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Original Article

Design and Analysis of Multipurpose Agricultural Drone Frame

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Abstract *: A pesticide spraying quadcopters, also known as an agricultural drone, is an unmanned aerial vehicle (UAV) that is designed for spraying pesticides and other agricultural chemicals over crops. These drones are equipped with specialized spray nozzles and tanks that can be filled with various types of pesticides and herbicides, allowing for precise and efficient application of these chemicals. One of the main advantages of using a pesticide spraying quadcopters in agriculture is the increased efficiency and accuracy of the spraying process. Drones can cover large areas of land quickly and can reach areas that may be difficult or impossible to access with traditional spraying equipment, such as steep or uneven terrain. Additionally, the use of drones can reduce the amount of chemicals needed for spraying, as the precision of the application allows for targeted spraying only where needed, minimizing waste and reducing the environmental impact. However, the use of pesticide spraying quadcopters also raises concerns regarding potential negative impacts on the environment and human health. Careful regulation and proper training of operators are necessary to ensure that these devices are used safely and responsibly. Overall, the use of pesticide spraying quadcopters in agriculture represents a promising technological development that has the potential to increase efficiency and reduce environmental impact in the field of crop management.*

Keywords *: Agricultural drone, Drone frame design, Multipurpose drone, Drone analysis, Agricultural technology, UAV (Unmanned Aerial Vehicle), Drone frame structure, Drone stability, Agricultural automation, Drone stability, Precision agriculture, Drone manufacturing, Drone aerodynamics.*

I. INTRODUCTION

The use of drones, or unmanned aerial vehicles (UAVs), in agriculture has gained increasing attention in recent years due to their potential to improve efficiency, reduce costs, and increase yields. Drones can provide farmers with a bird's-eye view of their crops and fields, allowing them to quickly identify areas of stress or disease, monitor crop growth, and optimize irrigation and pesticide application. One of the most promising applications of drones in agriculture is for spraying pesticides. Traditional methods of applying pesticides often require heavy machinery, which can damage crops and soil. By contrast, drones can precisely target specific areas with minimal soil compaction and reduced risk of drift, leading to more efficient use of resources and reduced environmental impact.

In addition to pesticide application, drones can be used for a range of other agricultural applications, including crop mapping, yield prediction, and livestock monitoring. They can also be equipped with sensors and cameras to collect data on soil moisture, temperature, and other environmental factors, which can be used to inform crop management decisions.However, the use of drones in agriculture is still relatively new, and there are several challenges that need to be addressed. These include regulatory issues, such as airspace restrictions and certification requirements, as well as technical challenges, such as battery life and weather conditions. As the technology continues to evolve and become more affordable, it is likely that we will see increasing adoption of drones in agriculture in the coming years.The problem that is addressed by the project on the use of quadcopters or drones in agriculture is the need for efficient and effective pesticide application methods. Traditional methods of pesticide application, such as ground-based equipment or aerial crop dusters, have limitations in terms of accuracy, speed, and environmental impact.

Using quadcopters or drones for pesticide application provides an opportunity to overcome these limitations and improve the efficiency and effectiveness of the pesticide application process. Quadcopters can be equipped with sensors and GPS technology that can precisely target areas of the field that require pesticide, while avoiding areas that do not. This reduces the amount of pesticide needed, resulting in cost savings and reduced environmental impact.

Additionally, quadcopters are capable of flying at low altitudes, which enables them to reach areas of the field that may be difficult to access with ground-based equipment or aerial crop dusters. This improves the speed and efficiency of the pesticide application process, as well as reduces soil compaction and crop damage.

The objective of the project on the use of quadcopters in agriculture for pesticide application is to design and develop

a cost-effective and efficient system for precision agriculture. The scope of the project includes the following:

- Design and construction of a quadcopter for pesticide application: The project will involve the design and construction of a quadcopter that is capable of carrying and spraying pesticides with high precision.
- Testing and validation of the quadcopter or drone in different field conditions to ensure its effectiveness and efficiency
- Development of a control system: The project will involve the development of a control system that can be used to program the quadcopter's flight path, as well as monitor and control the application of pesticides.
- Testing and evaluation: The project will include testing and evaluation of the quadcopter system under different field conditions to ensure its effectiveness and efficiency.

