AgniVeer: Design and Development of a Drone with Assisted Fire Surveillance and Response System

Dissertation

Submitted in partial fulfillment of the requirement of the degree

Of

Bachelors of Technology

in

Electronics & Communication Engineering

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2020-2024

CERTIFICATE

This is to certify that the project entitled ("AgniVeer: Design and Development of a Drone with Assisted Fire Surveillance and Response System") is a bonafide work carried out by Dhanya Borah (ECE-65/20), Himangshu Sekhar Tamuli (ECE-70/20), Trishamoyee Borah (ECE-92/20), Riaz Ali Ahmed (ECE-93/20) in partial fulfillment for the award of degree of Bachelor of Technology in Electronics & Communication Engineering from Dibrugarh University Institute of Engineering and Technology under Dibrugarh University, Dibrugarh, Assam during the academic year 2020-2024.

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We do hereby declare that the work presented in this dissertation is exclusively our own under the supervision of Mrs. Parismita Gogoi, Assistant Professor of Department of Electronics and Communication, Dibrugarh University Institute of Engineering and Technology, Dibrugarh University and was carried out by the authors. The extent and source of information derived from existing literature have been indicated in the dissertation at appropriate places.

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ACKNOWLEDGEMENT

We are profoundly grateful to our project guide Mrs. Parismita Gogoi and Head of the Department Dr. Haraprasad Mondal for their expert guidance and continuous encouragement throughout to see that this project rights its target. Their immense knowledge, profound experience and professional expertise in this arena have enabled us to complete this report successfully. Without their support and guidance, this project would not have been possible. We could not have imagined having a better supervisor in our project report.

We would like to express deepest appreciation towards Dr. Mukul Chandra Bora, Director Dibrugarh University Institute of Engineering and Technology under Dibrugarh University whose invaluable guidance supported us in this project.

At last, we express our sincere heartfelt gratitude to all the staff members of Electronics & Communication Engineering Department who helped us directly or indirectly during this course of work.

Thanks for all your encouragement.

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ABSTRACT

In a world where fire accidents are becoming more frequent, first responders constantly risk their lives to save others. Unfortunately, history shows that these brave individuals often do not survive. To save as many lives as possible, it's essential to delegate dangerous tasks to machines. Drones are an excellent solution, offering great mobility and eliminating the risk to human personnel. Equipped with flame or temperature sensors and a KK2.1 LCD flight controller for communication, drones can gather information quickly and efficiently. This "AgniVeer" project focuses on designing and developing a drone equipped with an advanced fire surveillance and response system. This system enhances firefighting capabilities, especially in challenging environments where traditional methods fall short. The core innovation of AgniVeer lies in its integration of infrared (IR) sensors for real-time fire detection and a submersible motor-controlled spraying mechanism for rapid response. The drone's IR sensors accurately detect thermal anomalies indicative of fire outbreaks. When a heat source is detected, the system automatically triggers the submersible motor, activating the attached spraying tank. This tank, filled with water or a fire-retardant solution, then sprays over the affected area. The spraying mechanism is designed to cover a wide area, ensuring effective fire suppression. During development, the IR sensors' sensitivity and accuracy were rigorously tested, along with the reliability of the submersible motor and spraying system under various environmental conditions. Results showed that AgniVeer could promptly detect and respond to fire incidents, significantly reducing the risk of fire spreading and enhancing overall firefighting effectiveness. AgniVeer represents a significant advancement in drone technology for disaster management. Its real-time surveillance capabilities, coupled with a quick-response fire suppression system, offer a robust solution for mitigating the impact of fires. This project addresses current firefighting challenges and lays the groundwork for future innovations in automated disaster response systems.

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CHAPTER 1

INTRODUCTION

Firefighting has always been a critical yet challenging task, especially in inaccessible or hazardous environments where traditional methods fall short. The rapid detection and suppression of fires are essential to prevent widespread damage and loss of life. In this context, technological advancements offer promising solutions to enhance firefighting efficiency and safety. The "AgniVeer" project aims to leverage the capabilities of unmanned aerial vehicles (UAVs) by designing and developing a drone equipped with an advanced fire surveillance and response system.

The AgniVeer drone integrates cutting-edge infrared (IR) sensors and a submersible motor-controlled spraying mechanism to address the complexities of fire detection and suppression. The IR sensors are capable of detecting thermal anomalies indicative of fire outbreaks, even in dense smoke or low visibility conditions. Once a fire is detected, the drone's system automatically activates the submersible motor, which controls the spraying tank filled with water or a fire-retardant solution. This spraying system is designed to cover a wide area, effectively quenching flames and preventing the fire from spreading. Fire accidents lead to serious injury and huge losses of life and personal property. Often fire accidents occur unexpectedly and suddenly. According to a study, in the year 2017, out of 27,027 deaths, every fifth deaths caused due to fire took place in India. In 2017, around 9 million fire incidents and 1.2 lakhs deaths were recorded all over the world. It is very difficult for the fire personnel to predict the situation inside the building subjected to fire, so with the help of drones they can identify the cause of fire and decide how to approach and enter the location.

The motivation behind AgniVeer stems from the increasing frequency and intensity of wildfires and urban fires, which pose significant threats to communities and ecosystems worldwide. Traditional firefighting methods often involve significant risks to personnel and may be hampered by terrain or environmental conditions. AgniVeer aims to mitigate these risks by providing a versatile, efficient, and autonomous solution that can operate in diverse environments, including urban settings, forests and industrial areas.

The development of AgniVeer involved interdisciplinary collaboration, encompassing expertise in drone technology, sensor integration, mechanical engineering, and fire safety. The project underwent extensive testing to ensure the reliability and effectiveness of its components, particularly the IR sensors and the spraying mechanism, under various environmental conditions. In summary, AgniVeer represents a significant leap forward in the application of drone technology for disaster management. By combining real-time fire detection with an autonomous suppression system, it offers a robust and innovative approach to modern firefighting challenges.

1.1 THE IMPORTANCE OF FIRE RESPONSE SYSTEM

Fire response systems are critical components of public safety infrastructure, playing a vital role in protecting lives, property and the environment from the devastating impacts of fires. The significance of these systems can be understood through several key perspectives:

I. **Life Safety:** The foremost importance of fire response systems lies in their ability to save lives. Early detection and swift suppression of fires significantly reduce the risk of injury or death. Fire response systems provide critical alerts and initiate firefighting efforts before the situation escalates, allowing for timely evacuation and reducing casualties.

II. **Property Protection:** Fires can cause extensive damage to homes, businesses and infrastructure, resulting in substantial economic losses. Effective fire response systems help contain and extinguish fires quickly, minimizing damage and preserving valuable assets. This is particularly important in densely populated urban areas and industrial settings where the potential for property damage is high.

III. **Environmental Preservation:** Wildfires and industrial fires can have severe environmental consequences, including the destruction of forests, wildlife habitats and the release of toxic pollutants. Advanced fire response systems help mitigate these impacts by controlling fires at an early stage, preventing large-scale environmental degradation and promoting ecosystem stability.

IV. **Economic Impact:** The economic repercussions of fires are significant, encompassing direct costs related to property damage and indirect costs such as business interruptions and loss of productivity. Fire response systems contribute to economic stability by reducing the frequency and severity of fires, thereby lessening the financial burden on communities and industries.

