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Real-Time Crop Monitoring and Precision Spraying Using Smart Agricultural Drone

Mr. Pomnar Prashant Shantaram[1], Mr. Dhinge Tanmay Manish[2], Ms. Nikam Shraddha Pramod[3], Mr. Gunjal Siddhesh Vishwas[4], Ms. P. S. Patil[5], Mr. N. R. Thakre[6], Dr. V. A. Wankhede[7]
[1,2,3,4]Students of Department of E&TC Engineering SNJB's S.H.H.J.B Polytechnic, Chandwad
[5]Lecturer in E&TC Engineering SNJB's S.H.H.J.B Polytechnic, Chandwad
[6]HOD in E&TC Engineering SNJB's S.H.H.J.B Polytechnic, Chandwad
[7]Principal of SNJB's S.H.H.J.B Polytechnic, Chandwad

Abstract: The use of unmanned aerial vehicles (UAVs) in agriculture has introduced a revolutionary way to improve farm productivity, precision, and crop health monitoring. This project focuses on the design and development of a quadcopter drone tailored for precision farming tasks. The drone employs a lightweight, durable carbon-fiber frame that ensures stable operation under varying field conditions. Its navigation is managed by a Pixhawk flight controller, supported by an onboard Raspberry Pi system. A Pi Camera connected to the Raspberry Pi captures real-time images of crop leaves, which are processed through trained image recognition models to identify two common leaf diseases. Depending on the diagnosis, the drone activates one of two dedicated pesticide pumps to administer targeted treatment, thereby minimizing chemical waste and avoiding unnecessary spraying. By merging aerial mobility, intelligent vision systems, and automated decision-making, the proposed system aims to reduce environmental impact, cut costs, and increase crop yield through sustainable and precision-based practices.
Keywords: Agricultural Drone[1], Precision Agriculture[2], Smart Crop Monitoring[3], IoT[4], Precision Spraying[5]

I. INTRODUCTION

The agricultural sector is rapidly adopting modern technologies to meet the rising demand for food while simultaneously reducing labor costs and optimizing resource use. Among these emerging tools, drones have become a vital part of precision agriculture. They provide farmers with aerial perspectives that assist in monitoring crop conditions, identifying stress factors, and conducting precise pesticide or fertilizer applications.

This project introduces the development of a quadcopter drone specifically designed for agricultural operations. The four-rotor setup provides a balance of control, efficiency, and stability, making it suitable for small to medium-sized farms at an affordable cost. The carbon-fiber frame was chosen for its strength, light weight, and resistance to harsh environmental conditions, which are critical for long-term agricultural use.

The drone integrates a Pixhawk flight controller to enable both autonomous navigation and manual control, along with waypoint-based mission execution. Complementing this is a Raspberry Pi, which serves as the onboard processing unit. Paired with a Pi Camera, it captures and analyzes live images of crop leaves. Using a trained database and machine learning algorithms, the system identifies two specific crop diseases and triggers one of two pesticide pumps to treat the affected areas only.

By merging real-time image processing with selective spraying, the system ensures accurate disease management, reduces chemical consumption, and improves plant health. Ultimately, this project demonstrates how UAVs can revolutionize traditional farming by combining automation, precision, and sustainability in a single platform.

II. LITERATURE REVIEW

The adoption of UAVs in agriculture has been widely studied across different contexts. A review of existing literature highlights how drones are being used for tasks such as crop monitoring, spraying, disease detection, and yield prediction. However, while many studies showcase the potential of UAVs, there are still significant research gaps that provide opportunities for further exploration.

1) A Comprehensive Survey of UAVs in Open Fields and Greenhouses (Aslan et al., 2022): Reviewed drone applications for spraying, mapping, yield estimation, and weed detection. Gaps include limited greenhouse operations and lack of cost-effective designs.

