS-i6 provides intuitive control and precise handling for an enjoyable RC experience.

Arduino: Arduino is frequently integrated into drone technology due to its versatility and ease of use in programming. In drone applications, Arduino boards serve as central control units, managing tasks such as flight stabilization, navigation, and payload control.

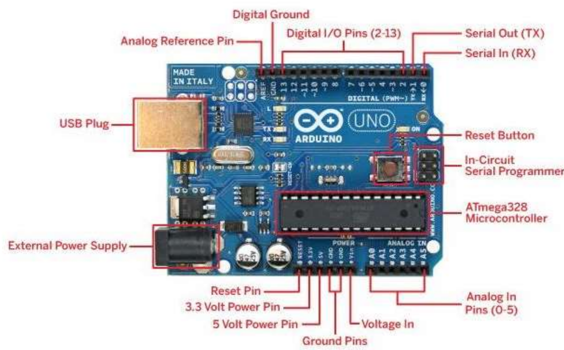

Fig 4.2.11. Arduino

They interface with various sensors and actuators to gather data and execute commands, enabling precise flight maneuvers and autonomous operations. Arduino's open-source nature allows for customization and expansion, facilitating the integration of additional functionalities like GPS navigation, obstacle avoidance, and image processing. This flexibility makes Arduino a popular choice among drone enthusiasts, hobbyists, and professionals seeking to develop innovative and specialized drone applications.

Bluetooth Module: Bluetooth plays a vital role in facilitating communication among drones. These transmitter-receiver devices enable bidirectional communication by transmitting and receiving radio signals. Operating within designated radio frequency bands, usually ranging from 2.400 GHz to 2.4835 GHz, they ensure dependable and interference-resistant communication channels. Through the pairing of Bluetooth-enabled drones, a communication link is established, fostering the exchange of essential data. This includes commands issued by the operator, telemetry information, and, in certain instances, live video feeds. This seamless connection enables synchronized operations among drones and enhances their overall functionality. Bluetooth technology serves as a cornerstone in modern drone communication systems, offering reliability and efficiency in facilitating data exchange and coordination between multiple aerial platforms.

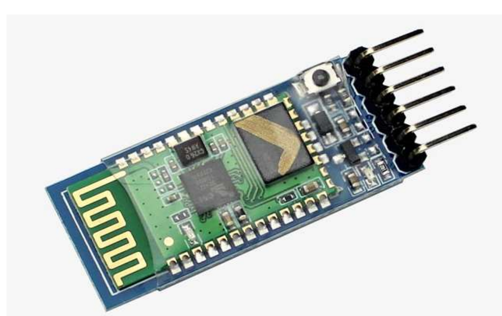

Fig 4.2.12. Bluetooth module

The HC-05 Bluetooth module is a widely used and versatile Bluetooth serial transceiver module. It is commonly employed in electronics projects to enable wireless communication between microcontrollers, such as Arduino boards, and other devices like smartphones, tablets, or computers.

Key features of the HC-05 Bluetooth module include:

1.Bluetooth Version: The HC-05 module typically utilizes Bluetooth version 2.0 + EDR (Enhanced Data Rate) technology, providing reliable and relatively high-speed wireless communication.

2.Serial Communication: The HC-05 module interfaces with microcontrollers or other devices via a serial UART (Universal Asynchronous Receiver-Transmitter) interface. This allows for easy integration with a wide range of microcontrollers, such as Arduino, Raspberry Pi.

3.Pairing and Connection: The HC-05 module supports both pairing and connection with other Bluetooth devices. Pairing is the process of establishing a secure link between two devices, while connection refers to the establishment of a communication channel between paired devices.

4.Range: The HC-05 module typically has a range of up to 10 meters (33 feet) in open space, although this range may vary depending on environmental factors such as obstacles and interference.

4.3 Firmware installation and calibration

Accelerometer calibration

Accelerometer calibration in drones is a crucial step to ensure accurate flight performance and stability. Accelerometers measure the acceleration forces acting on the drone in various directions, helping the flight controller maintain stability and orientation.