V. **Community Resilience:** Effective fire response systems enhance the overall resilience of communities. By improving preparedness and response capabilities, these systems ensure that communities can recover more quickly from fire-related incidents. This resilience is crucial for maintaining public confidence and ensuring long-term societal stability.

VI. **Technological Advancement:** The development and implementation of modern fire response systems drive technological innovation. These systems often incorporate advanced sensors, automated response mechanisms and real-time monitoring capabilities, pushing the boundaries of what is possible in fire safety and emergency response.

VII. **Regulatory Compliance and Insurance:** Many regions have stringent fire safety regulations that mandate the installation and maintenance of fire response systems. Compliance with these regulations is essential for legal and insurance purposes. Effective fire response systems not only fulfill regulatory requirements but also can result in lower insurance premiums due to reduced risk.

In conclusion, fire response systems are indispensable in safeguarding human lives, protecting property, preserving the environment and supporting economic stability. Their importance is underscored by the growing challenges posed by urbanization, climate change, and industrial activities, which increase the frequency and severity of fire incidents. By investing in advanced fire response systems, societies can enhance their resilience and readiness to face these challenges.

1.2 ROLE OF CO2/H2O IN FIRE CONTROL

Carbon dioxide (CO2) and water (H2O) are two of the most commonly used agents in fire suppression. Each has distinct properties and mechanisms that make them effective in controlling and extinguishing fires. Understanding their roles and applications is essential for effective fire management.

Carbon Dioxide (CO2)

Mechanism of Action:

1. **Oxygen Displacement**: CO2 extinguishes fires primarily by displacing oxygen in the vicinity of the flame. Since oxygen is essential for combustion, reducing its concentration below 15% effectively smothers the fire.
2. **Cooling Effect**: Although not as significant as water, CO2 has a cooling effect on the fire. When released, it expands rapidly and absorbs heat, lowering the temperature in the immediate area.

Advantages:

1. **Non-Conductive**: CO2 is non-conductive and safe to use on electrical fires, making it ideal for protecting electrical equipment and facilities.

2. **Residue-Free**: Unlike water, CO_2 leaves no residue, which is particularly beneficial in environments where clean-up is problematic or costly, such as data centers, laboratories and manufacturing facilities.

Applications:

- **Electrical Fires**: CO_2 is commonly used in environments with electrical hazards.
- **Enclosed Spaces**: It is effective in enclosed or confined spaces where it can accumulate and displace oxygen more effectively.

Water (H_2O)

Mechanism of Action:

1. **Cooling**: Water extinguishes fires primarily through its cooling effect. When water is applied to a fire, it absorbs a significant amount of heat as it turns to steam, thereby reducing the temperature below the ignition point.
2. **Steam Formation**: The conversion of water to steam helps to displace oxygen around the fire, contributing to its suppression.

Advantages:

1. **Readily Available**: Water is abundant and easily accessible, making it the most common firefighting agent worldwide.
2. **High Heat Absorption**: Water has a high specific heat capacity and latent heat of vaporization, making it highly effective at absorbing heat and reducing temperatures.
3. **Versatile**: Water can be used in various forms, such as mist, spray, or foam, to adapt to different types of fires and environments.

Applications:

- **Structural Fires**: Water is extensively used in fighting structural fires, including residential, commercial and industrial buildings.
- **Wildfires**: In wildfire scenarios, water is often dropped from aircraft or delivered through hoses to control and extinguish large areas of burning vegetation.

Combined Use in Firefighting

In some cases, CO_2 and water can be used in combination to maximize fire suppression effectiveness. For example, water can be used to control and cool large areas of fire, while CO_2 can be applied to specific hotspots, especially where electrical equipment is involved.

Limitations

- **CO_2**: Not suitable for outdoor use or in well-ventilated areas where it can dissipate quickly. It can also pose asphyxiation risks in confined spaces.
- **Water**: Not suitable for oil, grease, or electrical fires due to the risk of spreading the fire or causing electrical shocks.

1.3 TYPES OF DRONES

Drones can be classified based on several criteria, according to Waats et al. (2012).

Six categories have been outlined below.

Micro Air Vehicles: Due to their small size, they are commonly referred to as Nano Air aircraft, which enables military variants of these aircraft to be carried in soldiers' backpacks and enable unobtrusive surveillance in cramped places. These aircraft typically operate at lower altitudes, less than 330 meters.

Vertical take-off and landing: Due to these aircraft's inability to take off and land, they're typically used in situations where terrain constraint makes this type of aircraft necessary. Their flight heights vary depending on the mission profile, typically at lower altitudes and with long flight durations as hovering consumes a lot of battery power.

Low Altitude-Short Endurance: By eliminating the need for runways, miniature unmanned aerial systems are able to achieve rapid deployment and transportation to launch an aircraft from a catapult, you need to have less than three meters of wing spans and a weight of between 2 and 5 kilograms as a result of weight and capacity tradeoffs, range and connectivity are typically reduced to 1-2 hours, but within a few kilometers of ground stations

Low Altitude-Short Endurance Close: In this case, unmanned aircraft weighing and requiring greater runway capacity and weight will be considered tiny. They can fly for up to 1500m in altitude and have relatively high flight time.

Medium Altitude Long Endurance: drone of this type can carry a high weight at a relatively higher altitude for an extended period of time at an extreme upper end of their payload range. It is common for these aircraft to fly at altitudes of up to 9,000 meters, flying thousands of kilometers from their base station through hundreds of flights lasting several hours. Military defense services use these extensively and some areas of civil applications have also seen an escalation in their usage.

High Altitude Long Endurance: Featuring larger and more complicated aircraft than most commercial aircraft, these are the biggest and most complicated planes in the world Several thousand kilometers can be covered and flight time is in excess of 330 hours in space. These drones are capable of flying at 20,000 meters and beyond.

1.4 ROLE OF DRONES IN FIRE CONTROL

Drones, or unmanned aerial vehicles (UAVs), have emerged as valuable tools in fire control and management due to their ability to perform various tasks that enhance the efficiency and safety of firefighting operations. Here are the key roles that drones play in fire control:

1. Surveillance and Monitoring

Real-Time Aerial Views:

- Drones provide real-time aerial imagery and video feeds of fire-affected areas, allowing incident commanders to assess the situation quickly and accurately.

- This capability is especially crucial in large-scale wildfires and urban fires where ground visibility may be limited.

Thermal Imaging:

- Equipped with thermal cameras, drones can detect hotspots and monitor fire spread through smoke and darkness, providing vital information that is not visible to the naked eye.

- Thermal imaging helps identify residual heat sources after the main flames are extinguished, ensuring thorough fire suppression and preventing reignition.

2. Mapping and Analysis

High-Resolution Mapping:

- Drones create high-resolution maps of fire-affected areas, enabling detailed analysis and planning.

- These maps can be used to assess damage, plan evacuation routes and strategize firefighting efforts.

Topographic and Vegetation Analysis:

- Drones can analyze topography and vegetation, helping predict fire behavior based on the landscape and fuel load.

- This information aids in developing effective firebreaks and containment strategies.

3. Early Detection and Rapid Response

Early Fire Detection:

- Drones equipped with advanced sensors can detect fires in their early stages, even before they become visible to humans.

