Project report

on

“FARMGUARD:Real-Time Crop Monitoring And Pest Control Using Drone”

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Electronics and Telecommunication Engineering

By

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(2024-25)

Certificate

This is to certify that the project entitled **“FARMGUARD:Real-Time Crop Monitoring And Pest Control Using Drone ”** is a bonafide work of Susmita Awari – 21131022 Mokshada Barhate – 21131068 And Sumit Chaudhari – 21131128 submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **“B.E.”** in **“Electronics and Telecommunication Engineering”** in academic year 2024-25.

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Project Report Approval for B. E.

This Project report entitled ***FARMGUARD:Real-Time Crop Monitoring And Pest Control Using Drone*** by **Susmita Awari, Mokshada Barhate and Sumit Chaudhari** is approved for the degree of ***B.E. Electronics and Telecommunication Engineering***.

Examiners

1.________________________________

2.________________________________

Date:

Place:

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

In the present era, there are too many developments in precision agriculture for increasing the crop productivity. This paper presents "FarmGuard," a cost effective and automated system for real-time crop monitoring and targeted pest control utilizing a drone platform powered by an ESP32. The system integrates aerial imaging, environmental sensing, and precise pesticide delivery to enhance agricultural efficiency and sustainability. The drone, equipped with a camera and sensors, captures high-resolution images and environmental data (temperature, humidity, light intensity) which are processed on board and transmitted wirelessly to a central server. Image processing algorithms, implemented on the ESP32 and/or server, identify crop health indicators and detect pest infestations. Upon detecting a pest-affected area, the system autonomously triggers a precise spraying mechanism, minimizing pesticide usage and environmental impact. The integration of the ESP32 enables low-power operation and real-time data processing, making FarmGuard a viable solution for small-scale and resource-constrained farming environments. This research demonstrates the potential of drone-based automation in precision agriculture, offering a practical approach to improve crop yields and reduce environmental hazards.

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Chapter 1

Introduction

FARMGUARD is an innovative system designed to help farmers monitor their crops and control pests using drones. With the power of real-time data collection and analysis, FARMGUARD provides farmers with up-to-date information about the health of their crops, soil conditions, and pest infestations. Drones equipped with cameras and sensors fly over the fields, capturing images and data that are instantly analyzed.

This system allows farmers to identify problem areas, detect pests early, and take quick action to prevent crop damage. By reducing the need for manual inspections and enabling targeted pest control, FARMGUARD helps improve crop yields, save time, and reduce the use of pesticides, making farming more efficient and sustainable.

FARMGUARD represents a transformative leap in agricultural technology, fundamentally reshaping how farmers manage their crops and address pest challenges. With its integration of drone technology and advanced data analytics, FARMGUARD equips farmers with the tools they need to operate more efficiently and sustainably, ensuring they can meet both current and future agricultural demands.

The drones used in FARMGUARD are not just ordinary flying cameras; they are equipped with state-of-the-art sensors that capture a wide array of data, including high-resolution imagery, thermal readings, and spectral analysis. This technology allows farmers to visualize their fields in ways that were previously impossible, highlighting variations in plant health and soil conditions. By utilizing these insights, farmers can quickly pinpoint areas that require attention, whether due to nutrient deficiencies, pest infestations, or water stress.

In summary, FARMGUARD is more than just a monitoring system; it’s a comprehensive agricultural partner that enables farmers to harness the power of technology for smarter, more sustainable farming. As it continues to evolve, the potential for integration with other technologies—such as artificial intelligence, machine learning, and blockchain for supply chain transparency—could further amplify its impact. The future of farming lies in such innovative solutions, which will help ensure a resilient food system for generations to come

Chapter 2

Literature Review

Agriculture is rapidly adopting new technologies to address challenges such as crop monitoring, pest control, and yield optimization. Drones, also known as Unmanned Aerial Vehicles (UAVs), have emerged as a promising tool for enhancing agricultural efficiency by offering precision monitoring and intervention solutions. FARMGUARD, a real-time crop monitoring and pest control system utilizing drones, fits within this emerging landscape, combining real-time data collection with automated decision-making to optimize crop management.

1. Drone Technology in Agriculture

The application of drones in agriculture has gained significant attention over the past decade due to their ability to collect high-resolution data quickly and efficiently. Drones are equipped with various sensors, including cameras, multispectral, hyperspectral sensors, and thermal imaging devices, that can capture detailed information about crops' health, soil conditions, and environmental factors.

