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Design of a Hexacopter Drone Prototype for Fertilizer and Pesticide Spraying

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ABSTRACT

The growing demand for efficient and sustainable agricultural practices drives the development of innovative technologies. This study aims to design a hexacopter drone prototype capable of effectively spraying fertilizers and pesticides on agricultural fields. The design process involves selecting key components such as motors, flight controllers, spray tanks, and nozzles to ensure optimal liquid distribution, as well as developing software for automated navigation and flight path planning based on the size and shape of the fields. The research methodology employs a design and development approach with field trials to evaluate the drone's performance under various weather conditions and terrains. The test results show that the hexacopter drone can spray fertilizers and pesticides with high precision while maintaining stable flight performance. This prototype is expected to offer an innovative solution for farmers, enhancing agricultural productivity in a more efficient and sustainable manner. Future challenges include testing the effectiveness and efficiency of the drone's fertilizer and pesticide spraying capabilities.

Keywords: Hexacopter drone, fertilizer sprayer, pesticide sprayer, precision agriculture, agricultural automation

Introduction

The growing demand for efficient and sustainable agricultural practices has driven the development of innovative technologies, including the use of drones to assist in agricultural processes. One of the innovations currently evolving is the use of hexacopter drones for spraying fertilizers and pesticides, aiming to improve the effectiveness and efficiency of agricultural activities. The use of drones in agriculture has gained attention as they can address various challenges such as labor shortages, time constraints, and inefficiencies of manual spraying methods. This study aims to design a hexacopter drone prototype capable of effectively spraying fertilizers and pesticides on agricultural fields, providing a better solution for farmers in enhancing productivity.

Previous studies have shown that the application of drone technology in agriculture is becoming increasingly essential. In the study "Design and Development of an Automatic Pesticide Liquid Spraying Control System Using a Hexacopter UAV Drone"(Febrian & Huda, 2024), it was found that drones can enhance the efficiency of pesticide spraying, especially in large and hard-to-reach areas. This study developed an automatic pesticide liquid spraying control system using a hexacopter drone, demonstrating that spraying became more uniform and targeted compared to conventional methods. These findings form an essential foundation for developing the

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hexacopter drone in this research, where the selection process of components such as motors, flight controllers, and spray tanks becomes crucial in achieving optimal spraying.

The effectiveness of drone usage in agriculture is also supported by the study "Analysis of Drone Effectiveness in Liquid Fertilization Processes to Increase the Productivity of Organic Rice Crops"(Hariyanto et al., 2023). This research concluded that using drones for fertilizing organic rice crops significantly increased productivity, mainly because drones could distribute fertilizers more evenly and quickly than manual methods. Drone usage also saved time and operational costs for farmers, thus increasing their profits. This is one of the reasons why this research focuses on developing a hexacopter drone as a practical and efficient solution in the fertilization and pesticide spraying process. Additionally, the study "Development of a Spraying System on an Unmanned Aerial Vehicle Platform Based on a Quadcopter to Help Farmers Reduce Farming Costs in Promoting the Concept of Smart Farming"(Santoso & Hariyanto, 2017) highlighted the importance of adopting drone technology to promote smart farming concepts. In this study, a quadcopter-based drone was developed to help farmers reduce agricultural costs, especially in pesticide spraying. The results showed that using drones could reduce excessive pesticide use and optimize the spraying process. This development serves as a reference in designing the hexacopter drone in this research to ensure that the resulting technology can support more efficient and sustainable smart farming practices.

