# Agricultural Drone for Pesticides Spraying

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***Abstract*** **The "Agricultural Drone for Pesticides Spraying" project introduces an innovative and efficient approach to crop protection and pest management in agriculture. Leveraging drone technology, this project offers an autonomous and precise solution for spraying pesticides and agrochemicals over farmland. The agricultural sector faces the challenge of efficiently and evenly applying pesticides to protect crops from pests and diseases. Traditional methods, such as manual spraying or tractor-mounted systems, are often time-consuming, labour-intensive, and may lead to uneven distribution. In contrast, the agricultural drone is equipped with a specially designed spraying system, controlled by an embedded microcontroller, and accurately navigates the farm using GPS technology.**

## I. INTRODUCTION

The agricultural industry is the foundation of India's economy and contributes to approximately one-fourth of the country's GDP. This project aims to develop a quadcopter capable of spraying pesticides on agricultural lands. 36.50 % of crops are lost to disease, pests, and weeds in the current global crop production system. Research indicates that developing countries lose about 1.8% to 2.2% of their total agricultural GDP due to economic losses. Reports from the ACCII estimate that crop losses due to pests and diseases are approximately Rupees.50,000 crores. **An agricultural drone is an unmanned aerial vehicle used in agriculture operations, mostly in yield optimization and in monitoring crop growth and crop production**. Agricultural drones provide information on crop growth stages, crop health, and soil variations. Multispectral sensors are used on agricultural drones to image electromagnetic radiation beyond the visible spectrum, including near-infrared and short-wave infrared. As drones entered use in agriculture, the Federal Aviation Administration (FAA) encouraged farmers to use this new technology to monitor their fields. However, with the unexpected boom of agricultural drones, the FAA quickly retracted such encouragement, pending new rules and regulations. With incidents such as drones crashing into crop dusters, the FAA and the AFBF (American Farm Bureau Federation) began discussions to agree on regulations that would allow the beneficial use of such drones in a safe and efficient manner.

Drones (UAV)

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In 2016, the FAA published rules for commercial drone operations. These rules require that commercial drone operators pass a knowledge exam, register their aircraft, and fly in accordance with published restrictions. While satisfied overall with the rules, the American Farm Bureau Federation would like small adjustments to some of the restrictions that have been implemented.

Many countries, such as India, Malaysia, Singapore and Australia, have implemented laws regarding the use of drones. Such laws are still nonexistent in many countries around the world, and 15 countries have outlawed all drone operations. The EU plans to implement a common set of drone regulations for all of its members.

The use of agricultural drones has ethical and social implications. One benefit is that they are able to monitor and control the use of pesticides properly. This allows minimizing the environmental impact of pesticides. However, drones do not require permission to fly over another person's property at altitudes of under 400 feet (120 m). They may have microphones and cameras attached, and the resulting concern for potential privacy violation has caused some opposition towards drone. One other improvement with using drones is the precision that they operate with.

Other companies might start flying their drones in unregulated areas to survey their competition and the condition of their crops and agricultural yield.

Working of Hexacopter

This project keeps the Hexacopter lightweight and easy to control while also providing a solution needed to avoid manual spraying. The hovering of a hexacopter requires a certain number of points to be remembered to rotate it in the requested direction by changing motor speed on either side of the frame (left/right) while keeping the direction of the other two motors unchanged it will generate 'Yaw'. As a result, the second two movements - roll and pitch - are generated by varying the speed of the motors. To elaborate, the hexacopter was defined by Hoang and Poon as an aerial vehicle with four rotors rotated at a certain speed to provide steering, thrust, and stability. In 1907, the first hexacopter was built, though it was operated, and in the late 20th century, the Breguet brothers developed an autonomous version of the hexacopter. The hexacopter utilizes a brushless motor to drive each rotor, which an electronic speed controller. The ESC receives signals from the battery-powered flight controller. SIX rotors rotate clockwise and anticlockwise, with three diagonally opposite rotors rotating clockwise and three anticlockwise. The hexacopter's rotors produce torque about the center, the stabilizing effect of the hexacopter comes from two opposing motor pairs rotating against each other, giving rise to a net moment/torque of 0 at its center. A hexacopter will yaw, roll, or pitch as the angle of incidence of one or more rotors varies.