Here's an overview of the accelerometer calibration process for drones

1.Access Calibration Mode: Most drone flight controller software provides a calibration mode specifically for sensors, including accelerometers. Access this mode through the drone's flight controller software or app.

2.Place the Drone on a Level Surface: Ensure the drone is placed on a completely level surface, free from any vibrations or movements. This step is essential for obtaining accurate calibration results.

3.Initiate Calibration: Abide by the instructions provided by the flight controller software to start the accelerometer calibration process. This typically involves selecting the option for accelerometer calibration and confirming your intention to proceed with the calibration, following the standard procedures outlined by the software.

4.Follow On-Screen Instructions: The flight controller software will guide you through the calibration process. This may involve moving the drone into specific orientations or simply waiting for the calibration to complete.

5.Complete Calibration: Once the calibration process is complete, the flight controller software will confirm the calibration status. It's essential to ensure that the calibration was successful and that no errors were encountered during the process.

6.Verification and Testing: After calibration, it's advisable to verify the drone's stability and responsiveness through a series of tests. Take off in a controlled environment and observe the drone's behaviour to ensure it responds accurately to control inputs and maintains stable flight.

Compass calibration

Compass calibration in drones is another essential step to ensure accurate navigation and orientation during flight. The compass sensor on a drone measures the magnetic field of the Earth and helps the flight controller determine the drone's heading or direction.

Here's a guide on how to perform compass calibration for drones

1.Access Calibration Mode: Most drone flight controller software provides a calibration mode specifically for sensors, including the compass. Access this mode through the drone's flight controller software or app.

2.Initiate Compass Calibration: Adhere to the flight controller software instructions to begin the compass calibration procedure. This typically entails choosing the compass calibration option and confirming your intent to calibrate, as guided by the software.

3.Rotate the Drone: Hold the drone firmly and rotate it horizontally around its vertical axis (yaw) several times, ensuring that it completes a full 360-degree rotation. This allows the compass sensor to detect the Earth's magnetic field from different directions.

4.Tilt the Drone: After rotating the drone horizontally, tilt it vertically (pitch) and rotate it around its horizontal axis (roll) several times. This helps calibrate the compass sensor to account for variations in the magnetic field in different orientations.

5.Complete Calibration: Once the calibration process is complete, the flight controller software will confirm the calibration status. It's essential to ensure that the calibration was successful and that no errors were encountered during the process.

6.Verification and Testing: After calibration, it's advisable to verify the drone's navigation and orientation accuracy through a series of tests. Take off in a controlled environment and observe the drone's behaviour to ensure it accurately maintains its heading and orientation.

Battery monitor

Based on the cell count and capacity of the battery we can select the configuration. Battery monitoring in drones is a critical aspect of flight safety and performance. Drones rely on batteries to power their motors, flight controllers, and other electronic components, so it's essential to keep track of the battery's status to prevent unexpected power loss during flight.

Here's how battery monitoring works in drones

1.Battery Voltage Monitoring: Most drones are equipped with voltage sensors that continuously monitor the voltage level of the battery. Voltage is a primary indicator of the battery's state of charge. As the battery discharges, its voltage decreases, providing an estimate of remaining battery capacity.

2.Battery Capacity Estimation: Flight controllers often use algorithms to estimate the remaining battery capacity based on the voltage level and discharge characteristics of the battery. This estimation helps the pilot gauge how much flight time is remaining and when it's time to land the drone safely.

3.Low Voltage Warning: Flight controllers are programmed to issue low voltage warnings when the battery voltage drops below a certain threshold. This threshold is typically set to ensure that there's enough remaining charge in the battery to safely land the drone. The warning alerts the pilot to initiate a landing and prevent the battery from reaching a critically low level, which could damage the battery or cause the drone to lose power mid-flight.

Radio Calibration

Radio calibration in drones is the process of configuring the communication between the drone's radio transmitter (remote controller) and its flight controller. This calibration ensures that the flight controller accurately interprets the signals sent by the transmitter, allowing the pilot to control the drone effectively.