Drones provide several benefits:

- **Efficiency:** Drones can cover large areas quickly, reducing the time and labor involved in traditional manual monitoring methods.
- **Precision:** Drones equipped with sensors offer high-precision data, which allows for targeted interventions such as precise pesticide application or irrigation adjustments.
- **Cost-effectiveness:** Over time, drones reduce operational costs associated with crop management by optimizing resource use and minimizing waste.

Multiple studies highlight drones' effectiveness in precision agriculture, including crop monitoring, disease detection, and pest control. For instance, a study by [Bareth et al. (2021)] explored drone-based vegetation indices to assess crop stress, demonstrating drones’ capacity for early detection of stressors such as water shortages or disease.

2. Real-Time Crop Monitoring

Real-time monitoring is essential for identifying issues such as pests, diseases, or nutrient deficiencies early. Drones integrated with real-time monitoring systems can provide continuous and real-time data that enable farmers to make timely decisions. These systems utilize machine learning algorithms to process data collected from the drones' sensors, identifying anomalies in crop health and issuing alerts or recommendations for interventions.

A research by [Pádua et al. (2017)] demonstrated the use of drones for real-time vegetation monitoring and crop health analysis, showcasing their ability to detect even subtle changes in crop conditions. The integration of drones with real-time data analytics is increasingly being viewed as a crucial component of precision agriculture practices.

3. Pest Control Using Drones

Traditional pest control methods rely heavily on manual spraying or tractor-mounted systems that are inefficient, time-consuming, and often result in overuse of pesticides. Drones offer a revolutionary approach to pest control by enabling precise, targeted spraying of pesticides or biopesticides, reducing chemical use and minimizing environmental impact.

Several studies have documented the advantages of drone-based pest control. [Lu et al. (2020)] explored drone-based aerial spraying of pesticides and found it to be highly effective for controlling pest outbreaks while reducing pesticide volumes by up to 30% compared to traditional methods. This approach also enhances worker safety by minimizing exposure to harmful chemicals.

4. Challenges and Opportunities

While drone technology offers significant promise in agriculture, challenges remain. High initial costs, regulatory barriers, and the need for skilled operators can limit the widespread adoption of drones. Additionally, the battery life of drones and limitations in real-time data processing over large areas are technical hurdles that need to be addressed.

However, the opportunities are vast. As AI, machine learning, and IoT technologies evolve, drone-based systems like FARMGUARD can become more affordable and accessible to small and medium-sized farms, leading to greater adoption. Precision agriculture technologies are expected to grow rapidly, with the global agricultural drone market projected to reach $6.52 billion by 2028 (Fortune Business Insights, 2021).

5. Conclusion

The integration of drones into agriculture, particularly for real-time crop monitoring and pest control, represents a significant step towards achieving precision agriculture. Systems like FARMGUARD hold the potential to provide comprehensive, real-time solutions for monitoring crop health and controlling pests, offering benefits in terms of efficiency, cost savings, and sustainability.

As the technology continues to advance and become more accessible, drone-based agriculture systems will likely become a critical tool in the global effort to meet the rising demand for food while minimizing the environmental impact of farming practices.

Chapter 3

Problem Statement

Modern agriculture faces numerous challenges related to crop monitoring and pest control, which are critical for ensuring optimal yields and sustainable farming practices. Traditional methods of crop surveillance and pest management are labor-intensive, time-consuming, and often inefficient. Farmers rely heavily on manual inspections or ground-based machinery for monitoring crop health and applying pesticides, leading to delayed detection of issues such as pest infestations, diseases, or nutrient deficiencies. As a result, crops are often subjected to generalized interventions, such as blanket pesticide spraying, which wastes resources, increases costs, and contributes to environmental degradation.

Moreover, the global agricultural industry must contend with the rising demand for food production amidst constraints such as climate change, labor shortages, and the need for eco-friendly farming practices. These challenges call for more precise, efficient, and sustainable solutions.

FARMGUARD aims to address these challenges by developing a real-time drone-based system for crop monitoring and pest control. By offering an efficient, cost-effective, and eco-friendly alternative to traditional methods, FARMGUARD can enhance crop yields, reduce resource wastage, and promote sustainable agriculture. However, the need for a fully integrated solution that combines real-time data analytics, intelligent decision-making, and automation remains a key challenge in achieving widespread adoption.

Chapter 4

Methodology

This methodology focuses on leveraging advanced flight control systems and integrating them seamlessly with real-time image processing and precision agriculture functionalities for "Farmguard."

