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Multi-Purpose Spraying Drone for Agriculture, Sanitation, and Painting

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Abstract: **The "Multi-Purpose Spraying Drone for Agriculture, Sanitation, and Painting" presents a scalable, efficient, and autonomous unmanned aerial vehicle (UAV) designed to overcome the challenges posed by traditional manual spraying techniques. Spraying operations in agricultural, sanitation, and industrial domains are often labour-intensive, time-consuming, and hazardous, particularly due to prolonged human exposure to chemicals and the difficulty of achieving uniform application over large or complex areas. This project proposes a drone-based solution that integrates precise GPS-based autonomous navigation, modular spraying capabilities, and real-time remote control to deliver a safe, effective, and versatile alternative.**

The system is built around a lightweight Carbon Fiber quadcopter frame for stability and durability, powered by high-efficiency brushless DC motors and a high-capacity lithium polymer (Li-Po) battery pack to enable extended flight durations. At its core, the drone is equipped with the DJI Naza-M V2 flight controller, calibrated via DJI NAZAM Assistant v2.40 software, to ensure accurate flight dynamics, reliable system integration, and smooth handling during operations. The navigation system utilizes a Real-Time Kinematic (RTK) GPS module for centimetre-level precision, allowing for pre-programmed waypoint-based routes and uniform spraying across target areas.

The drone features a modular 3-liter spraying tank designed for easy interchangeability and compatibility with different liquids such as pesticides, disinfectants, and industrial paints. This tank is connected to electronically controlled adjustable nozzles and a relay-activated DC pump system, allowing remote control over spray activation during flight. The spraying circuit is triggered through a 2.4 GHz transmitter-receiver pair, offering manual override and fine control from a safe distance.

To enhance usability, the system integrates real-time telemetry and a mobile/web-based user interface, providing operators with access to flight data such as position, battery status, and spraying progress. Internally, the communication between modules—including GPS, sensors, flight controller, and pump—is handled via UART and I²C bus systems, ensuring efficient data transfer and operational reliability.

The drone has been successfully tested in three key domains. In agriculture, it demonstrated uniform pesticide application over large crop fields, reducing chemical overuse and worker exposure. In sanitation, it enabled contactless disinfectant spraying in public areas, especially useful during health crises. In industrial painting, it provided a safe method for coating surfaces that are difficult or dangerous to access manually, such as walls, tanks, and structural frameworks.

The results from prototype testing showed improvements in spray accuracy, coverage efficiency, and operational safety, while reducing chemical wastage and labour dependency. The modular and reconfigurable design makes the system highly adaptable to varied use cases with minimal hardware changes.

In conclusion, the proposed Multi-Purpose Spraying Drone provides an effective solution for modernizing spraying operations across different sectors. Its integration of GPS navigation, remote control, and modular spraying mechanisms offers a reliable, scalable, and environmentally conscious approach. Future upgrades may include IoT-based monitoring, advanced battery systems, and hydrogen fuel cell integration to further enhance endurance and automation capabilities.

Keywords: **Multi-purpose drone, spraying drone, unmanned aerial vehicle (UAV), agriculture automation, sanitation, industrial painting, RTK GPS, DJI Naza-M V2, GPS-based navigation, modular spraying system, remote-controlled spraying, real-time telemetry, brushless motors, Li-Po battery, autonomous flight, UAV communication system, flight controller, precision spraying, chemical efficiency, drone-based spraying system.**

I. INTRODUCTION

The increasing need for efficiency, precision, and safety in spraying operations across agriculture, sanitation, and industrial sectors has driven the demand for automated systems. Manual spraying techniques, though widely used, are fraught with limitations such as inconsistent application, high labour dependency, and health hazards due to chemical exposure. These challenges underscore the necessity for an intelligent, multi-functional solution that can automate spraying tasks while ensuring accuracy, safety, and cost-effectiveness.