- Early detection allows for quicker response, potentially preventing small fires from escalating into major incidents.

Rapid Response Delivery:

- Drones can quickly deliver fire retardants, water or other firefighting materials to areas that are difficult to reach by ground crews.

- This rapid response capability is crucial in containing fires in remote or inaccessible locations.

4. Support for Ground Crews

Safety and Coordination:

- Drones enhance the safety of firefighting personnel by providing situational awareness, identifying hazardous areas and guiding ground crews.

- They enable better coordination by acting as communication relays in areas where traditional communication infrastructure may be compromised.

Search and Rescue Operations:

- In addition to firefighting, drones assist in search and rescue operations by locating trapped individuals and delivering essential supplies until rescue teams arrive.

5. Post-Fire Assessment and Recovery

Damage Assessment:

- After a fire is extinguished, drones help assess the extent of damage to infrastructure, property and natural resources.

- This information is crucial for insurance claims, recovery planning and rebuilding efforts.

6. Training and Simulation

Training Exercises:

- Drones are used in training exercises to simulate real-life fire scenarios, enhancing the preparedness of firefighting teams.

- They provide valuable data for after-action reviews, helping improve tactics and strategies.

1.5 MOTIVATION OF THE PROJECT

The AgniVeer project is motivated by the urgent need to enhance fire surveillance and response amidst rising fire incidents due to climate change and urbanization. Traditional firefighting methods face significant limitations, such as accessibility challenges and risks to firefighters' lives. The rapid advancements in drone technology and sensor systems offer new opportunities for early fire detection, swift response and efficient resource allocation. Drones equipped with infrared sensors can detect and monitor fires in real-time, even in difficult conditions, while delivering firefighting agents to hard-to-reach areas. This approach minimizes environmental impact, reduces economic losses and enhances community safety and resilience. AgniVeer aims to provide a robust, efficient and safer fire management solution, addressing the immediate challenges and contributing to long-term stability and preparedness against fire disasters.

1.6 OBJECTIVE

The objective of the AgniVeer project is to design and develop a drone equipped with an advanced fire surveillance and response system to enhance firefighting capabilities. The drone will utilize infrared sensors for early fire detection and a submersible motor-controlled spraying mechanism to quickly suppress detected fires. AgniVeer aims to provide real-time monitoring, efficient fire suppression and improved safety for firefighters by addressing the limitations of traditional methods. This project seeks to reduce fire-related damage, minimize environmental impact and bolster community resilience through innovative technology and rapid response capabilities.

1.7 EXPECTED OUTCOME

- **Enhanced Fire Detection and Monitoring:**

  Early and accurate fire detection using advanced infrared sensors, providing real-time monitoring even in low visibility conditions.

- **Rapid and Effective Fire Suppression:**

  Swift deployment of a submersible motor-controlled spraying mechanism for immediate fire suppression, reducing response times and minimizing fire spread.

- **Increased Safety for Firefighters:**

  Reduced exposure to hazardous conditions by utilizing drones for surveillance and initial fire suppression, improving situational awareness and decision-making for ground teams.

- **Environmental and Economic Benefits:**

  Decreased environmental impact and lower economic losses due to effective containment and reduced property damage and business interruptions.

CHAPTER 2

LITERATURE SURVEY

The paper [1], "Design and Development of Heavy Drone for Fire Fighting Operation" by Vimalkumar R. and Karan Kumar Shaw highlights the significant potential of integrating drone technology into firefighting operations. The authors reference the alarming statistics of fire-related incidents and fatalities, particularly in India, and underscore the need for innovative solutions. They discuss the successful application of drones by the Los Angeles Fire Department during the 2017 wildfires, illustrating the practical benefits of drones in emergencies. Key technologies proposed for the firefighting drone include fire extinguisher balls, thermal imaging cameras and a water storage and pump system to enhance situational awareness and direct firefighting capabilities. The literature indicates that drones can significantly improve the safety and efficiency of firefighting operations by providing real-time data, covering large areas quickly, and reducing the need for human intervention in hazardous environments. The authors advocate for further research to fully integrate and optimise drones in firefighting arsenals worldwide.

This paper [2], "Automated Fire Fighting Drone for Wildlife Fire Detection and Extinguishing" from V.S. M’s Somashekhar R. Kothiwale Institute of Technology explores the innovative application of drone technology for combating forest fires. The authors note the high incidence of fire-related fatalities and injuries, emphasising the need for safer, more efficient firefighting methods. The project integrates unmanned aerial vehicles (UAVs) with advanced sensors, IoT systems, and automated mechanisms to detect and extinguish fires, particularly in challenging and hazardous environments. Literature on drone applications in firefighting highlights their potential to enhance situational awareness, reduce response times, and mitigate risks to human firefighters. The drone is equipped with brushless DC motors, a hexacopter body, fire detection sensors, and a payload mechanism for deploying fire extinguisher balls, which release CO2 to suppress fires. The integration of thermal cameras allows for accurate heat mapping and real-time data transmission, aiding strategic decision-making in fire management. The project's emphasis on autonomy and remote control underscores the broader trend in UAV research aimed at improving operational safety and efficiency in disaster response. Future advancements could include deep learning for automated fire detection, further enhancing the drone's capability to respond to wildfires autonomously. This literature review situates the project within the evolving field of UAV-based firefighting, underscoring its potential to transform traditional fire response strategies.

In this paper [3], the pivotal role of unmanned aerial vehicles (UAVs) equipped with infrared and visual cameras in forest fire detection and management is investigated. Kabra and Singh's research introduces a UAV system employing a thresholding algorithm for real-time fire detection, with the potential to integrate more advanced algorithms in the future. Their system's collaborative approach among multiple UAVs enhances surveillance efficiency by providing complementary fire views and broader coverage. Past studies have underscored the effectiveness of UAVs in swift fire detection and response, with continuous advancements in camera technology and image processing further augmenting their capabilities. The proposed system integrates various detection techniques, including area, colour, motion, and smoke detection, leveraging RGB and YCbCr colour spaces to enhance accuracy. Additionally, the inclusion of the Sobel Edge Detection algorithm facilitates refined fire boundary identification. Future directions may entail incorporating neural networks for decision-making, GSM modules for alerting fire stations, and the integration of water sprinklers, all aimed at mitigating false alarms and enhancing overall detection accuracy and response time.

In the realm of fire safety and emergency response, the integration of unmanned aerial vehicles (UAVs) presents a promising solution, as evidenced by recent advancements in drone technology. The research conducted by Sumitha C et al. [4] introduces a pioneering concept of a "Smart Drone Fire Extinguisher," leveraging UAVs equipped with flame sensors, GSM modules, and temperature sensors for rapid fire detection and response. The proposed system harnesses the mobility and agility of drones to navigate hazardous environments, providing crucial real-time data and enabling swift intervention without risking human lives. Furthermore, initiatives such as the Drone Efficacy Study (DES) demonstrate the potential of UAV-enabled search and rescue operations, showcasing faster response times compared to traditional methods. Integrating cutting-edge technologies like vibration-based sensors and pattern recognition algorithms further bolsters the effectiveness of UAV-assisted inspections for early detection of structural vulnerabilities. Moreover, the evolution of software tools like the Arduino IDE and the introduction of IDE 2.0 underscores the continuous efforts to enhance the development environment and support ecosystem for UAV applications. This interdisciplinary approach, blending hardware, software and sensor technologies, holds immense promise for revolutionizing firefighting and emergency response efforts, ultimately saving lives and minimizing economic losses.