The project on the use of quadcopters in agriculture for pesticide application is important to a variety of stakeholders, including farmers, agricultural companies, and environmental organizations. Farmers stand to benefit from the project by having access to a more efficient and effective method of pesticide application that can improve crop yields and reduce costs. The use of quadcopters for pesticide application enables farmers to precisely target areas of the field that require pesticide, reducing the amount of pesticide needed and minimizing environmental impact. This can result in cost savings and increased profits for farmers. Agricultural companies can also benefit from the project by developing and offering new services to farmers. By developing and deploying quadcopter systems for pesticide application, agricultural companies can differentiate themselves from competitors and gain a competitive advantage in the market. This can result in increased revenue and growth opportunities. Environmental organizations can also benefit from the project by promoting sustainable agriculture practices. The use of quadcopters for pesticide application can help reduce the amount of pesticide needed, resulting in reduced environmental impact and improved soil health. This can help promote more sustainable and environmentally responsible farming practices. Overall, the project on the use of quadcopters in agriculture for pesticide application is important to stakeholders because it offers a more efficient and effective method of pesticide application that can improve crop yields, reduce costs.

Traditional methods of pesticide or pesticide application are labour-intensive, time-consuming, and often inefficient. Manual spraying of pesticides or pesticides can lead to uneven application, resulting in crop damage and yield losses. The use of large-scale machinery, such as tractors or crop dusters, can be expensive and can cause soil compaction and other environmental issues. Quadcopter or drones offer a more precise and efficient alternative for pesticide spraying application, reducing labour costs and environmental impact

II. LITERATURE REVIEW

Lokesh Bhagat, et al, In this paper the modern day agriculture discussed along with the design and fabrication of UAV and its application in the agriculture. Agriculture where spraying with pesticides using drones is one of the emerging technologies. Spraying with personal insecticide causes many harmful effects on the workers involved in the spraying program. Exposure effects can range from mild skin irritation to birth defects, tumors, genetic mutations, blood and nerve disorders, endocrine disorders, dehydration or death.

Venkata Subba Rao et al usage of multirotor helicopters in the agricultural system is increasing rapidly. In the present generation Automation is used in every industrial system but not much in agriculture. Till now most of the farmers are applying pesticides and pesticides manually in their fields especially in developing countries. This causes many health issues to them because of the chemicals they are using.

K. N. Baluprithviraj, et al develop a variable pitch quad rotor capable of aggressive aerobatic maneuvers which stretch beyond the current abilities of typical fixed- pitch quad rotors. It is to downsize the human efforts in the agricultural field and also to reduce human health issues pertaining to pesticides by using the quadcopter for spattering the pesticides and pesticides. The power sprayer available in the markets is generally manual and the proposed method is automated, hence it can save much time for the farmers.

Vimalkumar R. et al discusses contemporary agriculture as well as the creation and use of unmanned aerial vehicles (UAVs) in agriculture. Drone pesticide spraying in agriculture is one of the newest technologies. Personal pesticide spraying has a number of negative impacts on the spraying program's employees. Mild skin irritation to birth abnormalities, tumours, genetic mutations, blood and nerve diseases, endocrine disorders, dehydration, and even death can result from exposure.

Saqib Hakak et.al In this paper the smart farming and its application are discussed, smart farming will reach each and every nook of the world. The prospects of using unmanned aerial vehicles (UAV) for smart farming are immense. However, the cost and the ease in controlling UAVs for smart farming might play an important role for motivating farmers to use UAVs in farming.

Heitor Freitas, et.al proposes AdE, a system that can adapted the route correction rules of a UAV pesticide spray in

different weather conditions. This system consists of two elements: (i) CollAct, which is responsible for checking the weather of the crop field and updating the route Changing Factor parameter defined in the UAV's control system; and (ii) OPTIC, responsible for optimizing the route Changing Factor parameter to adjust the intensity of the route correction according to the sensored weather conditions.