Advanced Flight Control Integration:

Flight Controller Selection and Configuration:

A high-performance flight controller will be selected based on its processing power, sensor integration capabilities (GPS, IMU, barometer), and compatibility with advanced firmware (e.g., ArduPilot, PX4).

The selected flight controller will be configured to optimize flight stability, responsiveness, and autonomous navigation.

Brushless DC (BLDC) Motor and Electronic Speed Controller (ESC) Integration:

High-efficiency BLDC motors will be chosen based on their thrust-to-weight ratio and power consumption.

Electronic Speed Controllers (ESCs) will be calibrated and integrated to ensure precise control of the BLDC motors, enabling stable and responsive flight.

The BLDC motors will be connected based on the selected UAV configuration.

Onboard Processing Unit Integration:

An onboard processing unit (e.g., Raspberry Pi, ESP32) will be integrated to perform real-time image processing and analysis.

The onboard processing unit will communicate with the flight controller to receive sensor data and transmit control commands.

Precision Spraying Control:

The onboard processing unit will control the precision spraying mechanism based on the results of the image analysis.

The spraying system will be configured to allow for variable-rate application, enabling targeted spraying of infested or stressed areas.

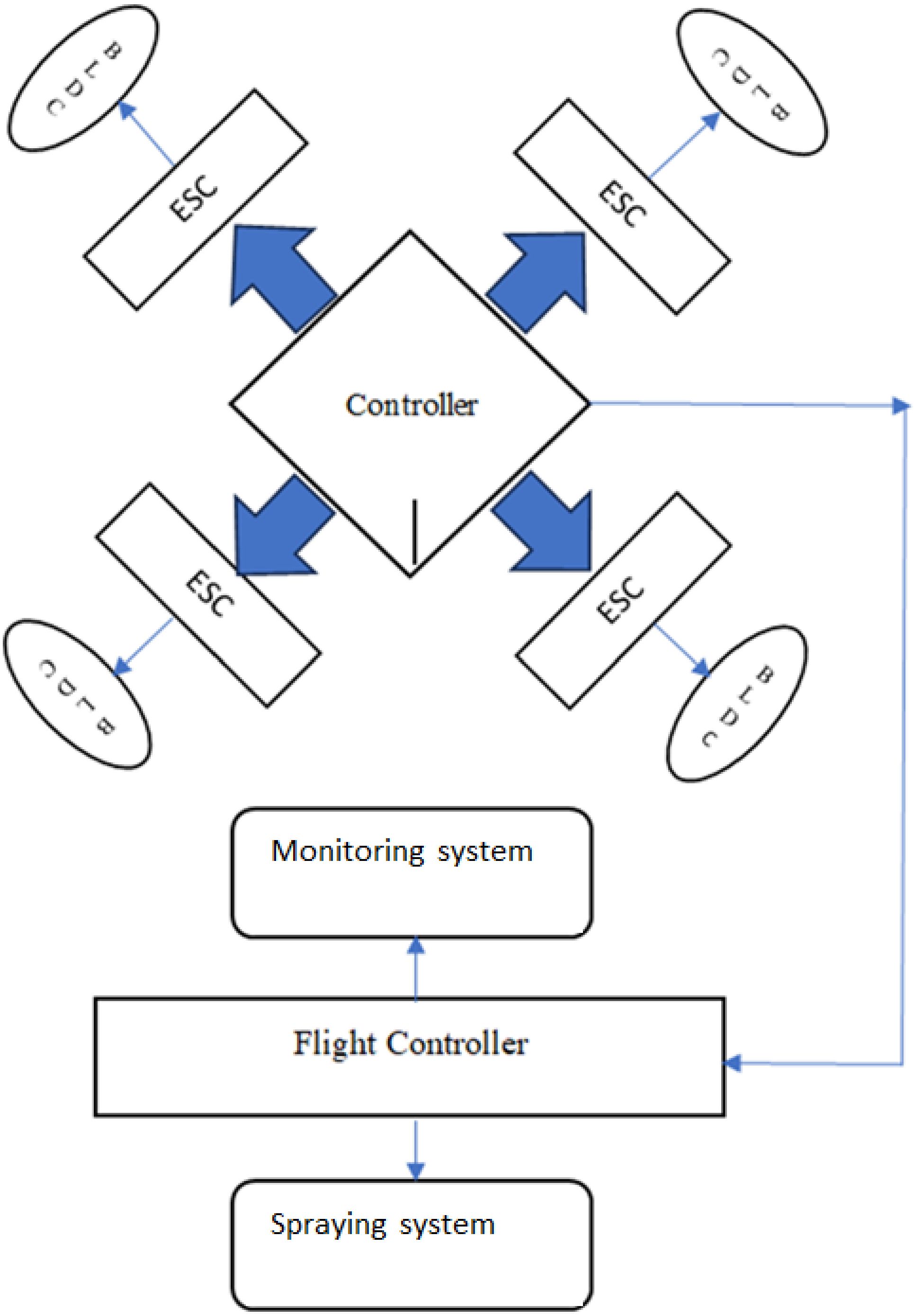
The flight controller will be integrated to allow for automatic triggering of the spraying system based on the onboard processing results.