On paper [5], utilizing drones as fire extinguishers presents a significant advancement in fire safety technology, as discussed by Titre et al. (2020). The unmanned aerial vehicle (UAV) system developed integrates modern technologies for various civil and military applications, providing an automatic and autonomous solution for fire detection and suppression. With the shrinking size and increasing capabilities of microelectronic devices, UAVs equipped with autopilot systems have become more capable and efficient, driving the growth of the UAV market. The paper highlights the potential of UAVs in enhancing air traffic management through information exchange systems and alternative separation procedures. Moreover, the research aims to provide a simple and low-cost solution for autonomous aerial surveillance and fire suppression, emphasizing the practicality and versatility of drones in mitigating fire hazards. This work contributes to the ongoing efforts to harness UAV technology for enhancing firefighting and emergency response capabilities, paving the way for future innovations in fire safety and disaster management.

This paper [6], presents a comprehensive approach to utilizing drones equipped with thermal imaging technology for detecting fire-prone environments. The authors emphasize the critical role of real-time data collection in preventing and mitigating the destruction caused by forest fires. By employing drones with thermal sensing capabilities, they aim to provide rapid intervention and reduce the impact of natural calamities. The system integrates various components, including brushless DC motors, thermal imaging cameras, GPS modules, Raspberry Pi and more, to enable autonomous flight and accurate detection of fire-prone areas. Through detailed design calculations and fabrication processes, the authors demonstrate the feasibility and effectiveness of their proposed solution. Additionally, they discuss the potential for future enhancements, such as incorporating advanced thermal cameras for higher accuracy and extending detection capabilities to night-time operations.

LIMITATIONS

1. **Limited Water Carrying Capacity:** Drones generally have restrictions on payload capacity due to their size and power. Carrying sufficient water to effectively combat fires could be challenging and frequent refills may be necessary, reducing operational efficiency.

2. **Battery Life Constraints:** The energy required for flight, water dispensation, and operating an infrared sensor can significantly drain battery life. This limits the drone's operational time and range, potentially requiring frequent recharging stops which can delay response times.

3. **Sensor Accuracy and Range:** Infrared sensors may face limitations in accurately detecting fires under varying environmental conditions, such as through smoke or fog. The range of the sensor also limits the area the drone can monitor effectively at any given time.

4. **Weather Dependency:** Drones can be sensitive to adverse weather conditions including high winds, rain, or extreme temperatures, which could limit operational days and effectiveness in emergency scenarios.

5. **Limited Intervention Capabilities:** While the drone can detect fires and dispense water, its ability to completely extinguish larger fires or perform other firefighting functions such as evacuating individuals or handling chemical fires is limited.

6. **Integration with Emergency Services:** Coordination with existing firefighting and emergency response services is necessary to ensure that the drone's actions are timely and augment rather than interfere with human efforts.

CHAPTER 3

SYSTEM DEVELOPMENT

3.1 HARDWARE TOOLS

3.1.1 KK2.1 Multi-rotor LCD Flight Control Board With 6050MPU and Atmel 644PA: This Control board can enhance your knowledge about Flight controllers as well as the working of the accelerometer and Gyroscope. The KK 2.1 Flight Controller Board with 6050 MPU Board and Atmel 644PA is the next generation of KK flight control boards. It comes preinstalled with the KK2.1 firmware and features advanced processor technology from STMicroelectronics, sensor technology, and intenseness system delivering incredible performance, flexibility and reliability for controlling any autonomous vehicle.

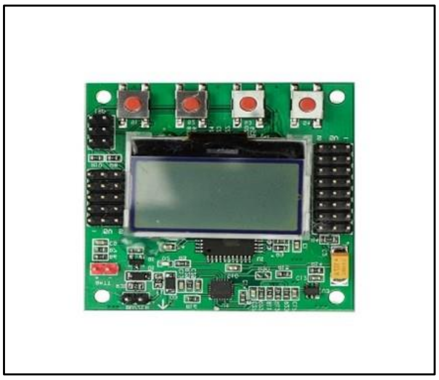


Fig 1 Flight Control Board

3.1.2 Fly Sky CT6B 2.4GHz 6CH Transmitter with FS-R6B Receiver: Fly Sky CT6B 2.4 GHz 6CH transmitter is an entry-level 2.4 GHz radio system offering the reliability of 2.4 GHz signal technology and a receiver. It is ideal for quadcopters and multirotors that require 6 channel operation.

Fig 2 6 Channel Transmitter

3.1.3 F450 / Q450 Quadcopter Frame (with Integrated PCB): This F450/Q450 Quadcopter Frame is made from 35% of Glass Fiber which makes it tough and durable. They have arms of ultra-durable Polyamide-Nylon which are the stronger moulded arms having a very good thickness so no more arm breakage at the motor mounts on a hard landing. The arms have support ridges on them, which improves stability and provides faster forward flight. They are strong, light and have a sensible configuration including a PCB (Printed Circuit Board) with which you can directly solder your ESCs to the Quadcopter for fast and easy assembly.

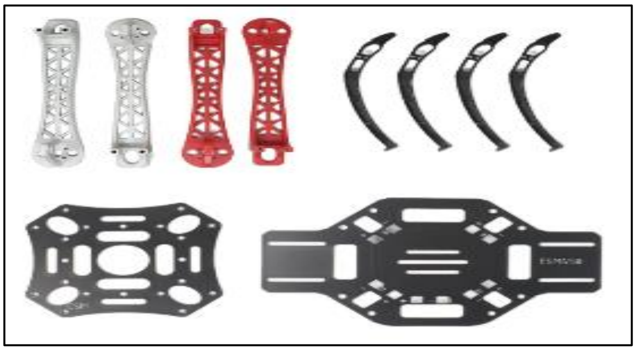


Fig 3 Quadcopter Frame

3.1.4 2**.54mm 1×40 Pin Male Single Row Straight Short Header Strip:** It is a 2.54mm 1×40 Pin Male Single Row Straight Short Header Strip. It has one row of 40 pins. Ideal for through-hole mounting. It has 11.5mm short pins and the plastic spacer can be adjusted according to the application.

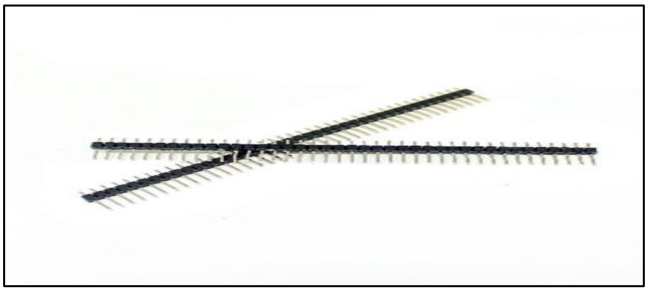


Fig 4 Header Strip

3.1.5 Orange HD Propellers 1045(10X4.5) ABS DJI Black: These Orange Propellers are light in weight and high strength propeller has a 15° angle design at the end of the propeller to avoid whirlpools while the multi-copter is flying. Orange propellers help to improve air-powered efficiency and aerofoil stability.