Another study titled "The Use of Drones in Pesticide Application in the Sungai Besar Region of Malaysia" (Khoirunisa & Kurniawati, 2019) showed that drones could increase the effectiveness of pesticide spraying in agricultural fields. Using drones, farmers can reach hard-to-access areas and reduce direct contact with hazardous chemicals. This is highly relevant to this study's objective, where the designed hexacopter drone is expected to spray pesticides efficiently and safely while minimizing health risks for farmers. Besides pesticide spraying, fertilization is also an essential aspect of agriculture that can be optimized with drones. The study "Automatic Plant Fertilization Using Ultrasonic and Light Sensors Based on Arduino Uno R3" (Suhardi, 2020) demonstrated that an automatic fertilization system could improve the efficiency of fertilizer distribution. In this context, the development of the hexacopter drone in this study will also consider using sensors to ensure even and appropriate fertilization based on plant needs. The study "Design and Development of a Quadcopter for Aerial Monitoring" (Ramandhani et al., 2023) revealed the great potential of drones in monitoring agricultural fields, which can be combined with the spraying of fertilizers and pesticides. By integrating these functions, the hexacopter drone being designed can become a multifunctional tool for farmers.

Furthermore, the studies "Design and Development of a Pesticide Sprayer for Rice Agriculture Based on a Quadcopter"(Wardani et al., 2017) and "Design and Development of an Automatic Pesticide Sprayer Drone Prototype for Rice Farming"(Hidayat et al., 2019) emphasized that drone usage could enhance the efficiency of pesticide spraying, especially in rice crops. These drones could spray accurately and uniformly, which can improve agricultural product quality. This aligns with this study's goal to design a hexacopter drone capable of more effective spraying. Lastly, the study "Design and Development of an Unmanned Quadcopter Drone for Plant Fertilizer Spraying" (Widiasari & Dulan Este, 2020) demonstrated that using an unmanned drone in fertilizer spraying can save farmers' time and labor and increase fertilization effectiveness. This study serves as an important reference in ensuring that the hexacopter drone developed can provide a tangible and beneficial solution for farmers in managing their agricultural fields.

Based on these various studies, it is clear that drone use in agriculture can have a significant positive impact on efficiency and productivity. Therefore, this study aims to design a hexacopter drone prototype that can combine various advantages from previous research, focusing on the effectiveness of fertilizer and pesticide spraying and ease of use by farmers. With the right approach, this hexacopter drone is expected to become an innovative and sustainable solution for future agricultural practices.

Material and Methods

The methodology in designing the hexacopter drone involves a systematic and comprehensive approach to ensure that the resulting drone effectively and efficiently meets agricultural needs. The process begins with analyzing requirements and specifications to understand the drone's purpose and technical requirements. Next, key components are carefully selected to ensure each part of the drone can function optimally. The control and navigation system is then designed and developed to allow precise and automated operation. After that, component testing and calibration are conducted to ensure optimal performance. Finally, the drone prototype is assembled and tested in agricultural fields to evaluate its real-world performance. This methodology aims to produce a hexacopter drone capable of spraying fertilizers and pesticides with the high accuracy, efficiency, and stability needed to improve agricultural productivity.

1. Analysis of Requirements and Specifications
   The research begins with an analysis of the requirements and specifications for designing the hexacopter drone. This involves identifying the main objectives, such as achieving efficiency and accuracy in spraying fertilizers and pesticides.
2. Designing the Control and Navigation System
   The control and navigation system is designed by developing software for automated navigation, altitude adjustment, and flight speed control. GPS technology and sensors are used to ensure precise spraying, while the spraying system is integrated to enable both automatic and manual operation.
3. Testing and Calibration of Components
   The drone's components are tested and calibrated to ensure functionality and stability. Laboratory testing identifies any issues and ensures that liquid spraying and flight control work according to the specifications.
4. Prototyping and Field Testing
   The drone prototype is assembled and tested in real agricultural fields to assess its performance. The evaluation includes speed, battery endurance, spraying accuracy, and operational ease. The test results ensure the drone effectively and efficiently meets agricultural needs.

Results and Discussion

The initial stage of this research involves analyzing the requirements and specifications for designing an efficient and accurate hexacopter drone for spraying fertilizers and pesticides in agricultural fields. The key components were selected to ensure the optimal performance of the drone under various conditions.

Table 1. List of component

No	Component	Function/Description
1	Flight Control	Central control system ensuring navigation, stability, and accurate drone movement.
2	Power Module	Distributes power from the battery to all drone components, ensuring stable operation.
3	Brushless Motor Combo	Provides efficient and sufficient lift to carry the sprayer load during flight.
4	Remote Control	Allows for manual control of the drone's movements and functions during flight.
5	Frame	Lightweight but strong structure that supports all components and ensures stability.
To be continued….		