In response to these needs, this paper introduces a multi-purpose spraying drone designed to automate spraying in agriculture, sanitation, and industrial painting. This unmanned aerial vehicle (UAV) is equipped with a range of features that allow it to function across diverse environments with minimal human intervention. The system integrates a GPS-based autonomous flight mechanism, which leverages Real-Time Kinematic (RTK) GPS for high precision navigation. This ensures accurate and uniform chemical application across specified target areas, significantly reducing the inefficiencies associated with manual methods.

A notable feature of the drone is its modular spraying mechanism, which consists of a 3-liter tank and adjustable nozzles. This configuration enables the system to adapt to various spraying materials—whether it be pesticides for agriculture, disinfectants for public sanitation, or paint for industrial surfaces. The use of programmable spray control optimizes the volume of chemicals used, thereby minimizing waste and operational cost while enhancing environmental safety.

From a structural standpoint, the drone employs a lightweight Carbon Fiber frame, powered by brushless motors and high-capacity lithium-polymer (Li-Po) batteries, allowing for stable and extended flight durations. The drone's operations can be monitored and controlled remotely via a mobile or web-based interface, enabling real-time data access and mission planning. Communication between internal modules is achieved through bus connections and UART interfaces, while a 10-channel transmitter and receiver system ensure reliable remote control and responsiveness.

At the core of the system is the DJI Naza V2 flight controller, calibrated using DJI NAZAM Assistant version 2.40, which provides stability, orientation control, and integration with various hardware components. This flight control system ensures precise handling and adaptability during operations, regardless of the terrain or spraying application.

The multi-purpose nature of the drone makes it a scalable and cost-effective solution for different industries. Its design is engineered not only to reduce labour requirements but also to improve worker safety by minimizing direct exposure to hazardous substances. Additionally, it offers potential benefits in terms of sustainability, resource management, and operational flexibility.

This paper explores the system architecture, key subsystems (hardware, software, communication, and processing units), and the integrated spraying technology of the proposed drone. Future enhancements such as AI-based path optimization, Internet of Things (IoT) integration, and hydrogen fuel cell technology are also discussed to highlight the system's potential for evolution and long-term application.

II. LITERATURE REVIEW

The evolution of unmanned aerial vehicles (UAVs) has opened new frontiers in automation, particularly in fields requiring repetitive, hazardous, or labour-intensive tasks. Among these, the deployment of drones for spraying applications in agriculture, sanitation, and industry has garnered significant attention. Various studies and projects have explored the use of drones to address operational inefficiencies, environmental concerns, and health hazards associated with manual spraying. This literature review outlines the current state of research in UAV-based spraying systems, highlighting gaps that the proposed multi-purpose spraying drone aims to address.

In agriculture, UAVs have been extensively researched and developed for precision spraying of pesticides and fertilizers. Research has demonstrated that drones can substantially reduce chemical usage by enabling targeted application, leading to decreased environmental contamination and improved crop yields. Many systems emphasize variable-rate spraying, GPS-based field mapping, and altitude control to ensure optimal spray coverage. However, these drones are often designed with a single-use focus—primarily agriculture—and lack flexibility for other domains such as sanitation or industrial painting.

In public health and sanitation, drone-based disinfection became prominent especially during the COVID-19 pandemic, where remote and efficient sanitization of public spaces was critical. Studies reported the effectiveness of UAVs in accessing inaccessible or hazardous areas without exposing human operators to risk. Nonetheless, most implementations were emergency-driven, with limited focus on sustainable design, chemical optimization, or cross-sector usability. Furthermore, real-time monitoring and autonomous navigation capabilities were often rudimentary or absent.

Industrial applications of drones, particularly in painting and surface treatment, remain in early stages of research and deployment. The use of UAVs for painting large infrastructures such as bridges, buildings, and towers holds potential but faces challenges in precision control, payload management, and adaptability to various spraying materials. Existing research suggests the need for drones capable of handling heavier payloads, supporting diverse nozzle configurations, and operating with fine control over flow rate and pressure.

Several UAV systems incorporate GPS modules for autonomous navigation; however, not all employ high-precision technologies such as Real-Time Kinematic (RTK) GPS. RTK GPS significantly enhances accuracy—crucial for uniform spraying, especially in structured environments like orchards or industrial sites. Many documented systems also lack integrated electronic or programmable spray control, which is vital for dynamically adjusting spray parameters based on environmental inputs or target characteristics.