Fig 5 Propellers

3.1.6 SimonK 30A BLDC ESC: Simonk 30A BLDC ESC Electronic Speed Controller is specifically made for quadcopters and multi-rotors. Which provides faster and better motor speed control giving better flight performance compared to other available ESCs. Simonk 30A BLDC ESC can drive motors that consume current up to 30A. It works on 2-3S LiPo batteries. This electronic speed controller offers a battery eliminator circuit (BEC) that provides 5V and 2A to the receiver.

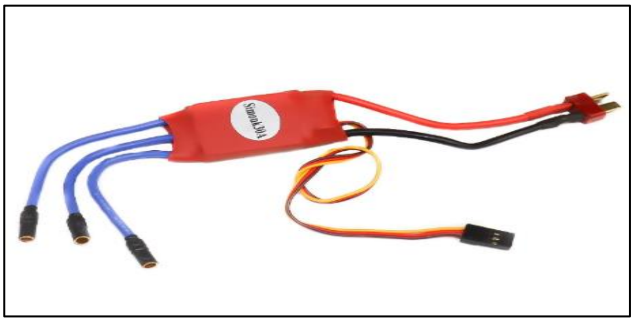


Fig 6 Electronic Speed Controller

3.1.7 A2212 1000 KV BLDC Motor: This motor provides a Motor kV of 1000. This motor is bi-directional which means it can rotate in CW or CCW direction by swapping the polarity of the input supply. The steel design is capable of withstanding competitive conditions. Lightweight design makes them suitable for a wide range of Quadcopter and Hex copter Frames. It has a compact size and offers great performance and value for money.

Fig 7 BLDC Motor

3.1.8 Orange 11.1V 4500mAh 35C 3S Lithium Polymer Battery: Orange 3S 35C Lithium polymer 4500mAh battery Pack (LiPo) is known for its performance, reliability, and price. The 4500mAh battery Pack (LiPo) delivers full capacity at a price everyone can afford; likewise, we assure a quality product and the best customer support. The Orange 3S 35C 4500mAh battery Pack (LiPo) is available with heavy-duty discharge leads; above all, it minimizes resistance and sustains high current loads. Orange batteries stand up to the punishing extremes of aerobatic flight and RC vehicles.

Fig 8 Lithium Polymer Battery

3.1.9 Jumper Wires: These Flexible Breadboard Jumper Wires are Ideal for creating circuits between your microcontroller and the breadboard for fast building a prototype of an electronic circuit. Soldering is not required. Wires are flexible, durable, reusable, easy to trace, and easy to connect and disconnect.

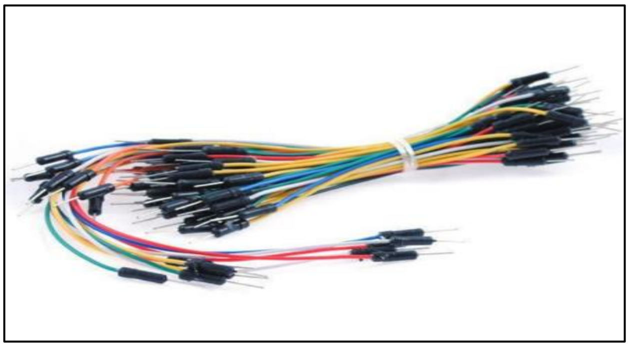


Fig 9 Jumper Wires

3.1.10 Horizontal Mini Submersible Pump DC 12V: A submersible pump (or electric submersible pump (ESP) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between the pump and the fluid surface

Fig 10 Submersible Pump

3.1.11 Flame Sensor Infrared Receiver Ignition Source Detection Module: Flame sensors typically utilise infrared sensors to detect the unique radiation emitted by flames. When a flame is present, the sensor detects the infrared radiation and generates an electrical signal. The fire detection system then processes this signal to trigger an alarm or activate fire suppression measures.

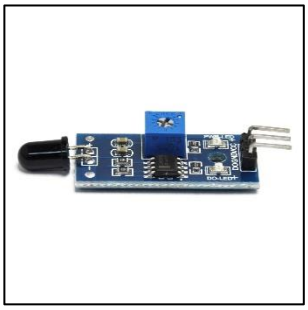


Fig 11 IR sensor

3.1.12 Container Box: We have used a lightweight, durable, and secure container such as a small plastic box to store water. Ensure it is securely mounted to the drone using metal strips to prevent shifting and maintain flight stability.

Fig 12 Container

3.1.13 2.54mm 1×40 Pin Female Single Row Header Strip: It is a 2.54mm 1×40 Pin Female Single Row Header Strip. It has a single row of 40 pins. Ideal for through-hole mounting.

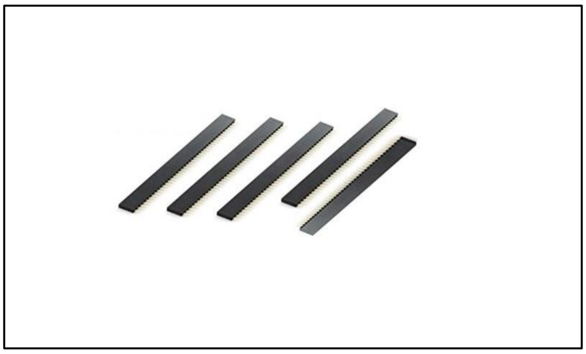


Fig 13 Female Header Strip

3.2 SOFTWARE TOOLS

3.2.1 ALTIUM CIRCUIT MAKER (Software for designing the circuit diagram)

CircuitMaker is electronic design automation software for printed circuit board designs targeted at the hobby, hacker and maker community. CircuitMaker is available as freeware and the hardware designed with it may be used for commercial and non-commercial purposes without limitations.

Fig14 Altium Circuit Maker

3.2.2 Tinkercad (Software for designing the 3D model)

Tinkercad is a free-of-charge, online 3D modeling program that runs in a web browser. Since it became available in 2011 it has become a popular platform for creating models for 3D printing as well as an entry-level introduction to constructive solid geometry in schools.