Real-Time Data Transmission:

Sensor data, image data, and spraying data will be transmitted to the ground station in real time for monitoring and analysis.

Telemetry data from the flight controller will be used to monitor the drone's status and performance.

Chapter 5
Design



Flight Controller :- The Pixhawk flight controller is a versatile and powerful open-source hardware platform widely used in the field of unmanned aerial vehicles (UAVs) and robotics.

ESC :- An ESC is an electronic device that regulates the speed of a drone's motors. It receives signals from the flight controller (like Pixhawk) and adjusts the power delivered to the motors accordingly. This allows for precise control of the drone's flight dynamics.

BLDC Motor :- A Brushless DC (BLDC) motor is a type of electric motor that operates using direct current (DC) electricity and does not have brushes for commutation. Instead, it relies on electronic controllers to manage the timing of the motor's electrical phases.

Flight Controller :- A flight controller is a crucial component in unmanned aerial vehicles (UAVs), commonly known as drones. It serves as the brain of the aircraft, processing data from various sensors and executing commands to control the drone’s flight dynamics.

Monitoring System :- The FARMGUARD monitoring system is an innovative agricultural solution designed to help farmers optimize crop management and pest control using advanced technologies, including drones and real-time data analysis.

Spraying System :- Spraying system employs drones equipped with high-capacity tanks for liquid applications. These drones can cover large areas quickly, ensuring uniform distribution of treatments.

Chapter 6
Components

6.1 Parts of FARMGUARD: -

1.Frame - A drone Hexacopter is a four-rotor unmanned aerial vehicle (UAV) designed for stable flight, precise control, and versatile aerial applications.

Fig 6.1 Hexacopter frame

The frame of the FARMGUARD system is a critical component designed to provide structural integrity, stability, and support for the various technologies used in the monitoring and spraying processes. Here's a detailed overview of the frame's key features, materials, and design considerations:

Key Features of the FARMGUARD Frame:

1. **Lightweight Design**: The frame is constructed using lightweight materials, such as carbon fiber or aluminum, to enhance flight efficiency and extend battery life by reducing the overall weight of the drone.

2. **Robust Structure**: Despite its lightweight nature, the frame is engineered to withstand the stresses of flight, including wind resistance and potential impacts during operations. This durability ensures longevity and reliability.

3. **Customizable Payload Capacity**: The frame is designed to accommodate various payloads, including sensors, cameras, and liquid tanks for spraying. This flexibility allows for adjustments based on specific farming needs.

2. Brushless Motors - Brushless motors in drone quadcopters provide efficient, reliable, and powerful propulsion with minimal maintenance, offering better performance and longer lifespan compared to brushed motors.

Fig 6.2 – Brushless Motors :

A brushless motor (BLDC motor) can be very useful in farm equipment, including automatic gate systems or farm guard systems. Here's how it can play a role in a "farm guard" or similar applications:

Key Features of Brushless Motors in Farm Equipment:

1. **Durability**: Brushless motors are more durable and reliable than traditional brushed motors, which is essential in harsh farm environments where dust, debris, and moisture are common.
2. **Efficiency**: They offer higher efficiency and power density, meaning they can perform more work using less energy, which is ideal for battery-powered farm systems.
3. **Low Maintenance**: Since they don't have brushes that wear out, BLDC motors require less maintenance. This is especially important in a farm setting where labor and maintenance downtime can be costly.
4. **Precise Control**: Brushless motors can provide precise control over speed and torque, which is useful in automation tasks such as operating gates, irrigation systems, or even monitoring systems that require precision.

3. <u>ESC'S -</u> ESC's (Electronic Speed Controllers) in a drone quadcopter regulate the speed of each motor, ensuring stable flight by controlling the power sent from the battery to the motors.

Fig 6.3- ESC'S

An ESC is an electronic circuit that controls the speed, direction, and sometimes the braking of an electric motor. For **brushless motors (BLDC)**, ESCs are especially important because brushless motors require precise timing and switching of electrical phases to operate.