## II. LITERATURE SURVEY

(Shivaji, et al. 2017) have detailed the implementation of an agricultural hexacopter with an automatic spraying mechanism. This paper describes the components used to develop a lightweight and cost-effective hexacopter, with a description of PIC microcontrollers that can be used to control the agricultural hexacopter. (Auat, Cheein and Carelli 2013) have described that a backpack sprayer can be equipped with a harness to place the sprayer on the operator's back. The maximum amount of liquid that could be carried in the tank is approximately 20 litres. A hand lever is used to continuously maintain pressure and thus make the output of the backpack sprayer smoother than the output of the handheld sprayer-mechanism. A simple and inexpensive backpack sprayer produces low pressure and mostly lacks a high-pressure pump, reassure regulation, and gauge features. (Zhang 2012) has stated that sprayers operated via engines create more consistent outputs, and they also cover the spray swath more uniformly. There are various other hand-operated sprayers that are not extensively utilized in agriculture. They are also found to work at a constant speed and provide noticeably more uniform coverage than manual spraying, where motorized sprayers can also spray at a higher pressure to give better coverage. (Kurkute 2018) studied and described the different types of agricultural drone systems based on micro-controller 8051, agricultural drone systems using presented. Ultimately, it is concluded that if the system design incorporates the use of Atmega644PA, then it will be the most efficient implementation. Further implementation may be achieved with the results of further experimentation. (Hanafi 2013) studied the hexacopter and its GUI controllers. In test results, the GUI controller sent control signals to the hexacopter controller and the hexacopter controller translated the signals to ensure the hexacopter remained balanced and stable. In hovering position, the Hexacopter was able to accommodate a load disturbance up to 250 grams. (Patel 2013) in his paper, discussed the use of hexacopters for reconnaissance, as well as demonstrating that small scale UAVs have a broad range of applications, such as safety inspection of

construction tools, traffic monitoring, search and rescue operations, and temperature and altitude measurements. (Chen 2020) in his paper, concluded that during the Tillering and Flowering stages of rice plants, the same spraying volume was used to compare the effects of different nozzle treatments on droplet deposition and rice planthopper control. There is a significant difference between the droplet density between the nozzles, as shown by the results.

*A. Proposed System*

The pesticide spraying mechanism, meticulously engineered and calibrated, delivers pesticides uniformly and efficiently over the crops. This system incorporates high-quality pumps, precision nozzles, and tanks capable of holding the required volume of pesticides. Moreover, a pesticide monitoring system equipped with sensors or cameras continuously monitors pesticide levels in the tank, guaranteeing precise dosage application and minimizing wastage. Safety is paramount in every aspect of the system design. Advanced obstacle avoidance systems, comprising sensors and intelligent algorithms, enable the drone to detect and navigate around obstacles such as trees, buildings, or power lines, ensuring safe and uninterrupted operations. Additionally, fail-safe mechanisms are implemented to automatically return the drone to base in the event of emergencies, further enhancing operational safety.

*B. Working Principle*

The working principle of an agricultural drone designed for pesticides spraying revolves around a combination of advanced technology and precision application methods, aiming to optimize crop protection while minimizing environmental impact and operational costs. At its core, the drone employs a multi-faceted approach to ensure effective and efficient pesticide delivery across the farm field. First and foremost, the drone is equipped with a sophisticated navigation system that enables autonomous flight and precise positioning. This navigation system typically relies on GPS or RTK technology to establish accurate flight paths and ensure optimal coverage of the targeted area. By leveraging GPS coordinates and predefined routes, the drone can navigate the field with exceptional accuracy, reaching even the most remote or inaccessible areas.