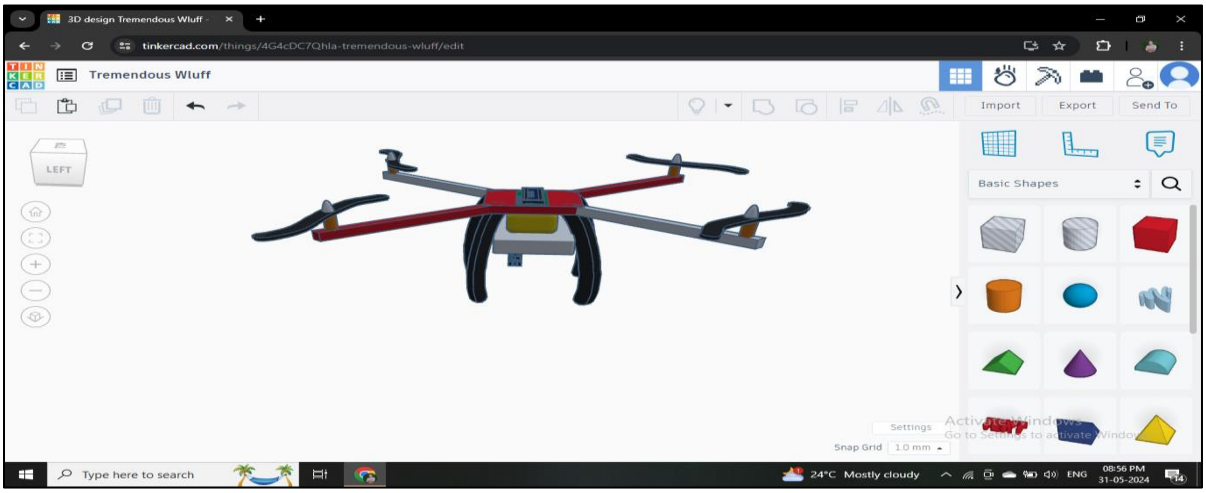


Fig 15 Tinkercad

CHAPTER 4

RESULTS AND DISCUSSION

4.1 CIRCUIT DIAGRAM

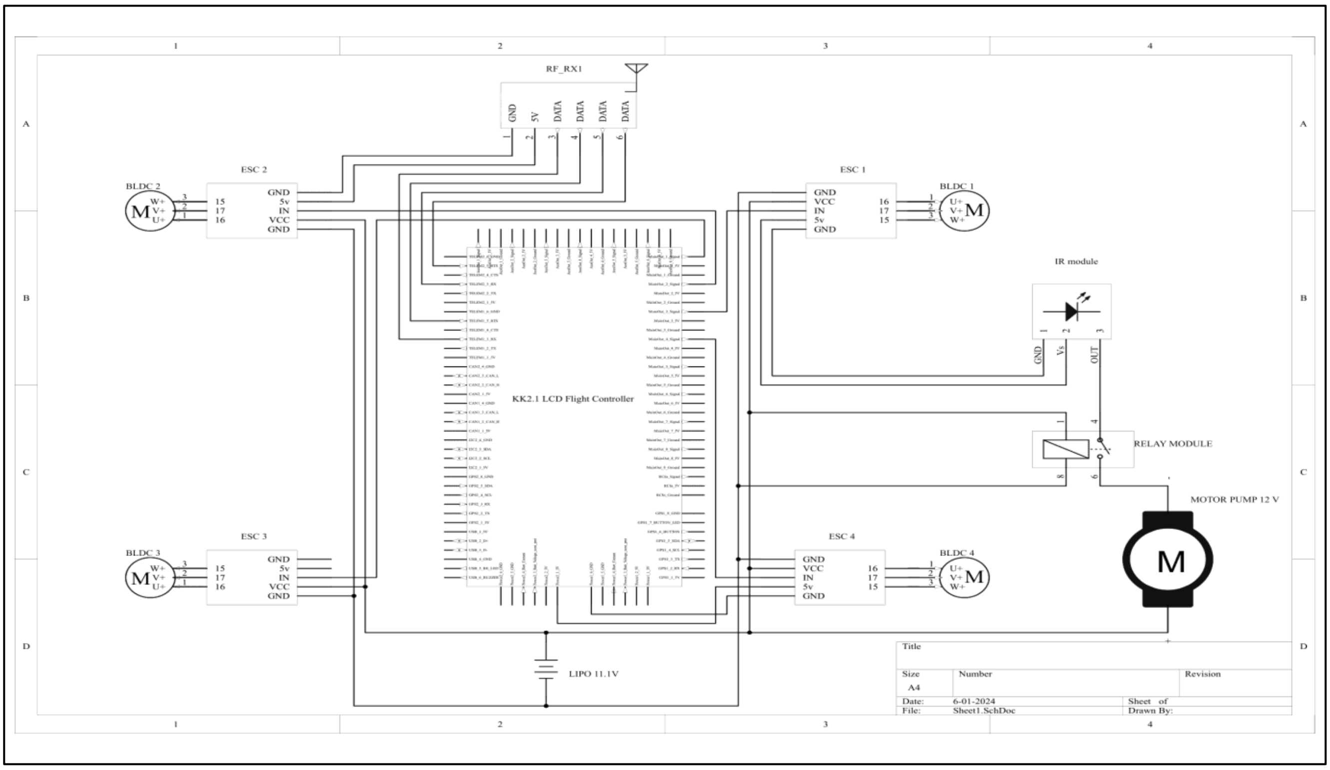


Fig 16 Circuit Diagram

4.2 WORKING PRINCIPLE / METHODOLOGY

A description of the quadcopter's design methodology follows. Transmitter is remotely controlled and receiver is mounted on the quadcopter and the receiver receives the signals sent by the transmitter. An accelerometer and a gyroscope sensor are inbuilt & used to process the signal after it is received by the receiver and passed to the flight controller. After being processed, the signal is sent to the electronic speed controller, which makes a switch and allows a specific amount of current to flow to the motor, depending on what signal it receives. The mechanical linkage between the motors and propellers generates thrust when they rotate—now, coming to the spraying mechanism. Water is pumped using the current provided by the Li-Po 3S quadcopter battery. Pressure causes the liquid inside the pipeline to flow through the pipeline and enter the nozzle, where it gets sprayed. It is possible to vary the input current of the transmitter, controlling the flow rate of the pump, therefore, controlling the intensity of the stream.