Here's how radio calibration works

1.Access Calibration Mode: Most drone flight controller software provides a calibration mode specifically for radio transmitters. Access this mode through the drone's flight controller software or app.

2.Power on the Drone and Transmitter: Ensure both the drone and the radio transmitter are powered on and within range of each other. Make sure the transmitter is properly bound to the drone's receiver.

3.Initiate Calibration: Refer to the flight controller software guidelines to begin the radio calibration process. This usually entails selecting the radio calibration option and confirming your intent to calibrate, following the software's instructions.

4.Move the Control Sticks: The flight controller software will prompt you to move each control stick (throttle, yaw, pitch, and roll) on the transmitter through its full range of motion. This allows the flight controller to detect and record the minimum and maximum values for each channel.

5.Set Trim and Endpoints: Some flight controllers may also allow you to adjust trim settings or endpoints during calibration. Trims are used to fine-tune the centre position of control inputs, while endpoints define the maximum and minimum range of motion for each channel.

6.Confirm Calibration: Once you've moved all the control sticks through their full range of motion, confirm the calibration in the flight controller software. The software will typically display a summary of the calibration results, indicating that the radio calibration was successful.

7.Verification and Testing: After calibration, it's advisable to verify that the drone responds accurately to control inputs from the transmitter. Take off in a controlled environment and test each control axis (throttle, yaw, pitch, and roll) to ensure smooth and precise control.

Flight modes

Flight modes in drones refer to the different preset configurations or control settings that dictate how the drone behaves in flight. These modes offer varying levels of control and automation, allowing pilots to choose the mode that best suits their needs and flight conditions. Here are some common flight modes found in drones

1.Stabilized Mode: Stabilized mode, also known as manual mode or attitude mode, is the most basic flight mode. In this mode, the drone's flight controller assists the pilot in maintaining stability by automatically stabilizing the aircraft's attitude (orientation) based on the pilot's control inputs. The pilot directly controls the drone's roll, pitch, and yaw angles using the transmitter sticks. However, the flight controller automatically levels the drone when the sticks are released, helping to prevent the aircraft from drifting or tipping over.

2.Altitude Hold Mode: Altitude hold mode adds an additional layer of automation by maintaining a consistent altitude above the ground. In this mode, the drone's flight controller uses altitude sensors (such as barometers) to measure the drone's altitude and adjusts the throttle automatically to maintain a constant height. The pilot retains control over the drone's horizontal movement (roll, pitch, and yaw), while the flight controller maintains the drone's altitude.

3.Land Mode: Land mode is a semi-autonomous flight mode designed to safely land the drone when activated. In this mode, the drone's flight controller initiates a controlled descent and landing sequence, typically bringing the drone to a gentle touchdown at a predetermined location. The pilot may activate land mode manually or configure the drone to automatically enter land mode when certain conditions are met, such as low battery voltage or loss of signal from the transmitter. Land mode is a safety feature that helps prevent accidents or damage to the drone by ensuring a controlled landing in case of emergencies or loss of control.

4.4 Communication between drones

The communication between the drones can be implemented using Bluetooth. By adjusting the distance between the drones within the Bluetooth range communication happens properly. The signal transmitted by the remote control will be received at the receivers end at the drone. This signal is stored in the Arduino and transmitted to another drone via Bluetooth. This transmitted signal is received by the Bluetooth in the second drone and passed to the Arduino, now the Arduino processes the signal and pass the signal to flight controller this triggers the action in the second drone. Initially first drone tries to lift of the load that we have if it can't lift off the load it gives a signal to the other drone now the second drone comes to the first drone and both the drones will lift the load. Finally, calculated the load capacity of combined drones. This technology aims to reduce the overall cost of drone systems used in agriculture. A drone with high load capacity is very expensive if we can split the work by using smaller drones it would be cost effective as the smaller drones are affordable. Multiple drones can sprinkle over a larger area by dividing the land area based on number of drones that are used in the system. This even makes time efficient as the number of drones increases the time required to cover the land decreases.