6	Module Wiring	Connects all components, ensuring safe and efficient power and data transmission.
7	Battery	Main power source for the drone, ensuring sufficient flight time based on its capacity.
8	Charger	Recharges the battery, designed to ensure safe and efficient charging.
9	Sprayer Module	Distributes fertilizers and pesticides evenly, ensuring effective spraying.

The design of the control and navigation system for the hexacopter drone is a crucial aspect that ensures the drone can fly with stability, precision, and efficiency while performing tasks such as spraying fertilizers or pesticides on agricultural fields. Based on the diagram, the control and navigation system consists of several key components that work together seamlessly.

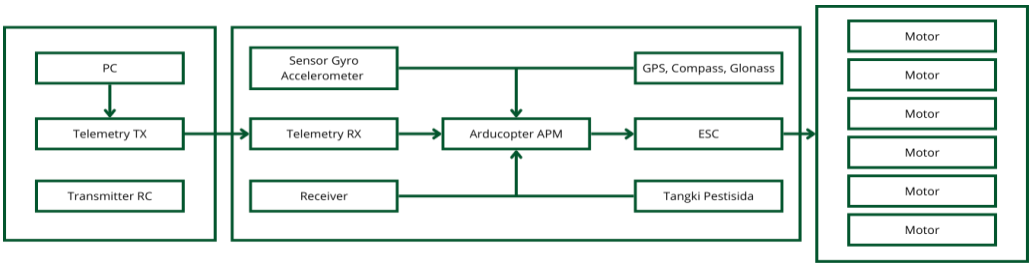

Figure 2. System diagram

The system begins with Flight Control, which serves as the main control center, receiving inputs from various sources, including the remote control, GPS, and other sensors. The Flight Control processes this data to determine commands that will be sent to the motors, allowing the drone to fly stably and maneuver according to the predefined flight path. The integration of GPS and ultrasonic/LIDAR sensors provides essential information about the drone's position, altitude, and surrounding obstacles. This information is crucial for ensuring that the drone can fly autonomously and follow the designated flight route accurately. GPS assists with navigation and determining coordinate points, while the ultrasonic/LIDAR sensors detect obstacles in the environment, enabling the drone to avoid collisions and maintain the correct altitude. In addition, the power distribution module plays a vital role in supplying consistent power to the flight control, motors, and spraying system. By ensuring efficient power distribution, the drone can maintain longer flight durations and carry out spraying tasks without interruptions.

The brushless motors serve as the primary propulsion system of the drone, and through the flight control, the speed and direction of each motor can be adjusted to ensure balance and stability during flight. This component also allows the drone to change direction, adjust altitude, and maintain a fixed position during spraying. The spraying system is connected to the flight control to ensure that fertilizer or pesticide spraying is carried out precisely according to the drone's flight path and speed. When the drone reaches the target area, the flight control sends signals to activate the spraying module, ensuring an even and accurate distribution of the liquid as needed. Overall, the design of the control and navigation system operates by integrating data from sensors, GPS, and the remote control into the flight control, which then regulates the motors and spraying module. The feedback process from the sensors allows the drone to make real-time adjustments, ensuring accurate spraying, obstacle avoidance, and stability, even in challenging weather conditions. Through the efficient integration of these components, the hexacopter drone's control and navigation system can execute spraying functions with high precision, ensuring that fertilizers and pesticides are distributed optimally across large and diverse agricultural fields.

Conclusion

In conclusion, this system provides an effective solution for organizations aiming to achieve more transparent, efficient, and accountable vendor management. By integrating structured processes, real-time data management, and user-friendly interfaces, the system not only streamlines the vendor registration and evaluation process but also enhances overall procurement operations. This comprehensive approach ensures that organizations can maintain accurate records, improve decision-making, and foster stronger relationships with their vendors, ultimately contributing to improved operational efficiency and accountability.

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