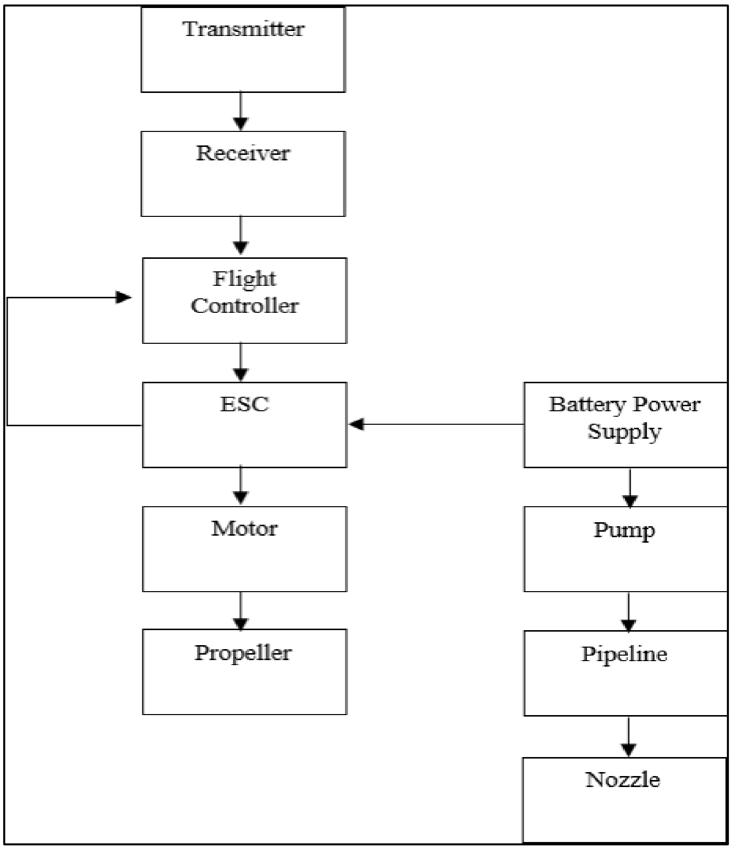


Fig:17: Block diagram of working process

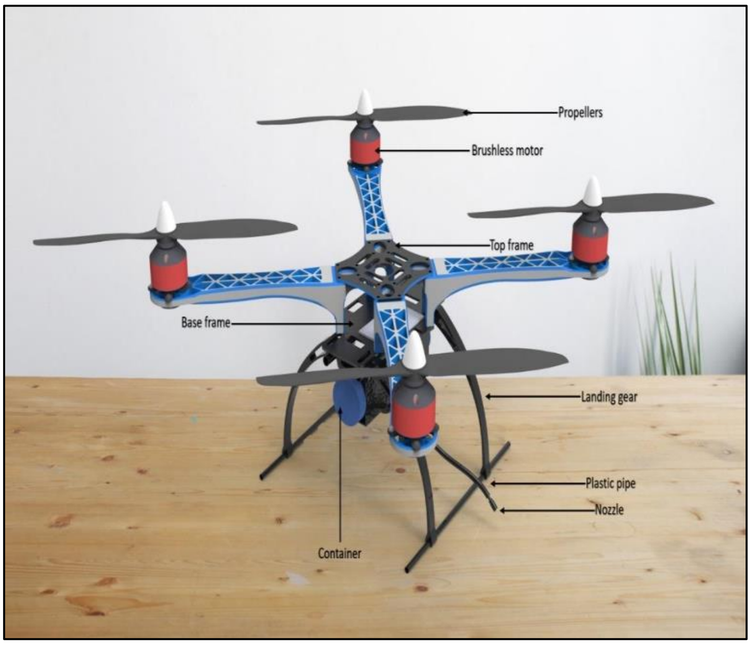
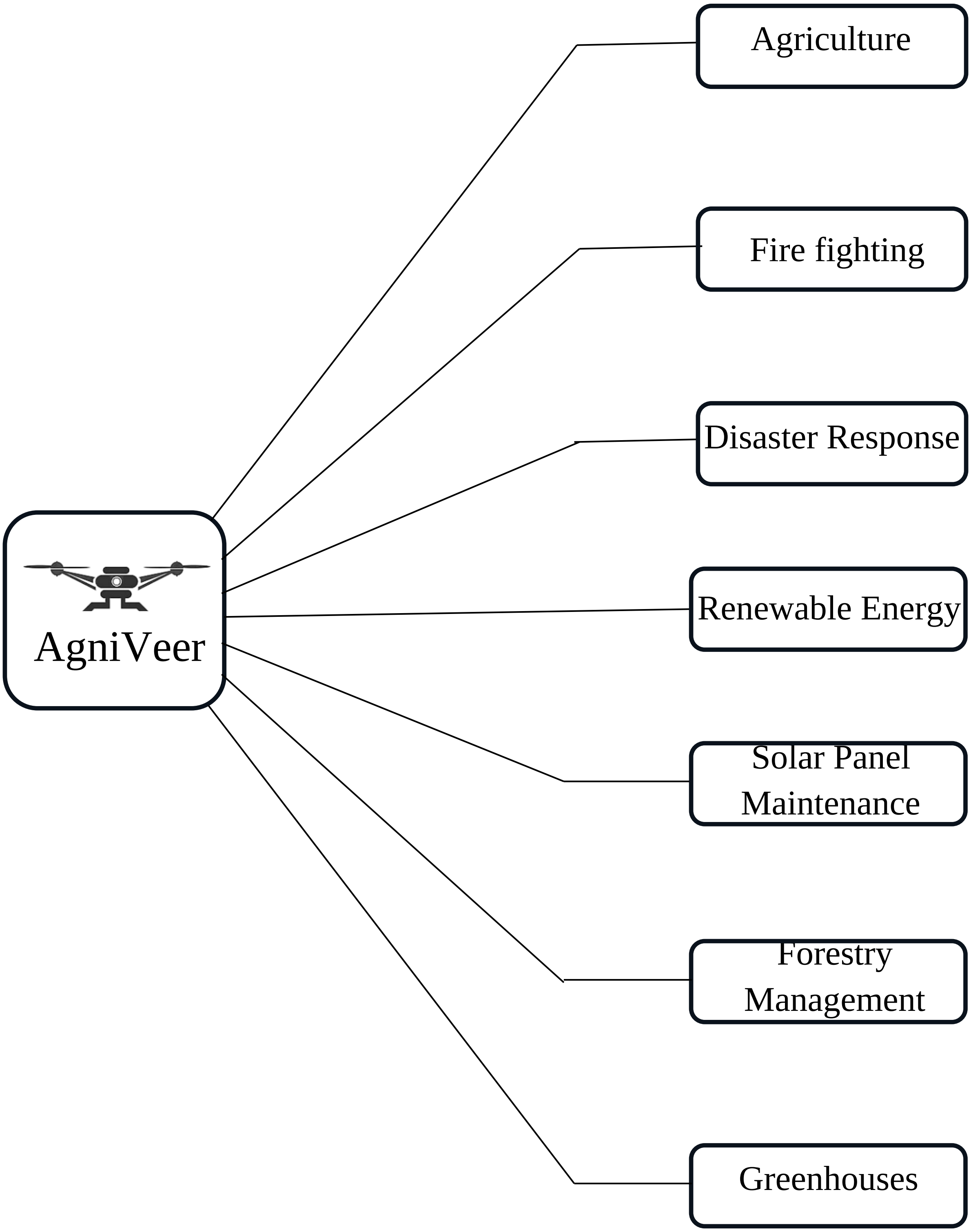


Fig:18: SolidWorks model of agricultural quadcopter with spraying mechanism.

4.3 USE CASE DIAGRAM



4.4 USEFUL FORMULAS & EQUATIONS

1. **Thrust Force:**

$$F_i = k_F \omega_i^2$$

Where F_i is the thrust generated by rotor i

k_F is the thrust coefficient and ω_i is the angular velocity of rotor i

Total Thrust:

$$F_{total} = \sum_{i=1}^{4} F_i$$

2. **Torques:**

Roll, pitch, and yaw torques:

$$\tau_\phi = l(F_2 - F_4)$$

$$\tau_\theta = l(F_1 - F_3)$$

$$\tau_\psi = k_M(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2)$$

Where τ_ϕ is the roll torque, τ_θ is the pitch torque, τ_ψ is the yaw torque, l is the distance from the center to the rotor and k_M is the drag coefficient.

3. **PID Controller Equations:**

Proportional (P):	$u(t) = K_p e(t)$
Integral (I):	$u(t) = K_i \int_0^t e(\tau) d\tau$
Derivative (D):	$u(t) = K_d \frac{d}{dt} e(t)$
Combined PID	$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$

where $u(t)$ is the control output, $e(t)$ is the error signal, and Kp, Ki and Kd are the proportional, integral and derivative gains respectively.

4. **Motor Power** For each motor

$$P_i = T_i \omega_i$$

where Pi is the power consumed by motor i, Ti is the torque produced by motor i and ωi is the angular velocity of motor i.

5. **Battery Capacity:**

$$Q = I \cdot t$$

where Q is the battery capacity, I is the current and t is the time.

6. **Energy Consumption:**

$$E=P\cdot t$$

where E is the energy consumed, P is the power, and t is the time.