2) UAVs in Agriculture (del Cerro et al., 2021): Categorized UAV types and applications. Gaps include limited comparisons of flight controllers and real-world testing.
3) Drones in Agriculture: A Review and Bibliometric Analysis (2022): Identified IoT and AI themes. Gaps include economic feasibility and lack of hardware-performance studies.
4) Adoption of UAVs in Agricultural Research (Lachowiec et al., 2024): Focused on adoption barriers. Gaps include little linkage between design features and usability.
5) Adoption of Drones in German Agriculture (2021): Applied TAM model. Gaps include region-specific context and limited link between specs and adoption.
6) Deep Learning in UAV Imagery for Agriculture (2024): Reviewed datasets and models. Gaps include dataset limitations, lack of hardware consideration.
7) Hexacopter for Fertilizer Spraying (Susitra et al., 2020): Demonstrated prototype. Gaps include endurance testing and material choice.
8) Hexacopter GPS Fertilizer Sowing (Nuryadi et al., 2021): Discussed GPS-enabled spraying. Gaps include lack of controller details and reliability evaluation.
9) Farmers' Acceptance of UAVs (Agronomy Journal): Reviewed adoption. Gaps include missing technical-performance linkage
10) Tilt-Rotor Hexacopter for Precision Agriculture (Pimentel et al., ~2024): Proposed tilt-rotor design. Gaps include simulation-only testing and payload issues.

Common gaps identified across literature: hardware optimization, GPS/telemetry reliability, real-world field tests, durability and maintenance studies, economic justification, non-GPS operation (greenhouses), farmer training, and balancing payload vs endurance.

III. METHODOLOGY

The development of the agricultural quadcopter drone followed a clear, step-by-step approach that included designing the system, integrating the components, setting up the software, and finally testing and validating the drone in the field. The main goal of this project was to create a drone that could assist farmers by performing precision agriculture tasks — such as monitoring crop health, spraying pesticides intelligently, and applying fertilizers based on actual disease detection.

To achieve stable flight and easy control, the drone was designed with a four-rotor (quadcopter) configuration. The frame was built from lightweight carbon fiber, chosen for its strength, durability, and ability to handle outdoor agricultural conditions. Brushless DC motors, paired with electronic speed controllers (ESCs) and 11–13 inch propellers, provided the required lift and smooth movement. A 6S Lithium Polymer battery, with a capacity of 10,000–15,000 mAh, powered the system and offered around 15–25 minutes of flight time depending on the payload and operation.

At the heart of the drone's control system was a Pixhawk flight controller, which managed both manual and autonomous flight modes. Using open-source firmware such as PX4 or ArduPilot, the drone could follow pre-programmed flight paths and perform missions automatically. To keep the system simple and reduce ground communication, telemetry was not included — instead, the drone operated independently using onboard intelligence.

One of the most innovative aspects of the project was the use of a Raspberry Pi microcomputer as the onboard brain for image processing. A Pi Camera mounted underneath the drone captured live images of the crops as it flew over them. The Raspberry Pi analyzed these images in real time using a pre-trained machine learning model that could recognize two types of crop diseases based on leaf appearance. Once a disease was detected, the system automatically decided which pesticide to apply.

Two small pumps, each connected to a separate pesticide tank, were used for targeted spraying. Depending on the disease identified, the Raspberry Pi activated the correct pump to apply the appropriate pesticide only to the affected area. This selective spraying method helped reduce chemical usage, save costs, and minimize harm to the environment.

