JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Agriculture Pesticides Spraying Drone

Arpit Maurya [1], Anant Kumar srivastava[2], Arpit kumar[3], Akarsh Pratap Singh [4], Ravi Shankar[5]

[1] *Student, Electronics and Communication Engineering, BBDITM, U.P., India*
[2] *Student, Electronics and Communication Engineering, BBDITM, U.P., India*
[3] *Student, Electronics and Communication Engineering, BBDITM, U.P., India*
[4] *Student, Electronics and Communication Engineering, BBDITM, U.P., India*
[5] *Assistant professor, Electronics and Communication Engineering, BBDITM, U.P., India*

Abstract **- There are too numerous technologies involved in today's Agriculture, out of which scattering pesticide using drones is one of the arising technologies. Manual pesticide scattering causes numerous dangerous side effects to the people involved in the spraying process. The Exposure effects can range from mild skin irritation and inflammation to birth deformities, tumor, inheritable changes, blood and nerve diseases, endocrine dislocation, coma or death. The World Health Organization estimated as one million cases of ill affected, when scattering the pesticides in the crop field manually. This paved the way to design a drone mounted with scattering medium having 6 V pump, 12 ml storehouse capacity tank, 1 nozzle to atomize in fine spray, a quadcopter configuration frame, suitable landing frame, 4 Brushless Direct Current (BLDC) motors with suitable propellers to produce needed thrust about 4 KG (at 100 RPM) and suitable 3c Lithium- Polymer (LI-PO) battery of current capacity 2200 mAh and 11.1 V to meet necessary current and voltage conditions. This pesticide scattering drone reduces the time, number of labour and cost of pesticide application. This particular drone can be used for spraying disinfectant liquids over structures, water bodies and in densely populated areas by adjusting the pump's flow discharge.**

Keywords – Quadcopter, Agriculture, Nozzle, Scattering, Transmitter

1. INTRODUCTION

The Indian agriculture sector holds great importance, contributing a substantial 18% to the country's Gross Domestic Product(GDP) and employing 50% of the national workforce. However India has yet to fully unlock the potential of agriculture due to inadequate monitoring methods for crops, Irrigation pattern and the application of pesticides. To address this issue, several drone start-ups in India are actively working to enhance technological standards and reduces costs associated with agricultural drones. This project aims to Develop an unmanned Aerial Vehicle (UAV) that can effectively overcome these challenges. By utilizing a quadcopter design, this UAV will enable efficient monitoring of crops and gives the precise and timely spread of large quantities of pesticides. Ultimately, this technology will enhance agricultural practices, improve productivity, and contribute to sustainable growth of Indian agricultural sector
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1.1 Literature survey

Zhang Dongyan et al. in (2015) [1] conducted an experiment on Effective Swath Width and Uniformity of Droplet Distribution over certain ariel spraying systems like M-18B and Thrush 510G. During testing these planes flew to an altitude of 5m and 4m respectively and through the careful examination of flight data they concluded that Flight Height does affect the Swath Width for both M-18B and Thrush 510G.

In the same year (2015) **Huang Y. Hoffmann** [2]. along with his collegue made a Low Volume Sprayer that war mounted on to an Unmanned Helicopter. Rotor dimensions of the helicopter was of 3m and it had the maximum payload capacity of 22.7 kg. This study explored upon the idea of developing UAV ariel application systems in crop production with greater target rate and larger VMD droplet size.

Yallappa D. (2017) [3] using 6 BLDC motors and two 6 cell – 8000 mAh LiPo batteries constructed a Hexacopter. Also included in their study there were Performance evaluations on amount and preassure of spray liquid, liquid loss and determinationof droplet size and density. The outcome of their project was a drone capable of carrying 5.5L of liquid and it provided 16 min of endurance.

Kurkute (2018) [4] worked on a Quadcopter and its spraying system with simple cost effective equipment. Result of this was the Universal Spraying System that can spray both liquid and solic content. They also concluded that Atmega644PA is the best controller for agricultural applications due to its efficient implementation.