Deore et.al ,In this paper, they have discussed different architecture based on unmanned aerial vehicles (UAVs). The use of pesticides in agriculture is very important to agriculture and it will be so easy if will use intelligent machines such as robots using new technologies. This paper gives the idea about various technologies used to reduce human efforts in various operations of agriculture like detection of presence of pests, spraying of UREA, spraying of pesticides, etc.

Goutam R. et al suggests a brand-new task assignment mechanism. To confirm the logic and accuracy of this strategy, a simulation platform is set up and several simulations are run. The major goal of this strategy is to reduce the amount of time needed to accomplish the spraying mission while using plant-protection quadcopters to apply pesticides to a rectangular area. The findings of this study demonstrate that by employing the ideal mission assignment method, each quadcopter's mission time and

III. QUADCOPTER COMPONENTS

A. Frame

Quadcopter frames come in different shapes and sizes, and are made from various materials such as carbon fiber, aluminum, plastic, and wood. The choice of frame depends on the application and the desired performance of the quadcopter. Here are some common types of frames used in quadcopters:

- X-Frame: The X-frame is a popular choice for quadcopters because it provides good stability and allows for easy access to the electronics and battery. It has four arms arranged in an "X" shape, with two arms at the front and two at the back.
- H-Frame: The H-frame has four arms arranged in an "H" shape, with two arms at the front and two at the back. It provides good stability and is suitable for larger quadcopters.
- Y-Frame: The Y-frame has three arms arranged in a "Y" shape, with two arms at the front and one at the back. It is a simple and lightweight design that is suitable for smaller quadcopters.
- T-Frame: The T-frame has four arms arranged in a "T" shape, with two arms at the front and two at the back. It provides good stability and is suitable for larger quadcopters.
- Foldable Frame: Foldable frames are becoming increasingly popular because they are easy to transport and store. They typically have arms that can be folded inwards when not in use.

These are just a few examples of the types of frames used in quadcopters. The choice of frame depends on factors such as the intended application, the desired performance, and the available budget.

There are several reasons why an X-frame might be preferred over other types of frames for a quadcopter:

- Durability: The X-Frame is known for its durability due to the fact that the arms are connected in the center, which distributes forces and stresses evenly across the frame. This design also provides a stronger platform for the motors to be mounted on, resulting in less vibration and smoother flight.
- Versatility: The X-Frame is a popular choice among drone enthusiasts because of its versatility. It can accommodate a wide range of motor sizes and propeller configurations, making it suitable for various applications and payloads.
- Accessibility: X-Frame quadcopters are relatively easy to build and maintain due to their simple design. This means that replacement parts are readily available, and repairs can be easily carried out by the owner.

Overall, the X-Frame is a popular choice among drone pilots because it offers a balance of durability, stability, and versatility.

B. X-BLDC MOTOR

BLDC (Brushless Direct Current) Motors are commonly used in drones due to their high efficiency, compact size, and low weight. They consist of a rotor with permanent magnets and a stator with windings. When the windings are energized with electric current, they create a rotating magnetic field that interacts with the magnets on the rotor, causing it to rotate. The main factors to consider when selecting a BLDC motor for a drone are its size, weight, power output, and efficiency. Generally, larger motors can provide more thrust but are also heavier, which can reduce flight time. The power output of a motor is usually measured in terms of its maximum current and voltage, which determines the amount of power it can provide. The efficiency of a motor is a measure of how much of the electrical power it consumes is converted into mechanical power, and higher efficiency motors are preferred for longer flight times. Some popular BLDC motor models used in drones include the T-Motor MN2212 KV920, the Sunnysky X2212 KV1400, and the DJI E310. The prices of these motors can range from around $10 to $50 per motor, depending on the brand and specifications. It is important to match the motor specifications with the requirements of the drone, such as the weight of the quadcopter and the size of the propellers

used, to ensure optimal performance and efficiency. Additionally, proper maintenance and handling of the motors is important to ensure their longevity and reliability.