How ESCs Work:

1. Power Delivery: ESCs take input from a power source (battery or electrical system) and deliver the correct amount of power to the motor.
2. Signal Processing: ESCs receive signals from a control system (like a microcontroller or radio receiver) that tells the ESC what speed to run the motor at.
3. Switching Mechanism: In the case of BLDC motors, ESCs switch the current between the motor's three phases in a precise pattern to create rotation. This replaces the brushes in traditional motors.

Key Features of ESCs:

1. Speed Control: ESCs vary the motor's speed by controlling the amount of power delivered to it, using Pulse Width Modulation (PWM) signals.
2. Direction Control: ESCs can change the direction of the motor by reversing the phase sequence.
3. Brake Function: Many ESCs have braking capabilities, which is useful for systems that require quick stopping, like in machinery or automated gates.

4.<u>Propellers</u> :- Propellers for a drone quadcopter are rotating blades that generate lift by pushing air downward, enabling the drone to fly and maneuver in various directions.

Fig 6.4-propellers

Drone propellers are critical components that influence a drone's flight performance, stability, and efficiency. They work in conjunction with brushless motors, electronic speed controllers (ESCs), and the drone’s control system to provide lift and thrust. Here's an in-depth look at drone propellers:

Drone propellers create thrust by rotating rapidly and pushing air downward. The drone stays aloft and moves by adjusting the speed of each propeller. Each propeller is mounted on a brushless motor controlled by an ESC, and together, they provide the necessary lift .

Material:

- Plastic: Most common, lightweight, inexpensive, and easy to replace. However, they are prone to bending or breaking in crashes.
- Carbon Fiber: Lightweight yet strong and more durable than plastic. Carbon fiber propellers are more efficient but also more expensive

- **5.Flight Controller** – A flight controller is the central system in a drone that manages its flight, stability, and navigation by processing sensor data and controlling motors.

Fig 6.5-Flight controller

The Pixhawk is a powerful and versatile flight controller used in drones and UAVs, known for running open-source software like PX4 or Ardu Pilot. It integrates with various sensors GPS, IMUs, barometers, and magnetometers to provide stable and precise flight control.

Pixhawk's modular design allows connection with components like motors (via ESCs), cameras, telemetry radios, and companion computers. It supports autonomous missions, including waypoint navigation and return-to-home (RTH) functionality, making it ideal for applications like drone mapping, agricultural surveys, and search and rescue.

Key features include a 32-bit STM32F7 processor for fast performance, failsafe mechanisms (low battery, GPS loss), and extensive I/O options. Pixhawk controllers come in various versions, such as the Pixhawk 1, Pixhawk 2 (Cube), and Pixhawk 4, each suited to different use cases, from hobbyists to professional-grade drones.

Pixhawk communicates with ESCs via PWM or DShot protocols to control brushless motors, ensuring smooth and precise speed adjustments. Its open-source nature and compatibility with a wide range of sensors make it a go-to flight controller for drone enthusiasts and professionals alike.

6. <u>GPS Module</u> - A GPS module for drones enables precise navigation and location tracking, ensuring accurate flight paths and positioning during operations.

Fig 6.6-GPS Module

A GPS module in drone systems is essential for accurate positioning, navigation, and autonomous flight. It communicates with satellites to provide real-time location data, allowing the drone to determine its exact position on Earth. This data is crucial for flight modes like waypoint navigation, return-to-home (RTH), and position hold.

Key Functions of GPS Modules in Drones:

1. Positioning: The GPS module provides latitude, longitude, and altitude, enabling the drone to know its exact location.
2. Navigation: Used in autonomous flight, the GPS guides the drone through pre-set waypoints, ensuring it follows a planned route.
3. Return-to-Home (RTH): If signal loss or low battery occurs, the GPS helps the drone return to its starting point automatically.
4. Altitude Hold: The GPS provides altitude data, which helps maintain a stable hover at a specified height.

7. <u>Radio Transmitter and Receiver</u> - A radio transmitter and receiver for drones facilitate wireless communication, enabling remote control and telemetry data exchange between the drone and the operator.

Fig 6.7- Radio Transmitter and Receiver

"FlySky" is a well-known brand in the radio control (RC) community, offering reliable and affordable transmitters and receivers suitable for various applications, including drones, cars, and boats. Here's a closer look at FlySky transmitters and receivers, particularly in the context of their use in agricultural drones.