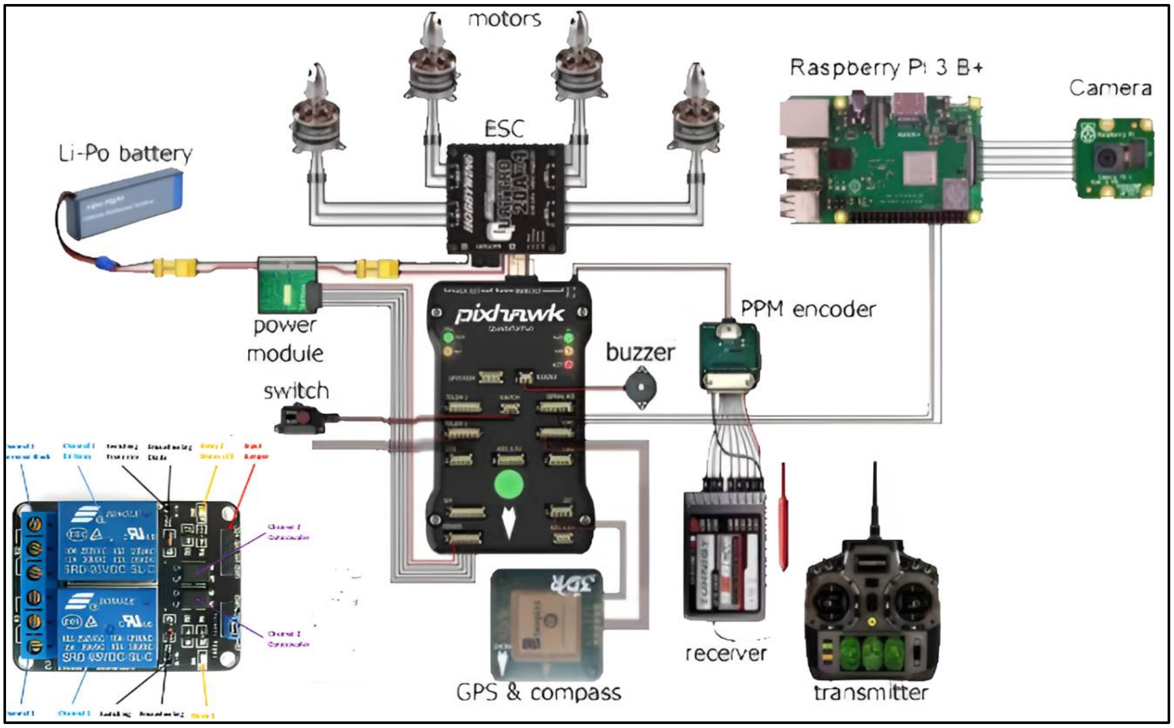
To ensure accurate and smooth operation, the drone was assembled with vibration-dampening mounts, and the Pixhawk controller was carefully calibrated — including compass, ESC, and level calibration. The software was configured with multiple flight modes like Stabilize, Loiter, and Auto. The flight paths were created using GPS waypoints through ground control software, while the spraying mechanism responded dynamically to real-time disease detection rather than just fixed coordinates.

Field tests were carried out in an agricultural area to evaluate the system's overall performance — including flight stability, disease detection accuracy, and spraying precision. The drone performed well during testing, showing reliable autonomous navigation, accurate disease identification, and efficient pesticide application. Data such as battery performance, classification accuracy, and flight behavior in different weather conditions were also recorded for analysis.

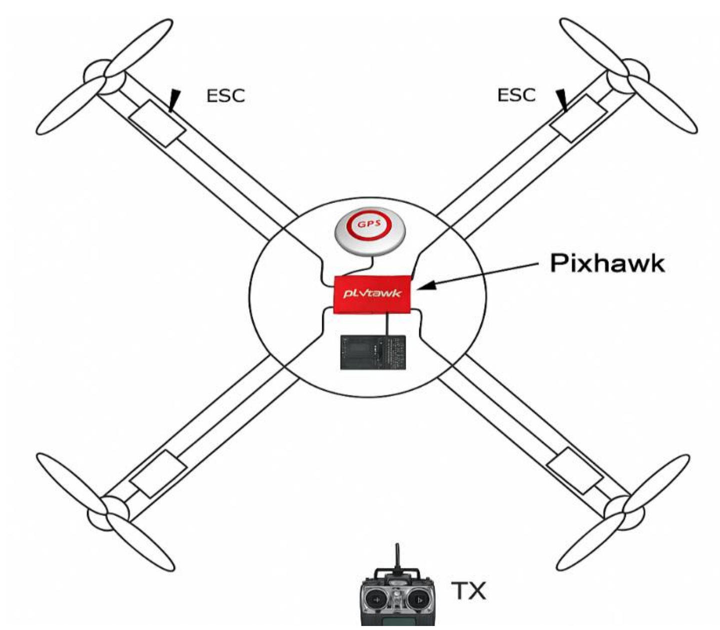
In conclusion, this methodology proved that combining computer vision, artificial intelligence, and drone technology can make a big difference in modern farming. The developed system helped reduce manual labor, saved pesticide, and provided a practical example of how smart technology can make agriculture more efficient and sustainable.