*C. Role of Pesticides in Agriculture*

Rainfall, humidity levels, and moisture content are some factors that control the agricultural yield that a particular piece of land produces. Utilization of fertilizers and pesticides is inevitable if you want to increase crop yield. However, few health- related problems can arise due to prolonged exposure to such chemicals during manual spraying. A few examples include mild skin irritation to congenital disabilities, changes in genetics, falling into a coma, or even death in severe cases. Providing safe farming to the farmers is the key to improving agribusiness efficiency and productivity. The spraying of pesticides and application of fertilizer can be tedious processes. Agricultural pesticide spraying has become a requirement, but it also proves to be a dangerous procedure for farmers. They take many precautions, especially when spraying pesticides, such as wearing appropriate clothing, gloves, masks, and so on, to prevent any adverse effects. The pesticides cannot completely be avoided since the required outcome must also be achieved. Thus, using robots for these purposes provides the best of both productivity and efficiency solutions.

*D. Research done on Spraying Mechanism*

In this paper we design and develop a hexacopter to aid in crop spraying in agricultural lands. A backpack sprayer can be fitted with a harness to allow the operator to carry the sprayer on their back. About 2 liters of liquid can be accommodated in the tank. The backpack sprayer keeps pressure with a hand lever, whereas handheld sprayers use a trigger, which produces a smoother output. Backpack sprayers that are simple and inexpensive produce low pressure and lack many features, such as a high-pressure pump, pressure regulation, and gauge. Engines are more reliable at generating consistent outputs, creating more uniform spray swaths. Hand-operated sprayers are also available, although they are not commonly used in agriculture. Furthermore, motorized sprayers also can spray at a higher pressure to provide greater coverage compared to manual sprayers that work at a constant speed.

*E. Research done on Agricultural Hexacopter*

Chen et al. selected and then compared the performance of three nozzles to demonstrate how

pesticide spraying per area can be reduced to make agricultural drones last longer. There is insufficient research on spray systems based on the existing studies, which have focused exclusively on nozzle performance. Therefore, more research is needed to develop spraying systems for agricultural drones. Professor B. Balaji et al. (2018) tested a hexacopter UAV that sprays pesticides while monitoring crops and the environment using Raspberry Pi's running Python. DH11, LDR, and Water Level Monitoring sensors are also on their UAV. Researchers concluded from their experiment that that UAVs could be used in agricultural fields to save up to 90% of water, chemicals, and labour cost. Sharda et al. To reduce environmental pollution, a nozzle with an automatic selectivity control can be used to regulate the application of pesticides locally and cost. Rashul Desale et al. (2019) developed an approach to agricultural applications based on UAVs. In addition to spraying, their UAVs are also used to monitor agricultural fields via cameras and GPS. Cost and weight were taken into account in their design. This microcontroller was equipped with inbuilt firmware - kk 2.1.5. Kurkute et al. developed a simple yet cost-effective spraying mechanism for a hexacopter UAV. Spraying can be accomplished with the universal sprayer for both liquids and solids. A hexacopter system equipped with Atmega644PA has been found to be the most suitable for agricultural purposes because of its efficient implementation in their research. In essence, aerial agricultural vehicles are low-cost drones with better and more advanced sensors and imaging systems. An aerial spraying mechanism with an f450 hexacopter frame is the basic idea behind this device. Spraying pesticides to places that human cannot easily reach are achieved using this model. Spraying of liquid contents is done by the nozzle spraying system.

Table 1.: Specification of components used

| Sl. No. | Components | Model | Quantity |
|---|---|---|---|
| 1. | Hexacopter Frame | F550 | 1 |
| 2. | Propeller | 1045 (2CW+2CCW) | 6 |
| 3. | Brushless Motor | A2212 1400KV | 6 |
| 4. | Electronic Speed Controller (ESC) | 30A | 6 |
| 5. | Li-Po Battery | 2200mAH 3S | 1 |
| 6. | Flight Controller | KK 2.1.5 | 1 |
| 7. | Radio Transmitter | FS-CT6B | 1 |
| 8. | Radio Receiver | FS-R6B | 1 |
| 9. | Mini Water Pump | 12V DC | 1 |

## III. HARDWARE DESCRIPTION

*A2212 935Kv Brushless DC motor*

A DC motor of 935kV refers to a direct current (DC) motor designed to operate at a specific voltage of 935 kilovolts (kV). This type of motor is commonly used in various industrial applications, robotics, electric vehicles, and renewable energy systems due to its efficiency, reliability, and controllability. Understanding the characteristics and applications of a DC motor with a 935kV rating can provide valuable insights into its performance and utility in different fields.