7. Stability and Control

Linear Quadratic Regulator (LQR):

Cost Function:

$$J=\int_0^\infty(\mathbf{x}^T\mathbf{Q}\mathbf{x}+\mathbf{u}^T\mathbf{R}\mathbf{u})dt$$

where x is the state vector, u is the control input and Q and R are weight matrices.

State-Space Representation:

$$\dot{\mathbf{x}}=\mathbf{A}\mathbf{x}+\mathbf{B}\mathbf{u}$$

$$y=Cx+Du$$

where x is the state vector, u is the input vector, y is the output vector and A, B, C, and D are matrices representing the system dynamics.

8. Battery Discharge and Efficiency

Peukert's Law:

$$t=C/I^k$$

where t is the time, C is the battery capacity, I is the discharge current and k is the Peukert constant.

4.5 RESULTS

Stage-1: Aligning the Quadcopter frame with legs for spraying container

Aligning the quadcopter frame with legs for a spraying container involves ensuring a stable and balanced configuration to optimize the efficiency and safety of the spraying operation.

Fig 19 Quadcopter frame with legs

Stage-2: Weighing Estimation with thrust calculation for relative stability.

An F450 frame structure was used for the design and quadcopter development process. The dimensions needed for the product design were gathered from the user manual and other works. We calculated the total weight the quadcopter will need to carry and tabulated it in

Table 1 Weighing Estimation

Sl. No	Components	Mass(kg)	Quantity
1.	KK2.1 Multi-rotor LCD Flight Control Board With 6050MPU And Atmel 644PA	0.021	x 1
2.	Liquid	0.500	x 1
3.	F450 / Q450 Quadcopter Frame	0.312	x 1
4.	Mini Water Pump	0.400	x 1
5.	HD Propellers1045(10X4.5) ABS	0.052	x 4
6.	SimonK 30A BLDC ESC	0.108	x 4

7.	A2212 1000 KV BLDC Brushless DC Motor.	0.208	x 4
8.	Orange 11.1V 4500mAh 35C 3S Lithium Polymer Battery.	0.205	x 1
	TOTAL	1.806	

Thrust that the motor generates is given using the below formula

Tm = √2 X π X (P x ηh)

2 X rp2 × ρair 3

Where, ηh = propeller hover efficiency = 0.7-0.8

P= shaft power = current X voltage X motor efficiency

R = Propeller radius (meters)

ρair = Air density =1.22kg/m^3

V= Voltage = 10 V

I = Current =16 A

ηh = Motor efficiency =75 % = 75/100 = 0.75

Tm= √2 × π × (P × ηh)2 × rp

2 × ρair 3

Tm= √2 × π × (0.7 X 10 X 16 X 0.75)2 × 0.1252 × 1.225 3

Tm= 9.467 N

Therefore, Thrust calculated Tm= 9.467 N

Tm= 9.467/9.81

Tm =965 g

Therefore, each motor will generate 965 g of thrust.

Since there are 4 motors present in the following quadcopter, total thrust generated is given by Tm X 4.

Total thrust = T = 965 × 4 = 3860 g

T = 3.86 kg

While working with less efficiency in motors, factor of safety needs to be considered.

Let's take efficiency to be 0.7

Thrust T is given by:

$T = 3.86 \times 70/100$

$T = 2.702$ kg

Thus, minimum thrust generated by all the motors present is 2.702 kg

Now, since we have calculated minimum thrust generated by all the motors present, we then proceed with thrust calculation of quadcopter with spraying mechanism. Here the spraying apparatus is also taken into account while performing thrust calculations as opposed to a standalone quadcopter. Thrust calculation of quadcopter (with spraying mechanism) Required thrust upon assembling the sprayer apparatus to the quadcopter. It will be given by T2.

T2= (wt. of the quadcopter +wt. of spraying apparatus) ×2/4

$T2 = (906+900) \times 2/4$

$T2 = 1806/2$

$T2 = 903$ g

Since thrust generated by a single motor is 965 g and this thrust is greater than the amount of thrust required with the union of drone and spraying mechanism. We can conclude that the quadcopter will be in safe condition for successful operation and will therefore work as intended.

Stage-3: Integration of spraying tank with IR Thermal Heat automation

The integration of the spraying tank with IR thermal heat automation in the AgniVeer drone involves creating a seamless system where the infrared (IR) thermal sensors detect heat anomalies indicative of fire and the spraying mechanism is automatically activated to suppress the fire. This process includes sensor integration, data processing and automated actuation of the spraying system.

Fig 20 Spraying tank with IR Sensor

Stage-5: Troubleshooting

The Troubleshooting stage in the drone-assisted precision agriculture project involves addressing flight control instability, sensor inaccuracies, communication failures, spraying mechanism malfunctions, software bugs and power-related issues. Rigorous examination of flight controller settings, sensor calibration, communication protocols, spraying mechanisms and codebase ensures the reliability and efficiency of the technology. Continuous refinement and validation of components and systems are essential to mitigate challenges, guaranteeing the project's seamless operation in agricultural environments.

Fig 21 Top View

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

CONCLUSION

The AgniVeer project represents a significant advancement in the field of fire management, combining cutting-edge drone technology with automated fire detection and suppression systems. By integrating infrared (IR) thermal sensors and a submersible motor-controlled spraying mechanism, AgniVeer provides a rapid, precise and efficient response to fire incidents. This innovation addresses the limitations of traditional firefighting methods, such as accessibility challenges and risks to personnel by enabling early detection and immediate intervention. The project's outcomes demonstrate that the AgniVeer system can significantly reduce the time between fire detection and suppression, minimizing damage and enhancing safety. The real-time data provided by the IR sensors allows for continuous monitoring and dynamic adjustment of the suppression efforts, ensuring effective containment of fires. This not only reduces the environmental and economic impact of fires but also bolsters community resilience and safety. AgniVeer sets a new standard in firefighting technology, offering a scalable and versatile solution adaptable to various fire scenarios, from urban settings to remote wilderness areas. The successful integration of these technologies underscores the potential for further innovations in automated disaster response systems, paving the way for smarter, safer and more effective fire management strategies. Through this project, AgniVeer contributes to the ongoing efforts to protect lives, property and the environment from the devastating effects of fires.

FUTURE SCOPE

In the first part we have started a step towards our future scope by collecting different types of image and video datasets of different breed of crops in nearby agri field of Aithaan area near Brahmaputra, Dibrugarh as we will be going to integrate this drone with smart agriculture techniques.

- **Enhanced AI and Machine Learning Integration**

  To develop advance algorithms to improve fire detection accuracy and reduce false positives.

Fig 23 Dataset Images of Different crops in nearby areas of Dibrugarh

- **Expanded Sensor Capabilities**

  Incorporate additional sensors, such as gas detectors and visual cameras, to provide a comprehensive analysis of fire conditions.

- **Improved Autonomy and Navigation**

  Enhance autonomous navigation capabilities to allow drones to operate in complex environments with minimal human intervention.

- **Scalable and Modular Design**

  Develop modular drone designs to allow easy customization and scalability, catering to different firefighting needs and environments.

- **Collaboration with Ground and Aerial Units**

  Integrate the drone system with existing firefighting infrastructure, enabling seamless communication and coordination with ground crews and aerial firefighting units.

- **Enhanced Payload and Delivery Systems**

  Increase the payload capacity to allow for the delivery of larger quantities of fire retardants or other firefighting materials

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