IV. BLOCK DIAGRAM

The block diagram shows integration of the battery, Pixhawk, Raspberry Pi, Pi Camera, and spraying pumps. Pixhawk handles flight control, while Raspberry Pi manages real-time disease detection and spraying. The circuit distributes power through the PDB, regulates voltage, and uses relays to activate pumps.



Circuit Diagram



Flow Chart

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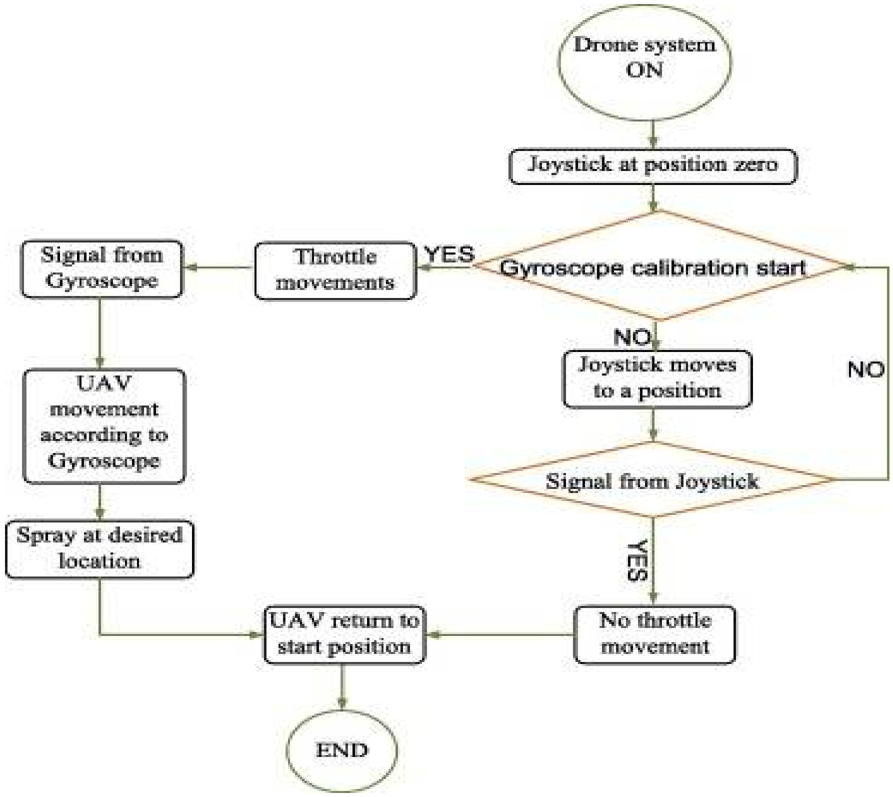


Basic Assumptions

Parameter	Value
Total Takeoff Weight (TOW)	3 kg (including frame, battery, payload, etc.)
Number of Motors	4 (quad)
Thrust-to-Weight Ratio	2:1 (for stable hover + safe maneuvering)
Desired Battery Voltage	You can choose: 4S (14.8V) or 6S (22.2V)
Efficiency Loss	~15–20% typical

Final Suggested Setup

Component	Suggested Specs
Motors	5010 750KV (or similar)
Props	13x4.5" or 14x4.8"
ESCs	40A–50A, DShot or BLHeli, 2–6S
Battery	6S 5000mAh 40–60C (LiPo)
Frame	≥550 mm diagonal, carbon fiber, high gear
Flight Controller	Kakute F7 / Pixhawk / F4 Pro V3
Estimated Flight Time	~8–10 min hover time (6S), with 3 kg weight

V. CONCLUSION

The development of a quadcopter drone with a Pixhawk flight controller, Raspberry Pi, Pi Camera, and a dual-pump pesticide spraying system offers a practical solution for precision agriculture. By combining autonomous navigation with real-time analysis of crop health, the drone can perform essential farming tasks like disease detection and selective pesticide spraying with little human involvement. The Pixhawk controller provides stable flight, accurate waypoint following, and reliable missions. The lightweight carbon fiber frame improves endurance, maneuverability, and strength in changing field conditions.