1. Type: Brushless DC motor
2. Model: A2212
3. KV Rating: 935 RPM/V (KV stands for revolutions per minute per volt)
4. Max Efficiency Current: 4-10A
5. Max Efficiency Voltage: 7.4-11.1V
6. Max Efficiency Power**: 74W
7. Dimensions: 27.5mm x 27.5mm x 30mm
8. Weight: Approximately 47g
9. Shaft Diameter: 3.17mm
10. Mounting Hole Spacing: 16mm x 19mm

Fig 1.: Brushless DC Motor

Propellers

The hexacopter's thrust is generated by propellers, which translate rotary motion into linear motion; therefore, propellers are involved in lifting the quadcopter. It is possible to adjust propeller speeds by altering the voltage that is being supplied to the propeller motor, which is what an Electronic Speed Controller does. In order to produce lift, the hexacopter uses 2 set of clockwise and another set of counter-clockwise rotating propeller.

Fig 2.: Propellers

Propellers are crucial components of any aircraft, including drones, as they convert the rotational motion of the motor into thrust, which propels the aircraft forward or upward. Here are some key aspects of propellers:

1. Size: Propellers are typically specified by their diameter and pitch. The diameter is the size of the circle described by the tips of the blades as they rotate, usually measured in inches. The pitch is the distance the propeller would move forward in one revolution if it were moving through a soft solid (like a screw into wood), also measured in inches.
2. Material: Propellers are commonly made from materials like plastic, carbon fiber, or wood. Each material has its own characteristics in terms of weight, durability, and performance.
3. Number of Blades: Propellers can have different numbers of blades, with two and three-blade designs being the most common for drones. The number of blades can affect the thrust, efficiency, and noise level of the propeller.
4. Rotation Direction: Propellers are designed to rotate either clockwise (CW) or counterclockwise (CCW). This is important for multi-rotor aircraft like drones, where the rotation direction of each propeller must be opposite to create stable flight.
5. Performance: Propeller performance is influenced by factors such as blade shape, blade angle, and air foil design. High-performance propellers are designed to maximize thrust while minimizing noise and vibration.
6. Matching: It's essential to choose propellers that are compatible with your motor and aircraft. Propeller size, pitch, and other factors must be matched to the motor's specifications for optimal performance.

Electronic Speed Controllers

ESCs provide speed control for the motors, which change according to the power supplied by the battery. ESC selection is based on the motor's current rating and is made based on hooking the brushless DC motors to the female pins of the ESC.

The ESC selected for this hexacopter is the 30A ESC.

Fig 3.: Electronic Speed Controllers

Electronic Speed Controllers (ESCs) are devices that control the speed of brushless motors in drones, RC airplanes, and other electric vehicles. Here's an overview of their key features and functions:

1. Control: ESCs regulate the speed of brushless motors by adjusting the voltage and current supplied to them. This control allows for precise speed and direction control of the motor.
2. Compatibility: ESCs are designed to work with specific types of motors based on their size, KV rating, and other factors. It's essential to match the ESC with the motor to ensure compatibility and optimal performance.
3. Input Signal: ESCs typically accept a PWM (Pulse Width Modulation) signal from a flight controller or receiver to control the motor's speed. The PWM signal determines the speed and direction of the motor.
4. BEC (Battery Eliminator Circuit): Many ESCs include a BEC, which provides a regulated voltage output to power the receiver and other electronics in the vehicle. This eliminates the need for a separate battery for these components.
5. Programming: Some ESCs allow for programming to customize settings such as throttle range, braking force, and motor timing. This programming is typically done using a programming card or through a computer interface.
6. Safety Features: ESCs often include safety features such as overheat protection, over-current protection, and low voltage cutoff to protect the motor and battery from damage.
7. Size and Weight: ESCs come in various sizes and weights to suit different applications. Larger ESCs are used for high-power applications, while smaller ESCs are used for lightweight vehicles.