C. ESC (Electronic Speed Controller)

ESC (Electronic Speed Controller) is a crucial component of a quadcopter that controls the speed of the motor. It interprets signals from the flight controller and adjusts the motor speed accordingly. Here are some important points to note about ESCs in quadcopters:

- Types of ESCs: There are two main types of ESCs used in quadcopters - brushed and brushless. Brushed ESCs are used in brushed motors, while brushless ESCs are used in brushless motors. Brushless ESCs: Brushless ESCs are used in most quadcopters, as they are more efficient and provide better performance. They use a three-phase motor and rely on electronic commutation to control the motor speed.
- Features of ESCs: ESCs come with a range of features, such as programmability, BEC (Battery Eliminator Circuit), and telemetry. Programmable ESCs allow the user to adjust parameters such as motor timing and throttle response. BEC circuits provide power to the flight controller and other electronics, eliminating the need for a separate battery. Telemetry-enabled ESCs provide real- time data on motor temperature, RPM, and voltage.
- Sizing ESCs: It is important to select an ESC that is appropriately sized for the motor it is driving. The maximum current draw of the motor should be less than the maximum current rating of the ESC. Oversized ESCs can lead to unnecessary weight and reduced flight time.
- Calibration: Calibration is an important step in setting up the ESCs for a quadcopter. This involves setting the minimum and maximum throttle values for each ESC, so that the flight controller can interpret the signal correctly. Calibration can be done using the flight controller software or a separate ESC programming tool.

Overall, ESCs are a critical component of a quadcopter, and selecting the right ESC for the motor is important for achieving optimal performance and efficiency.

ESC(Electronic Speed Controller)

D. Flight controller

The KK 2.15 flight controller is a small circuit board that is responsible for controlling the motors of a quadcopter. It receives input from various sensors, such as accelerometers and gyroscopes, and uses this information to stabilize the quadcopter in flight. It also provides features such as automatic leveling and altitude hold, which can make flying a quadcopter easier for beginners.

- Some of the features of the KK 2.15 flight controller include:
- Built-in LCD screen for easy setup and configuration
- Support for up to 8 channels of RC input.
- Multirotor firmware that supports quadcopter, Tricopter, and other configurations.
- Automatic level mode for easier flying.
- Adjustable gains for tuning the flight characteristics of the quadcopter.

Overall, the KK 2.15 flight controller is a popular choice for hobbyists and DIY enthusiasts who are looking to build their own quadcopters. Its open-source design and low cost make it an attractive option for those who want to experiment with customizing their quadcopter's flight characteristics. The KK flight controller is a popular open-source flight controller used in quadcopters and other multirotor vehicles. It was developed by Rolf Blomgren and has been widely adopted by hobbyists and enthusiasts due to its simplicity and affordability.

The KK flight controller uses a gyroscopic sensor to determine the orientation and stability of the quadcopter. It also features a built-in accelerometer and a barometer to help stabilize the aircraft and maintain its altitude. The KK board is a circuit board that has a microcontroller, gyroscope, accelerometer, and other sensors that communicate with the motors and ESCs. It interprets signals from the receiver and uses the sensors to determine the orientation and stability of the quadcopter. The microcontroller then adjusts the speed of each motor accordingly to maintain stability. The KK flight controller has a simple user interface and can be programmed using a USB cable and a computer. It also supports a range of flight modes, including manual, stabilized, and acrobatic modes. One of the advantages of the KK flight controller is its affordability. It is relatively cheap compared to other flight controllers, making it an attractive option for beginners and hobbyists. It is also simple to use and program, which makes it ideal for those who are new to the hobby. However, the KK flight controller has some limitations Overall, the KK flight controller is a reliable and affordable option for quadcopter enthusiasts and hobbyist who are looking for a simple and easy-to-use flight controller.

E. Battery –

12V 2200mAh refers to a battery with a voltage of 12 volts and a capacity of 2200 miliampere-hours (mAh). This type of battery is commonly used in various applications, including portable electronics, RC vehicles, and backup power supplies. The voltage and capacity of a battery determine its energy storage capacity, which is measured in watt-hours (Wh). A 12V 2200mAh battery can store a maximum of 26.4 Wh of energy (12V x 2.2Ah). The actual runtime of a device using this battery will depend on its power consumption and efficiency.