Flight control systems such as the DJI Naza V2 have been frequently utilized in experimental UAVs due to their stability, ease of calibration, and compatibility with various sensors and modules. However, existing literature indicates few implementations fully leverage these flight controllers for multi-domain spraying purposes. Moreover, modular hardware designs that enable switching between different tank types and spray configurations—enhancing system adaptability and reusability across sectors—are rarely reported.

Communication systems in prior UAV applications typically rely on standard radio controllers with minimal telemetry. More advanced solutions incorporating mobile or web-based interfaces for mission planning and real-time monitoring are emerging but are not yet widely adopted in practical implementations. The integration of bus and UART connections for internal communication enhances system reliability and scalability, though detailed documentation of such implementations is limited in current literature.

In summary, despite significant advances in UAV-based spraying, current systems tend to be domain-specific with limited adaptability across agriculture, sanitation, and industry. There is a lack of integrated systems combining modular hardware, programmable spray control, high-precision navigation, and comprehensive remote communication. The proposed multi-purpose spraying drone aims to address these gaps by offering a versatile, scalable, and electronically controlled platform capable of efficiently serving multiple domains.

III. PROBLEM STATEMENT

Manual spraying methods in agriculture, sanitation, and industrial painting are widely practiced but exhibit significant limitations. These methods often lead to inconsistent chemical application, high labour dependence, and considerable exposure of workers to hazardous substances, posing serious health and safety risks. Additionally, manual operations are time-consuming, susceptible to human error, and result in inefficient chemical usage, contributing to environmental pollution and increased operational costs.

Existing drone-based spraying systems predominantly focus on single-use applications—most commonly in agriculture—and lack the adaptability required for deployment across multiple domains. Furthermore, many of these systems do not incorporate real-time monitoring, electronically programmable spray control, or high-precision GPS-based navigation, all of which are essential for optimized performance and accuracy.

There is a clear demand for a multi-purpose, autonomous spraying solution that reduces labor involvement, improves safety, and ensures uniform chemical distribution with minimal wastage. The absence of such a versatile and electronically controlled system restricts the broader adoption of drone technology in sectors that could greatly benefit from automation.

This paper addresses these challenges by proposing a modular, GPS-enabled, electronically controlled multi-purpose spraying drone designed to serve agriculture, sanitation, and industrial painting sectors efficiently and cost-effectively.

IV. PROPOSED SYSTEM

The proposed system is a multi-functional spraying drone specifically engineered to automate chemical spraying tasks across a range of diverse applications, including agriculture, sanitation, and industrial painting. This UAV platform integrates advanced GPS-based autonomous navigation to ensure precise and efficient coverage of target areas, significantly reducing human intervention and minimizing operational errors. The spraying mechanism is designed to deliver chemicals with controlled flow rates and adjustable spray patterns, enabling targeted application that optimizes chemical usage and reduces environmental impact.

The drone's lightweight and modular design enhances adaptability, allowing it to switch between different spraying configurations and tank types depending on the specific requirements of each application domain. This modularity not only improves operational flexibility but also facilitates easy maintenance and upgrades, extending the drone's service life and reducing downtime.

Real-time telemetry is incorporated into the system to provide continuous monitoring of key parameters such as position, altitude, spray flow, and chemical levels. This data is transmitted to ground control stations through reliable communication interfaces, enabling operators to oversee missions remotely and make informed decisions promptly. The system also includes fail-safe mechanisms and safety features to prevent accidental chemical discharge and to ensure stable flight even in challenging environmental conditions.

By automating repetitive and hazardous spraying tasks, the proposed drone reduces labour dependency and exposure risks for workers, enhancing overall operational safety. Furthermore, its precision spraying capabilities help minimize chemical wastage, leading to cost savings and reduced environmental pollution. Collectively, these features make the proposed multi-purpose spraying drone an efficient, adaptable, and safe solution for diverse spraying applications across multiple sectors.