CHAPTER 5

RESULT AND DISCUSSION

After calculating the load capacities of drones practically they came out lesser than the theoretical values. To get the load capacity of the drones we must subtract the payload (the parts that are included in the drone) from total carrying capacity of all the motors combined. This provides the theoretical load capacity of each drone.

5.1 Calculations

Here are the specifications of the motor and ESC

Maximum RPM of the motor = 7500

Thrust provided by the motor = 700N

Load of the motor = 600gm

Quadcopter

Thrust of each motor = 700N

Expected payload from the quadcopter:

Payload = (4 X (payload of motor)) - (quadcopter weight)

= 2400gm – 1200gm

= 1200gm

Hexacopter

Thrust of each motor = 700N

Expected payload from the hexacopter:

Payload = (6 X (payload of motor)) - (hexacopter weight)

= 3600gm – 1500gm

= 2100gm

Total payload of the system

Total payload = (payload of quadcopter) + (payload of hexacopter)

=2100gm + 1200gm

Total payload = 3300 gm

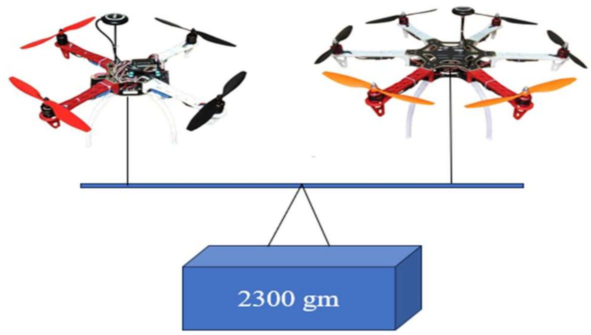

Fig 5.1. Expected payload of total system

Theoretical values

No of motors	Thrust	Load
1	700N	600gm
4(quadcopter)	2800N	1200gm
6(hexacopter)	4200N	2100gm

Table 5.1

Practical values

No of motors	Thrust	Load
1	700N	400gm
4(quadcopter)	2800N	800gm
6(hexacopter)	4200N	1500gm

Table 5.2

Final design of quadcopter and hexacopter

Fig 5.2. Final design of quadcopter and hexacopter

CHAPTER 6

CONCLUSION

Swarm technology offers an enticing opportunity to boost the carrying capacity of small drones through collective utilization. This innovation relies on advanced communication technology, seamlessly connecting multiple drones to operate in sync. Unlike larger, costlier traditional drones, this approach enables smaller drones to collaboratively tackle tasks that might otherwise demand their larger counterparts. Consequently, it expands the potential applications of drone technology, rendering it both cost-effective and adaptable across various scenarios. Whether for surveillance missions or payload deliveries, the combined efforts of small drones prove remarkably effective. By leveraging the strengths of each individual drone within a swarm, this approach maximizes efficiency and versatility. Moreover, its affordability enhances accessibility, opening doors to a wider range of users and applications. In essence, swarm technology represents a paradigm shift, empowering small drones to collectively accomplish feats once reserved for their larger and pricier counterparts.

CHAPTER 7

FUTURE ENHANCEMENT

Utilizing this technology enables us to augment the collective payload capacity of small drones. The communication infrastructure integral to this innovation can be seamlessly deployed across numerous drones simultaneously. In contrast to their larger counterparts, which often incur significant costs, employing this technology translates to a reduction in overall expenditure. By harnessing the collaborative power of small drones, we effectively mitigate the limitations imposed by individual payload capacities. This approach not only optimizes resource utilization but also enhances operational efficiency. Furthermore, the scalability of this technology ensures adaptability to varying mission requirements, offering a versatile solution across diverse applications. Through strategic coordination and synchronized efforts, small drones collectively surpass the capabilities of their larger counterparts. Consequently, organizations can achieve their objectives more cost-effectively and efficiently. Moreover, the accessibility afforded by this technology democratizes drone usage, making it attainable for a broader range of users and applications. In essence, by leveraging the collaborative potential of small drones, this technology heralds a new era of enhanced payload capacities and cost-effective operations.

CHAPTER 8

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APPENDIX