Lithium-Ion Polymer Battery

The primary component of Lithium-Ion Polymer Batteries is poIymer electrolyte: a rechargeable polymer battery that uses lithium-ion technology. In hexacopters, these batteries are commonly used. It takes completely two hours for full charging. In quadcopters, depending on the payload, a fully charged battery can operate for 15-20 minutes. The Li-Po battery selected for this hexacopter is the 2200mAh 35C 3S1P 11.1V Li-Po Battery Pack.


Fig 4.: Li-Po Battery

Lithium-ion polymer (LiPo) batteries are rechargeable batteries that are commonly used in drones, RC vehicles, portable electronics, and other applications where high energy density and lightweight are important.

Radio transmitter and receiver

This 6-channel receiver features a 2.4 GHz frequency technology. This receiver has 6 channel receiver pins. The first four-channel pins of receiver are connected to the controller input pins using servo wires. Using the joystick movement input provided by the user, the receiver transmits the signal to the controller.

A radio transmitter and receiver are key components of a radio communication system. They work together to send and receive radio waves carrying information such as voice, data, or commands. Here's a brief overview of each:

1.Radio Transmitter:

A radio transmitter converts electrical signals into radio waves for transmission through the air. It typically consists of a modulator, which encodes the information onto a carrier wave, and a power amplifier, which increases the signal strength for transmission.

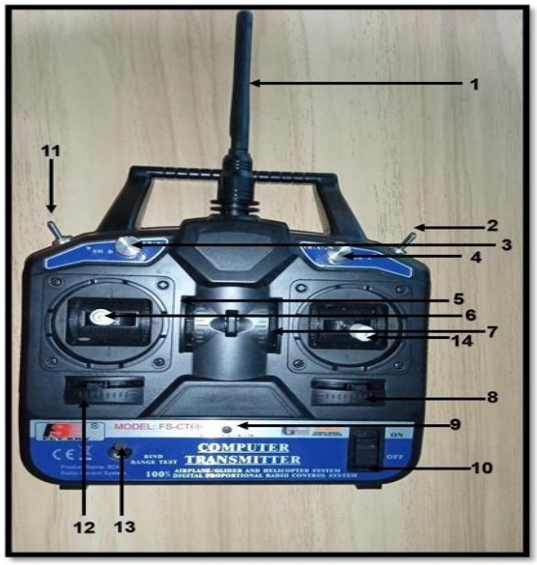


Fig 5.: Radio Transmitter

2.Radio Receiver:

A radio receiver picks up radio waves from the air and converts them back into electrical signals. It typically consists of an antenna, which captures the radio waves, and a demodulator, which extracts the original signal from the carrier wave.

Fig 6.: Radio Receiver

Flight controller

This hexacopter uses the KK2.1.5 Flight Control Board as its flight controller having Atmel 644PA and 6050MPU. Installing and setting up the device is made easy using the screen and software in-built in it. It also includes many multi-rotors craft types. These are pre-installed. Propeller direction can also be verified on this flight controller. The on-screen prompts are intuitive, clear and easy to understand. KK Boards with 6050 MPU have the most stability, and it has an auto-leveling feature.

It is powered by an ATMEL Mega 644PA 8-bit microcontroller. It seems like you're referring to the KK 2.1.5 flight controller, which is a popular choice for multirotor aircraft such as drones. The KK 2.1.5 is a versatile and affordable flight controller that offers features suitable for both beginners and experienced users. Here are some key features of the KK 2.1.5:

The KK 2.1.5 features a built-in LCD display that allows users to easily configure and tune their aircraft without needing to connect it to a computer.

It supports auto-leveling mode, which helps stabilize the aircraft and makes it easier to fly, especially for beginners. The KK 2.1.5 supports multiple flight modes, including acrobatic mode for advanced maneuvers and stable mode for smoother flight.

The KK 2.1.5 is known for its simple setup process, making it a good choice for those new to building and configuring multirotor aircraft.