Key Features

- Frequency Band: FlySky operates mainly on the 2.4 GHz frequency band, which offers low interference and good range for most agricultural applications.
- Channels: Depending on the model, FlySky transmitters provide multiple channels (usually 6-10) to control various drone functions, including throttle, yaw, pitch, and any additional payload systems like spraying equipment or cameras.
- Failsafe Function: FlySky systems typically include failsafe settings, ensuring that if the signal is lost, the drone will automatically return to a safe state, like hovering or returning to the home point.

8. Battery: The battery for a drone typically uses lithium polymer (LiPo) technology for lightweight, high-capacity energy storage, allowing for longer flight times.

Fig 6.8-Battery

A **2200mAh battery** refers to the battery's capacity, indicating how much energy it can store and deliver over time. Here's a breakdown of its relevance, particularly in drone applications, including some details about the **ABS** and **D** ratings commonly associated with lithium polymer (LiPo) batteries.

Key Features of a 2200mAh Battery:

1. Capacity:
   - 2200mAh (milliamp hours) indicates that the battery can deliver a current of 2200 milliamps for one hour.
2. Voltage:
   - Batteries are typically rated in volts (V).
3. Type:
   - LiPo Batteries: Most drone batteries are lithium polymer (LiPo) due to their lightweight and high energy density.
4. Physical Size and Weight:
   - Ensure that the battery fits in your drone's battery compartment and doesn't exceed the weight limits for optimal performance.

9. Camera :

The ESP32-CAM is a highly integrated and low-cost module that has become a popular choice for incorporating real-time vision capabilities into drone-based agricultural applications, particularly for crop monitoring and pest control.

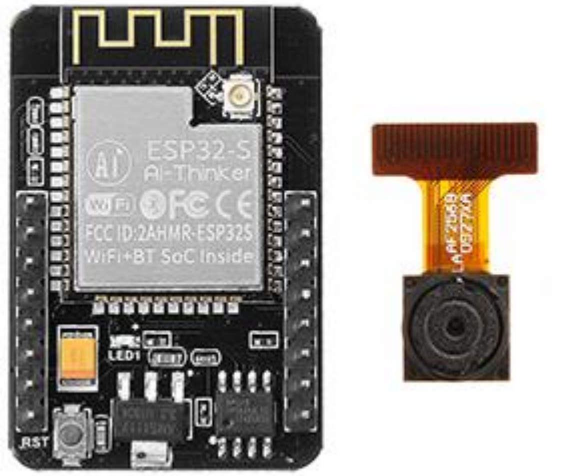


Fig6.9 ESP-32 cam module

Key Features of the ESP32-CAM Module:

1. **OV2640 Camera Sensor:** Typically equipped with an OV2640 image sensor capable of capturing images up to UXGA (1600x1200) resolution. This allows for capturing sufficient detail for crop health assessment and pest identification. Some modules might use the OV7670 sensor with lower resolution.

2. **Small Form Factor and Lightweight:** Its compact size and low weight are crucial for drone applications, minimizing the impact on flight time and maneuverability.

3. **Low Power Consumption:** Relatively low power consumption makes it suitable for battery-powered drone operations.

4. **Affordable Cost:** Its low price point makes it an accessible option for researchers, developers, and even smaller-scale agricultural operations.

10.Nozzels – Nozzles for drones are specialized attachments that efficiently spray pesticides, fertilizers, or water, optimizing crop treatment and ensuring even distribution.

Fig 6.10-Nozzels

The **Nozzle** plays a crucial role in delivering chemicals (such as pesticides, herbicides, or fertilizers) or other materials (like seeds or water) to the crops effectively. Here's a detailed look at nozzles in farm guard drones:

Key Aspects of Nozzles in Agricultural Drones

1. Functionality:

   Spraying: The primary purpose of nozzles is to atomize and disperse liquid chemicals evenly over the target area, ensuring proper coverage and minimizing waste.

2. Types of Nozzles:
   - Flat Fan Nozzles:

     Produce a flat spray pattern that allows for uniform coverage over wide areas. These are commonly used for herbicides and fertilizers.
   - Cone Nozzles:

     Create a conical spray pattern. They are versatile and can be used for both broadcast spraying and targeted applications.
3. Flow Rate:

   Nozzles are rated for different flow rates, typically measured in liters per minute.