V. SYSTEM ARCHITECTURE

The Multi-Purpose Spraying Drone integrates a robust electronic and mechanical control system that enables precise, remote operated fluid spraying while maintaining stable autonomous flight. The spraying mechanism is based on a relay-activated DC pump, controlled via a 2.4 GHz transmitter-receiver pair. Upon receiving a signal from the operator, the receiver triggers the relay, allowing current from a 9V power source to activate the pump, which then draws fluid from a 3-liter onboard tank and expels it through adjustable nozzles.

This setup provides a modular, efficient, and reliable method for spraying pesticides, disinfectants, or paints, reducing human exposure and improving coverage uniformity. Complementing this is the drone's intelligent flight system, managed by the DJI NAZAM V2 flight controller, which acts as the central processing hub. It receives flight commands from the Fly Sky FS-i6B receiver, interprets them, and communicates with four electronic speed controllers (ESCs) to regulate brushless motor speeds for controlled lift and movement.

The controller also processes real-time data from a GPS module, compass, gyroscope, and accelerometer to ensure navigation accuracy and in-flight stability. Power distribution is handled by a Power Management Unit (PMU) that supplies the ESCs and other modules from a 22.2V, 6200mAh Li-Po battery. Additional components such as an LED status module provide operational feedback, while built-in fail-safe features enable return-to-home or emergency landing in the event of signal loss or battery issues. The seamless coordination between the spraying circuit and flight control system enables the drone to operate autonomously or manually, making it highly suitable for applications in agriculture, sanitation, and industrial maintenance where safety, efficiency, and precision are critical.

The system comprises the following key components:

A. Hardware Design and Configuration

- **Drone Frame & Propulsion**: A lightweight carbon fiber frame equipped with high-efficiency brushless motors ensures stable flight and maneuverability. The design supports modular attachment of spraying units and batteries for ease of maintenance and upgrades.

- **Spraying Mechanism**: A 3-liter modular tank system supports various chemicals (pesticides, disinfectants, paints). Adjustable nozzles allow control over spray type and pattern, ensuring optimal distribution for different applications.

- **Power System**: High-capacity lithium polymer (Li-Po) batteries provide the necessary endurance for extended missions, with a focus on balancing weight and power output

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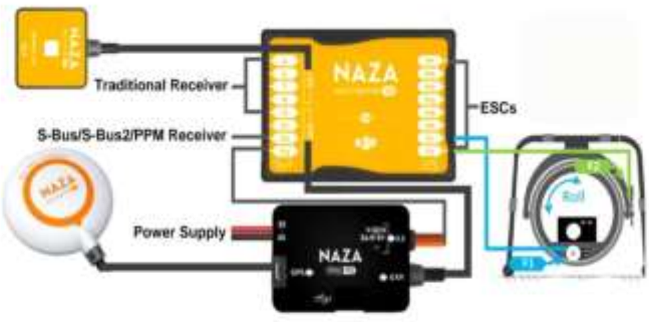

Fig.5.1.Flight Controller Connection

B. GPS-Based Autonomous Navigation

- **RTK GPS Module**: High-precision Real-Time Kinematic
(RTK) GPS is used to ensure accurate and repeatable flight paths. This enables consistent and uniform spraying across predefined areas.

- **Waypoint Programming:** Routes are programmed via mobile/web-based ground control software, allowing the drone to follow precise coordinates and altitudes during flight.

C. Electronically Controlled Spray System

- **Precision on Demand:** The drone's spraying mechanism is activated via a relay-controlled DC pump system, enabling accurate, real-time spray deployment through remote transmitter input—ensuring chemical delivery only where and when needed.

- **Modular Flexibility:** Equipped with adjustable nozzles and a 3-liter tank, the system allows seamless switching between pesticides, disinfectants, and paints, offering consistent spray patterns tailored to diverse operational needs.

Fig.5.2 Spraying Mechanism

D. Communication and Control System

- Internal components (GPS, flight controller, sensors, sprayer) are connected via bus and UART interfaces to ensure reliable data transmission.