A key part of this project is the integration of the Raspberry Pi with onboard image processing. Using a Pi Camera and a pre-trained image classification model, the system can detect two types of leaf diseases during flight in real time. Based on this analysis, it applies the correct pesticide directly on the affected plants through two micro pumps.

This minimizes chemical use and prevents unnecessary treatment of healthy crops. This focused approach not only lessens environmental impact but also improves resource use, reducing costs for farmers.

Field tests confirmed that the quadcopter can autonomously scan crops, identify diseased areas, and carry out selective spraying effectively. The modular design allows for future upgrades, such as larger tanks, better sensors, or more advanced disease detection methods. Overall, this project shows how smart drone systems can significantly boost agricultural productivity, support sustainable farming, and provide farmers—both small and large—with data-driven tools for crop management.

The use of a quadcopter equipped with a Raspberry Pi, Pi Camera, and a dual-pump pesticide system represents an exciting step toward smarter, autonomous farming. However, there are still areas for future improvement to expand the system's capabilities, efficiency, and practicality.

One major area for growth is the addition of advanced imaging technologies like multispectral, hyperspectral, or thermal cameras. These sensors, along with AI-based analysis on the Raspberry Pi, could provide better assessments of crop health, early disease detection, soil condition monitoring, and irrigation planning. Enhancing the onboard machine learning could help identify a broader range of plant diseases and stress conditions, allowing for better-informed and timely farming actions.

Improving navigation accuracy is also crucial. Adding RTK (Real-Time Kinematic) GPS or visual-inertial odometry would enable centimeter-level positioning accuracy. This level of detail is especially helpful for precision spraying, automated seed planting, or operating in areas where traditional GPS is less reliable. Higher accuracy could significantly reduce chemical use while improving treatment precision.

The modularity of the system could also be improved to allow for interchangeable payloads. For instance, the current spraying mechanism could be swapped for seed dispensers, imaging modules, or environmental sensors. This change would let the same quadcopter serve multiple purposes during the farming cycle. Improving the efficiency and weight distribution of the spraying system would also enhance battery life and flight time.

Energy solutions like solar panels or automated docking stations could support extended or continuous operation, which is particularly valuable for large farms. A hybrid power system or wireless charging at base stations could further minimize downtime between missions.

On the software side, linking the Raspberry Pi to cloud platforms or IoT systems would enable remote monitoring, centralized data storage, and AI-assisted decision-making. This connection would support real-time crop analytics, historical performance tracking, and mission planning for multiple fields from a single dashboard.

To make such systems more accessible to small and medium-scale farmers, future efforts could focus on creating low-cost, user-friendly drone kits with simplified interfaces and multilingual mobile apps. Training programs and local maintenance support could encourage adoption in rural and underserved areas.

Finally, following UAV regulations and safety standards will be increasingly important. Adding ADS-B transponders or basic obstacle detection and avoidance systems would ensure safe operation in shared airspace and facilitate future management of autonomous fleets.

In conclusion, while the current quadcopter system provides an effective solution for targeted pesticide application and disease detection, future improvements in hardware, AI, power systems, and connectivity could transform it into a fully autonomous, multipurpose agricultural assistant. These advancements could be key to achieving scalable, sustainable, and data-driven farming across various agricultural landscapes.