It is compatible with a wide range of receivers and transmitters, making it easy to integrate into existing radio systems.

The KK 2.1.5 is known for its reliability and robustness, making it a popular choice among hobbyists and enthusiasts.

Overall, the KK 2.1.5 is a versatile and user-friendly flight controller that offers a good balance of features and affordability, making it a popular choice for a wide range of multirotor aircraft applications.

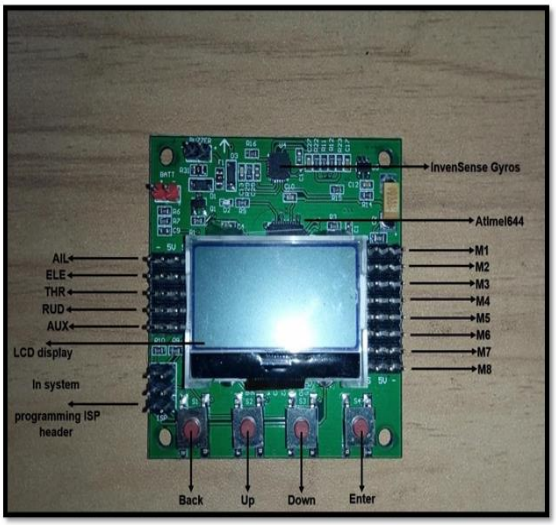


Fig 7.: Flight Controller

ESP32 Camera

The ESP32-CAM is a development board with an ESP32-S chip, an OV2640 camera module, microSD card slot, and several GPIO pins. It allows you to create IoT projects with camera functionalities, such as video streaming, face recognition, and image capturing. Here are some key features of the ESP32-CAM:

The ESP32 is a powerful microcontroller with Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications. The OV2640 is a 2MP camera module that can capture still images and video. The ESP32-CAM has a microSD card slot for storing images and videos captured by the camera. The board has several GPIO pins that can be used to connect sensors, actuators, and other peripherals. You can program the ESP32-CAM using the Arduino IDE or ESP-IDF (Espressif IoT Development Framework). The ESP32-CAM is suitable for various applications, including home security systems, remote monitoring, and DIY projects. The ESP32-CAM has limited memory and processing power compared to other microcontrollers, so it may not be suitable for complex image processing tasks.

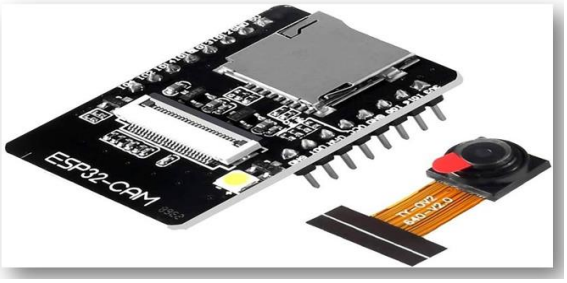


Fig 8.: ESP32 Camera

## IV. CONCLUSION

Agricultural UAVs show immense potential in agriculture. Drones have been rapidly growing over the past two decades, and they have revolutionized the Military, Agriculture sector and other sectors. In addition, this paper presents a technical specification for the drones used for spraying on agricultural lands and the importance of drones in Agriculture. The paper mainly demonstrates using a lightweight, cost-efficient hexacopter to improve yield and thus increase crop quality. However, there remain many limitations and shortcomings in these early stages of research and development, which will be worked on and improved upon in the future.

The future scope for agricultural drones designed for pesticide spraying is promising and multifaceted, heralding significant advancements in precision agriculture. These drones, equipped with state-of-the-art technology, offer numerous benefits that could revolutionize farming practices worldwide. Furthermore, the future scope for agricultural drones extends beyond pesticide spraying to encompass a wide range of agricultural tasks. From crop monitoring and mapping to soil analysis and irrigation management, drones can serve as versatile platforms for data collection and decision support. As advancements in sensor technology and battery efficiency continue, the capabilities of agricultural drones are poised to expand even further, unlocking new possibilities for optimizing farm management practices.

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