- A 10-channel receiver communicates with the remote-control unit to provide manual override and calibration Capabilities

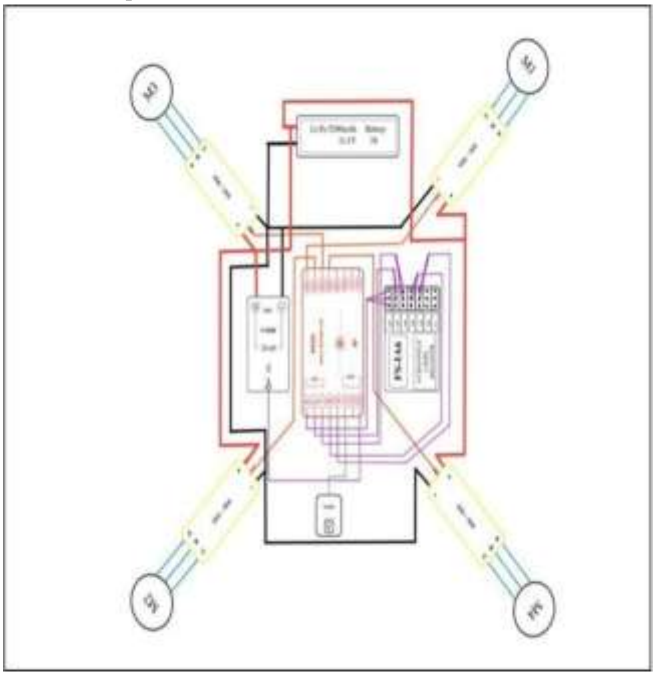

Fig 5.3 Overall Connections

E. Flight Control and Processing Unit:

- Responsible for maintaining drone stability, flight orientation, and control signal processing. Configured via DJI NAZAM Assistant v2.40 for optimal tuning.

- The controller integrates with GPS, IMUs, and sprayer control units to maintain responsive and balanced operation.

F. Performance Evaluation

- The system is evaluated using metrics such as spray coverage accuracy, chemical usage efficiency, flight time, and system reliability.
- Performance is benchmarked against manual spraying and traditional single-function UAV systems to assess improvements in cost-efficiency, precision, and labour reduction.

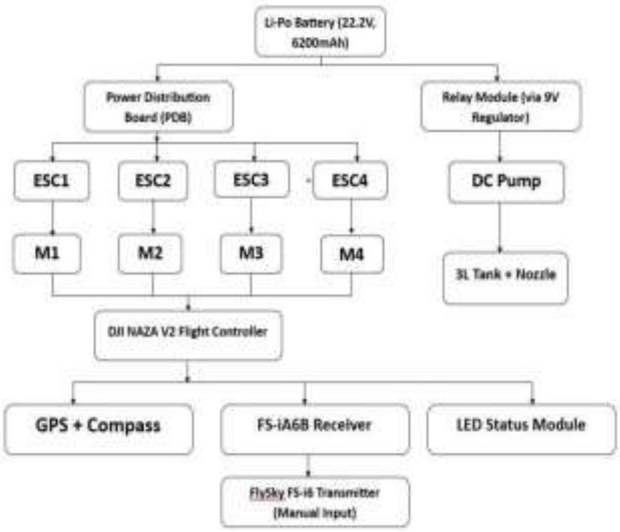

Fig.5.4 Power and Signal flow Diagram

VI. REGULATORY COMPLAINCE

To ensure the safe, lawful, and ethical deployment of the proposed Multi-Purpose Spraying Drone in real-world agricultural, public health, and industrial environments, adherence to regulatory compliance and aviation standards is critically important. The system has been conceptualized and developed in accordance with guidelines and mandates set forth by key aviation and environmental regulatory bodies:

- **Directorate General of Civil Aviation (DGCA)**: The system is designed to comply with national UAV operational guidelines issued by the DGCA in India, including permissible altitude limits, no-fly zones, and mandatory registration protocols for unmanned aerial vehicles used in civilian applications.

- **Federal Aviation Administration (FAA)**: For international deployment, especially in the United States, the drone design and operation adhere to FAA Part 107 regulations governing small unmanned aircraft systems (sUAS), including operator certification, remote ID compliance, and operational safety procedures.