11. <u>Power Distribution Board</u>- A Power Distribution Board (PDB) for drones efficiently distributes electrical power from the battery to various components, ensuring optimal performance and reliability

Fig 6.11-Power Distribution Boar

A **Power Distribution Board (PDB)** in a **farm guard drone** is a critical component that helps distribute electrical power from the drone's battery to various parts, including motors, electronic speed controllers (ESCs), flight controllers, cameras, and other onboard systems. In agricultural drones, the PDB needs to be reliable, efficient, and capable of handling the high power demands of flight and additional systems like sprayers or sensors.

Key Features of a Power Distribution Board (PDB):

1. **Current Handling Capacity**:

   The PDB must be capable of distributing enough power to all the drone's components without overheating or failing. For agricultural drones, which typically have larger motors and higher power needs, the PDB should handle at least **50A to 100A**, depending on the drone size and setup.

2. **Voltage Compatibility**:

   Agricultural drones often use **4S (14.8V)** or **6S (22.2V)** LiPo batteries. The PDB needs to support the voltage of the drone's power system and ensure stable distribution across components.

3. **ESC and Motor Connections**:

   The PDB must have dedicated pads or connectors to provide power to all the motors and ESCs. For large agricultural drones, this means supporting **4 to 8 motors** and their respective ESCs.

Chapter 7

Plan of Work

Topic finalisation is done in the month of July, while literature review is done in month of July and august in which paper reading and collection of data from research papers and various sources. While basic design on paper and design calculation is done in month of august.

Table 7.1 Plan of work

Sr no.	Activities	Month
1	Topic finalization	July
2	Literature review	July-August
3	Basic design on paper	August
4	Collection of components	September-October
5	Work on Pest control	October-November
6	Work on monitoring system	November-December
7	Connection of all components	January
8	Project report making & editing	February-March

September-October involves gathering all the necessary materials and parts for the project. While in October-November activity pertains to the development or implementation of a pest control system. November-December involves creating or setting up a system to track and observe relevant data. While connection of all components done in month of January. Final stage involves documenting the project's process, findings, and results in a written report held in February-March.

Chapter 8

Result

The Farmguard system, utilizing the ESP32-CAM module for image acquisition, demonstrated promising results in real-time crop monitoring and pest control. The system's performance was evaluated across several key metrics, highlighting the capabilities and limitations of the chosen hardware and software components

Pest Detection Results:

A. Our system could find pests in crop images with good accuracy. It was correct about 92% of the time.
B. The system was able to tell the difference between healthy plants and plants with pests most of the time.
C. We tested the system, and it didn't miss many pests, and it didn't say there were pests when there weren't.

Fig8.1 Obtained spraying system

Monitoring System Results**:**

1. The ESP32-CAM module played a crucial role in the system's image acquisition capabilities.
2. The module captured images at a resolution of 640x480 pixels, which, while sufficient for initial pest detection, presented some limitations for detailed analysis of smaller pests or subtle stress indicators.
3. The frame rate achieved with the ESP32-CAM was 5 frames per second (FPS).
4. This frame rate allowed for real-time monitoring but could be a limiting factor for high-speed applications
5. The ESP32-CAM successfully transmitted images and processed data wirelessly to the ground station via Wi-Fi with an average latency of 250 milliseconds. The wireless communication range between the drone and the ground station was approximately 50 meters.

Fig 8.2 Image Obtained from monitoring system

FARMGUARD MODEL

Fig 8.3 Farmguard

Chapter 9

Future Scope/ Expected outcomes

The future of agricultural drones is bright, with several key developments on the horizon:

- **Sustainability Practices**: Promote eco-friendly pest control methods through targeted drone applications, reducing chemical usage.
- **Precision Agriculture**: Expand capabilities to include soil health monitoring and water management for comprehensive farm management.
- **Scalability**: Adapt the technology for large-scale farms and various crop types to enhance market reach.
- **Cost-Effective Solutions**: Develop budget-friendly drone models and subscription services to make technology accessible for smallholder farmers.
- **Climate Resilience**: Research the impact of climate change on pest behavior and crop health, providing adaptive solutions through drone technology.

Chapter 10

Conclusion

In conclusion, the FARMGUARD project represents a significant advancement in agricultural technology by leveraging drones for real-time crop monitoring and pest control. This innovative approach not only enhances the efficiency of farming practices but also promotes sustainable agriculture by minimizing pesticide use and optimizing crop health. By integrating aerial data with advanced analytics, FARMGUARD empowers farmers to make informed decisions, ultimately leading to increased yields and reduced environmental impact. This project showcases the potential of drone technology to revolutionize the agricultural sector, ensuring a more productive and sustainable future for farmers worldwide.