REFERENCES

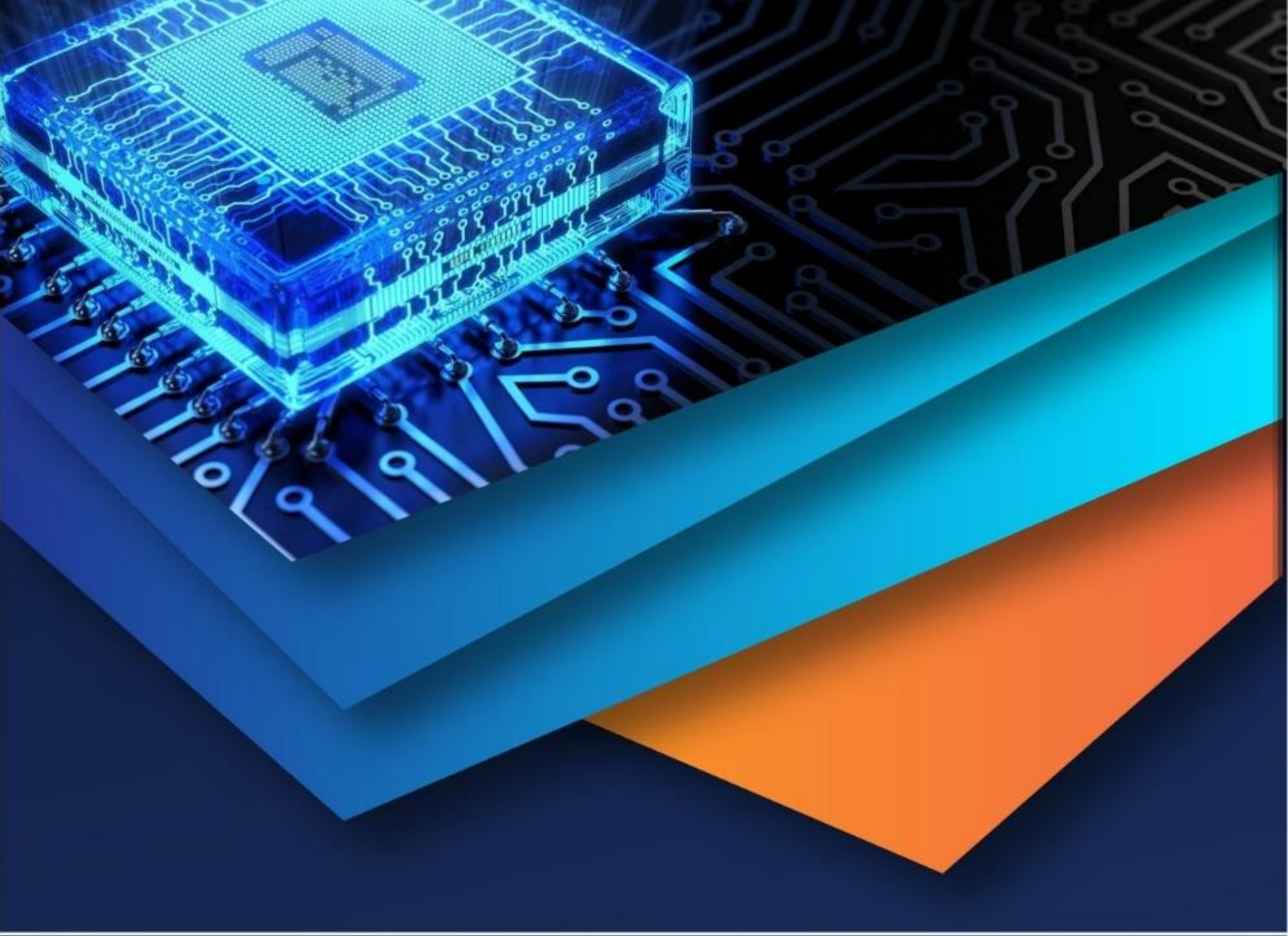
[1] Zhang, C., & Kovacs, J. M. (2012). "The application of small unmanned aerial systems for precision agriculture: a review." *Precision Agriculture*, 13(6), 693-712.

- Discusses the role of UAVs in agriculture and highlights research gaps in sensor integration and flight stability.

[2] Colomina, I., & Molina, P. (2014). "Unmanned aerial systems for photogrammetry and remote sensing: A review." *ISPRS Journal of Photogrammetry and Remote Sensing*, 92, 79-97.

- Reviews UAV platforms and payloads, emphasizing the importance of GPS and telemetry in agricultural mapping.

[3] González, L. F., Montes, G. A., Puig, E., Johnson, S., Mengersen, K., & Gaston, K. J. (2016). "Unmanned aerial vehicles (UAVs) and artificial intelligence revolutionizing wildlife monitoring and conservation." *Sensors*, 16(1), 97.



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