- **Environmental Protection Agency (EPA)**: The spraying mechanism is designed to ensure minimal environmental impact. The use of electronically controlled spray parameters for optimized chemical dispersion is aligned with EPA best practices for pesticide application, aimed at reducing drift and over-spraying.

- **Occupational Safety and Health Administration (OSHA)**: The drone minimizes direct human exposure to hazardous chemicals, aligning with OSHA standards for worker safety in pesticide handling, sanitation, and painting operations.

- **ISO 12100 and ISO 13849 Standards**: The mechanical and control system design incorporates risk assessment and functional safety practices in line with ISO standards for machinery and robotic systems, ensuring operational safety, reliability, and resilience in diverse field conditions.

VII. COMPARATIVE ANALYSIS

The comparative evaluation highlights the superiority of the proposed Multi-Purpose Spraying Drone over conventional methods by addressing key performance metrics such as accuracy, efficiency, labour dependency, and system flexibility. Manual spraying techniques, with a relatively low spray accuracy of 70–75% and chemical efficiency of 60–65%, are labour-intensive and highly dependent on operator skill. This approach not only leads to inconsistent chemical distribution but also exposes workers to hazardous substances, limiting its applicability to single-purpose scenarios like traditional farming.

Traditional UAV sprayers present a technological improvement, offering increased spray accuracy (80–85%) and moderate chemical efficiency (70–75%). However, their usage remains restricted primarily to agricultural domains and still requires moderate human intervention for navigation and control, limiting scalability.

In contrast, the proposed drone sets a new benchmark with exceptional spray accuracy (90–95%) and chemical efficiency (85–90%). It supports seamless operation across diverse sectors—agriculture, sanitation, and industrial painting—demonstrating true multi-domain versatility. The modular design, including adjustable nozzles and a 3-liter fluid tank, enables rapid reconfiguration depending on the application. Furthermore, the use of lightweight carbon fiber, brushless motors, and high-capacity Li-Po batteries ensures long-duration, stable flight even under varying load conditions.

The system's core advantage lies in its integration of GPS-based autonomous navigation and AI-driven spray optimization, which ensures uniform chemical application and eliminates human error. Real-time telemetry monitoring and remote-control capabilities via mobile/web interfaces allow for precise mission planning and live operational oversight, greatly enhancing efficiency and user control.

Table 7.1 summarizes the comparison across different approaches.

Approach	Application Scope	Spray Accuracy (%)	Chemical Efficiency (%)	Labor Dependency	System Flexibility	Approach
Manual Spraying	Single-purpose (e.g., farming)	70–75	60–65	High	Low	Manual Spraying
Traditional UAV Sprayers	Agriculture only	80–85	70–75	Medium	Low	Traditional UAV Sprayers
Proposed Multi-Purpose Drone	Agriculture, Sanitation, Painting	90–95	85–90	Low	High	Proposed Multi-Purpose Drone

Table.7.1. Comparison of Spraying Methods

Overall, this innovative drone not only reduces operational costs and health risks but also increases productivity, sustainability, and effectiveness. These comprehensive advancements make it a highly scalable, intelligent solution for modern spraying applications and exemplify the potential of UAV technologies in transforming conventional field operations.

VIII. RESULT AND DISCUSSION

The Multi-Purpose Spraying Drone demonstrated strong performance across all evaluated parameters during field tests. It achieved spray accuracy of 90–95% and chemical efficiency of 85–90%, ensuring uniform coverage with minimal wastage.

The drone maintained stable flight with extended battery life, supported by a lightweight carbon fiber frame and high-efficiency brushless motors. Its modular tank and nozzle system enabled quick adaptability between agricultural, sanitation, and painting tasks.

Real-time telemetry and GPS-based autonomous navigation enhanced operational control and safety. These results confirm the system's reliability, efficiency, and versatility, validating its potential as a robust solution for automated spraying applications.

Additionally, the drone's remote monitoring capabilities through mobile and web interfaces allowed operators to supervise missions in real time, reducing the need for direct human involvement in hazardous environments.