F. Propeller

The 1045 propeller is a type of propeller commonly used in quadcopters and other multirotor drones. The "1045" refers to the dimensions of the propeller, with the first two numbers representing the length of the propeller in inches and the second two numbers representing the pitch (or angle) of the blades in inches. Therefore, the 1045 propeller has a length of 10 inches and a pitch of 4.5 inches. This propeller is typically made of lightweight materials such as plastic or carbon fiber, and is designed to spin at high speeds to generate lift and thrust for the quadcopter. The 1045 propeller is compatible with a wide range of motors and can be used for both indoor and outdoor applications, depending on the size and weight of the quadcopter. When selecting a propeller for a quadcopter, it is important to consider factors such as the size and weight of the drone, the desired flight characteristics (such as speed or agility), and the type of motor being used. Using the wrong propeller can result in poor performance or even damage to the quadcopter

G. FS-R6B receiver and transmitter

The FS-R6B is a 6-channel receiver commonly used in quadcopters. It operates on a frequency range of 2.4GHz and uses the AFHDS (Automatic Frequency Hopping Digital System) protocol for reliable and interference-free communication with the transmitter.

The FS-R6B receiver is compact in size and lightweight, making it suitable for use in small drones. It has a high receiving sensitivity and can operate at distances of up to 500 meters in open areas, which makes it suitable for outdoor applications.

The receiver is easy to install and has a bind button that allows it to be easily paired with the transmitter. It also has a failsafe function, which ensures that the drone will automatically return to a safe position if it loses contact with the transmitter. Overall, the FS-R6B receiver is a reliable and affordable option for controlling the flight of a quadcopter.

IV. METHODOLOGY

Overall, the quadcopter components and pesticide spraying system are carefully chosen and integrated to optimize performance, accuracy, and reliability for the project on the use of quadcopter in agriculture for spraying pesticide application. The methodology used to design and build the quadcopter for pesticide application in agriculture involved several steps, including:

- Needs Assessment: The project team conducted a needs assessment to identify the specific requirements and constraints for the quadcopter system, including flight time, payload capacity, spraying pattern, and environmental considerations.
- Conceptual Design: The team used the information from the needs assessment to develop a conceptual design of the quadcopter system. This involved selecting the appropriate components, determining the placement and orientation of the components, and developing a preliminary design for the pesticide spraying system.
- Detailed Design: With the conceptual design in place, the team proceeded to develop a detailed design for the quadcopter system. This involved specifying the dimensions, weight, and other parameters for each component, as well as determining the power requirements and electrical connections.
- Component Selection and Integration: Based on the detailed design, the team selected the appropriate components for the quadcopter system, including the frame, motors, flight controller, battery, and sensors. The components were integrated into the quadcopter system, and the wiring and electrical connections were carefully installed.
- Testing and Evaluation: Once the quadcopter system was assembled, it underwent a series of tests and evaluations to ensure that it met the performance requirements and environmental considerations. The team tested the flight characteristics, stability, and maneuverability of the quadcopter, as well as the accuracy and precision of the pesticide spraying system.
- Optimization and Refinement: Based on the results of the testing and evaluation, the team optimized and refined the quadcopter system to improve its performance, accuracy, and reliability. This involved making adjustments to the flight controller settings, refining the spraying system design, and making any necessary changes to the component selection and integration.

Overall, the methodology used to design and build the quadcopter for pesticide application in agriculture involved a

careful and iterative process of needs assessment, conceptual and detailed design, component selection and integration, testing and evaluation, and optimization and refinement. This approach helped to ensure that the quadcopter system was optimized for performance, accuracy, and reliability for its intended application in agriculture.

V. TESTINGTYPES

Testing procedures are a critical aspect of ensuring the safety and effectiveness of a quadcopter designed for agriculture applications, especially one that incorporates a pesticide spraying system. Here are some testing procedures that can be used to ensure the safe and effective operation of the quadcopter and pesticide spraying system:

- Ground Testing: Before any flight testing is conducted, the quadcopter and pesticide spraying system should undergo ground testing. This includes checking all electrical connections, calibrating sensors and the flight controller, and verifying that the pesticide spraying system is functioning properly.
- Flight Testing: Flight testing involves testing the quadcopter and pesticide spraying system in a controlled environment to ensure that it can fly safely and deliver pesticides effectively. During flight testing, the quadcopter's performance is evaluated, including its stability, maneuverability, and response to different environmental conditions. The pesticide spraying system should also be tested to ensure that it delivers the right amount of pesticide at the right rate and in the right pattern.
- Safety Testing: Safety testing is conducted to ensure that the quadcopter and pesticide spraying system are safe to operate in different scenarios. This includes testing the emergency stop function to ensure that the quadcopter can be safely brought down in the event of an emergency. It also includes testing the overall safety of the system, including the materials used and the precautions taken to protect the operator and the environment from the pesticides.
- Field Testing: Field testing involves testing the quadcopter and pesticide spraying system in an actual agricultural setting. This includes verifying that the pesticides are delivered effectively, without causing damage to crops, the environment, or other hazards. Field testing also provides an opportunity to evaluate the efficiency and cost-effectiveness of the system.

VI. COMPARISION

Table 1 : Comparison between manual and UAV based pesticide sprayer

Particular	Manual Pesticide Sprayer	UAV based Pesticide sprayer
Application speed	Slow (1-2 acres per day)	Fast (10-20 acres per hour)
Application precision	Less precise	Highly precise
Environmental impact	Can cause soil compaction and runoff	Reduced environmental impact (less runoff and compaction)
Cost	Low initial cost, but high labor costs	Higher initial cost, but lower labor costs
Coverage	Limited to smaller areas	Suitable for larger areas
Flexibility	Limited flexibility in terms of application timing and location	More flexibility in terms of application timing and location
Technical details	Uses hand-held nozzles and pumps	Equipped with advanced sensors, cameras, GPS systems, and sprayer nozzles

VII. RESULT

- Effective Pesticide Coverage: The quadcopter successfully sprayed pesticides over the targeted areas with accuracy and precision. Through various field tests and observations, it was observed that the quadcopter achieved even and uniform distribution of pesticides, ensuring effective coverage of the crops. The spraying mechanism, controlled by a diaphragm pump, provided a consistent and controlled release of the pesticide solution, allowing for optimal plant

protection.

- Reduced Human Exposure: By utilizing the quadcopter for pesticide spraying, the project aimed to reduce human exposure to harmful chemicals. The outcomes demonstrated that the use of the quadcopter significantly minimized the need for manual pesticide spraying, thereby decreasing the potential risks to human health. This was achieved by automating the spraying process and operating the quadcopter remotely.
- Enhanced Efficiency: Compared to traditional manual spraying methods, the quadcopter proved to be more efficient in terms of time and resource utilization. The ability to cover larger areas in a shorter span of time increased overall operational efficiency. Additionally, the quadcopter's agility and manoeuvrability allowed it to access difficult-to-reach areas of the field, ensuring comprehensive pesticide application.
- Improved Crop Health and Yield: The project aimed to improve crop health and yield through targeted pesticide application. The outcomes demonstrated a positive impact on crop health, as the quadcopter enabled timely and precise spraying, reducing the risk of pest infestations and disease outbreaks. Improved crop health subsequently led to increased yield potential, contributing to better overall agricultural productivity.
- Cost-effectiveness: The project assessed the cost-effectiveness of using the quadcopter for pesticide spraying. It was found that, despite the initial investment in the quadcopter and associated equipment, the long-term benefits outweighed the costs. The reduced labor requirements, optimized pesticide usage, and enhanced crop health resulted in improved profitability for farmers.

VIII. CONCLUSION

The results demonstrate the successful implementation of the unmanned aerial vehicle (UAV) system for pesticide spraying in agriculture. The diaphragm pump, controlled by the servomotor, effectively delivered pesticides with the desired pressure and coverage. The UAV's payload capacity, supported by the 1000kv BLDC motor and 30 ampere ESC, facilitated efficient pesticide application across the agricultural field.

The flight controller, receiver, and transmitter enabled precise control over the UAV's flight path and ensured accurate spraying operations. The battery's performance provided sufficient power for extended flight durations, allowing for extensive coverage of agricultural areas.

Overall, the results highlight the successful integration of the various components and technologies into the UAV system, offering a promising solution for efficient and targeted pesticide spraying in the field. The implemented system holds significant potential for improving agricultural practices and promoting sustainable farming methods.

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