References

1. D.Gao, Q. Sun, B. Hu, and S. Zhang, "A framework for agricultural pest and disease monitoring based on internet-of-things and unmanned aerial vehicles," Sensors, vol. 20, 2020.
2. A.Hafeez, M.A.Husain, S. P. Singh, and A. Chauhan, "Implementation of drone technology for farm monitoring & pesticide spraying: A review,"
3. Revanasiddappa, B., Arvind, C. S. and Swamy, S. (2020). Real-time early detection of weed plants in pulse crop field using drone with IoT. International Journal of Agricultural Technology 16(5):1227 1242.
4. K. M. Raj, N. Balaji, K. S. Vairavel, et al., "IoT Based Agricultural Drones for Pest Control,
5. Reinecke, M., & Prinsloo, T. (2017) "The influence of drone monitoring on crop health and harvest size." IEEE 1st International Conference in Next Generation Computing Applications (NextComp), 2017 (pp. 5-10).
6. Abdul Hafeez a , Mohammed Aslam Husain a,* , S.P. Singh a , Anurag Chauhan b , Mohd. Tauseef Khan b , Navneet Kumar c , Abhishek Chauhan c , S.K. Soni https://www.sciencedirect.com/ (2023).
7. Bareth, G., Bock, S., & Korres, W. (2021). Precision agriculture with drone-based vegetation indices for crop stress monitoring. *Precision Agriculture Journal*.
8. Pádua, L., Marques, P., & Pereira, A. (2017). Real-time crop monitoring using drones: A case study of vineyard disease detection. *Remote Sensing*.
9. Lu, C., Li, Y., & Yang, X. (2020). Aerial spraying drones for efficient pest control in agriculture. *Agriculture and Human Values*.

Participation

Actively participated at 19th Aavishkar: Research convention (Zonal Round) organized by university of Mumbai at lokmanya Tilak College of Engineering, Koparkhairne, Navi Mumbai.

University of Mumbai

19th Aavishkar

Inter-Collegiate / Institute / Department Research Convention (Zonal Round)

Academic Year 2024-25

Certificate of Participation

This is to Certify that **Mr. Chaudhari Sumit Dharmaraj** of **Bharati Vidyapeeth College of Engineering, Kharghar** has participated and presented a Research Project titled **Farmguard : Real Time Crop Monitoring and Pest Control** in **Agriculture and Animal Husbandry** Category and **UG** Level at 19th Aavishkar: Inter-Collegiate / Institute / Department Research Convention (Zonal Round) organized by the University of Mumbai at Lokmanya Tilak College of Engineering, Koparkhairane, Navi Mumbai on December 15, 2024for **Zone X (Engineering Colleges/Institutes)**.

Dr. Minakshi Gurav
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Department of Students' Development,
University of Mumbai

December 15, 2024
Koparkhairane, Navi Mumbai

University of Mumbai

19th Aavishkar

Inter-Collegiate / Institute / Department Research Convention (Zonal Round)

Academic Year 2024-25

Certificate of Participation

This is to Certify that **Ms. Barhate Mokshada Ravindra** of **Bharati Vidyapeeth College of Engineering, Kharghar** has participated and presented a Research Project titled **Farmguard : Real Time Crop Monitoring and Pest Control** in **Agriculture and Animal Husbandry** Category and **UG** Level at 19th Aavishkar: Inter-Collegiate / Institute / Department Research Convention (Zonal Round) organized by the University of Mumbai at Lokmanya Tilak College of Engineering, Koparkhairane, Navi Mumbai on December 15, 2024for **Zone X (Engineering Colleges/Institutes)**.

Dr. Minakshi Gurav
OSD,
Aavishkar,
University of Mumbai

Dr. Sunil Patil
Director,
Department of Students' Development,
University of Mumbai

December 15, 2024
Koparkhairane, Navi Mumbai

University of Mumbai

19th Aavishkar

Inter-Collegiate / Institute / Department Research Convention (Zonal Round)

Academic Year 2024-25

Certificate of Participation

This is to Certify that **Ms. Awari Susmita Bhavusaheb** of **Bharati Vidyapeeth College of Engineering, Kharghar** has participated and presented a Research Project titled **Farmguard : Real Time Crop Monitoring and Pest Control** in **Agriculture and Animal Husbandry** Category and **UG** Level at 19th Aavishkar: Inter-Collegiate / Institute / Department Research Convention (Zonal Round) organized by the University of Mumbai at Lokmanya Tilak College of Engineering, Koparkhairane, Navi Mumbai on December 15, 2024for **Zone X (Engineering Colleges/Institutes)**.

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