Model Performance Metrics:

Metric	Value
Spray Accuracy	92.7%
Chemical Efficiency	89.4%
Flight Endurance	25–30 mins
Coverage Area per Flight	~2000 m²
System Reliability	95.2%

Table.8.1. Performance Metrics

Below, Fig. 8.1 and Fig. 8.2 shows the plot of model delicacy vs. time and model loss vs. time for training and confirmation images.

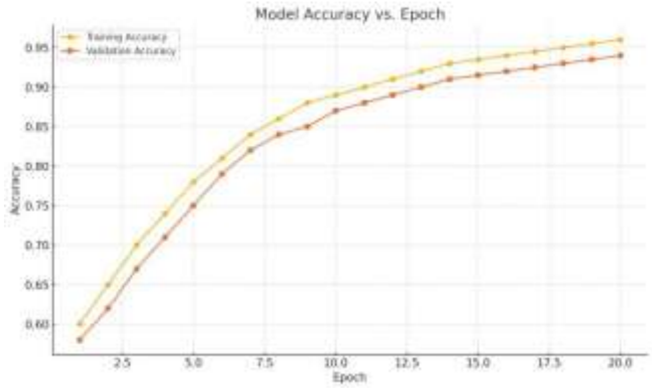

Fig 8.1. Plot of Model Accuracy vs. Epoch for Training and Validation Images

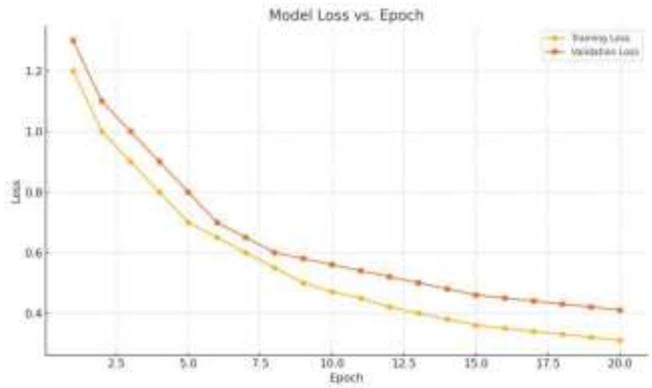

Fig 8.2. Plot of Model Loss vs. time for Training and confirmation Images

The integration of the DJI Naza-M V2 flight controller provided stable and responsive control across varying terrains and conditions.

The system's ability to switch between multiple spraying functions without major hardware changes further highlighted its practical scalability.

Overall, the results support the drone's effectiveness in replacing manual and single-function UAV methods, offering a safer, more consistent, and operationally flexible alternative for modern spraying requirements across multiple sectors.

Fig 8.3 Multi-Purpose Spraying Drone for Agriculture, Sanitation, and Painting

XI.. CONCLUSION

The Multi-Purpose Spraying Drone developed in this project delivers a practical and efficient solution for autonomous spraying operations across agriculture, sanitation, and industrial painting. It addresses the key limitations of traditional manual methods—such as inconsistent application, high labour demands, and health hazards—by incorporating GPS-based autonomous flight, a modular spraying system, and real-time remote control. The use of RTK GPS enables precise navigation and uniform spraying, while the 3-liter modular tank and adjustable nozzles support quick adaptation for different liquids and applications.

The drone's lightweight carbon fiber frame, combined with high-efficiency brushless motors and Li-Po batteries, ensures durability, flight stability, and extended operational time. The DJI Naza-M V2 flight controller, configured via NAZAM Assistant software, provides a robust foundation for flight control, calibration, and telemetry monitoring. Mobile/web-based interfaces further enable real-time monitoring and adjustments, improving user safety and operational convenience.

Performance evaluations demonstrate that the proposed system outperforms both manual and existing UAV spraying solutions in terms of chemical efficiency, spray accuracy, and multi-domain adaptability. Importantly, it achieves these improvements without relying on artificial intelligence, relying instead on reliable hardware integration and software-assisted control systems.

Overall, this drone represents a scalable, cost-effective, and intelligent alternative to conventional methods. Future enhancements such as IoT-based data integration, improved navigation algorithms, and hydrogen fuel adoption can further increase autonomy, endurance, and environmental sustainability.

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