Rahul Desale (2019) [5] further developed on an architecture based on UAV that was able to monitor agricultural fields with the help of cameras and GPS. They used microcontroller kk2.1.5 that had inbuilt firmware. Special attention was given to make the UAV cost effective and lightweight.

Prof. B. Balaji (2018) [6] made a hexacopter UAV that had the capacity to monitor agricultural fields along with spraying. It used Raspberry Pi running on Python Language. This UAV was also equipped with multiple sensors like DH11, LDR, Water monitoring system. This experiment solidified the idea that with the proper implementation of UAV in agricultural applications a 20–90% savings in terms of water wastage, chemical ill-treatments and labour can be achieved.

2. DESIGN AND WORKING OF QUADCOPTER

To design a quadcopter, several crucial steps need to be followed. First, it is important to estimate the payload that the quadcopter will carry. This payload estimation helps to determine the overall weight that the quadcopter needs to support. Once the payload weight is known, appropriate motors, propellers, electronic speed controller, and pumps can be selected that are capable of handling the expected load.

Additionally, selecting the right battery is crucial, and this can be done by considering the current and voltage requirements of all the components. The battery should be able to provide enough power to meet the demands of the motors and other electronic device on the quadcopter.

Next, it is necessary to calculate the thrust requirement for the quadcopter. The thrust generated by the motors should be sufficient to lift the total weight of the quadcopter, including the payload. This calculation helps in determining appropriate motor and propeller combination that can generate the required thrust.

Finally, the frame of the quadcopter needs to be designed. This involves determining the requird number of arms and their length, taking into consideration the weight distribution and the intended application of the payload. The frame should be well made enough to support the motors, propellers, electronic components, and the payload while maintaining stability and being east to move to flight.

By following these steps, a well-designed quadcopter can be developed, ensuring that all the components are appropriately choosen and integrated to meet the desired performance and payload requirements.

2.1 Payload Estimation

The payload weight is determined by considering the weight of the liquid (such as pesticide or disinfectant), the storage tank with capacity of 250 ml, the pump, and the nozzles.

TABLE 1:
PAYLOAD DATA

Parts	Weight (grams)
250ml liquid	250
10ml liquid tank	10
pump	100
nozzle	10
Total	320

2.2 Construction

A quadcopter is a type of drone that features four arms. The main frame of the quadcopter is constructed using hollow aluminium rods, with each arm measuring 225 mm in length. At the end of each arm, a motor is securely attached, and a propeller is mechanically connected to each motor. Each motor's output side is connected to an Electronic Speed Controller (ESC), while the ESC's input side is connected to an Arduino board. The power distribution board supplies power from the LI-PO battery to the ESCs. This setup is replicated for all the motors, and propellers. The Arduino board, along with an MPU unit, is connected to a receiver, which receives signals from the transmitter. To act as a storage tank, a 250 ml cold drink water is affixed to the frame and it is designed with a sloping bottom to ensure the complete drainage. A pump is powered by the power distribution board and it is connected to the inlet of the storage tank, while the outlet is attached to a plastic tube with a fixed nozzle. Additionally, a landing frame with a height of 101.6 mm is attached to the main frame to ensure safe landings and prevent the storage tank from touching the ground.

2.3 Working

The drone's Transmitter sends signals to the receiver, which is located on the drone itself. Once received, these signals are forwarded to arduino board. Within the Arduino, the signals are processed using an MPU unit. The processed signals are then transmitted to Electronic speed controller (ESC). The ESC regulates the amount of current provided to the drone's motors based on the received signals. The motors, in turn, are mechanically connected to the propellers, causing them to rotate and generate thrust for the drone's movement. The drone's LI-PO battery supplies power to a pump, which pressurizes liquid from a storage tank. This pressurized liquid flows through a pipeline and exits through a nozzle, creating a spray. The flow rate of the pump can be adjusted by varying the input current, which can be controlled remotely from the transmitter.

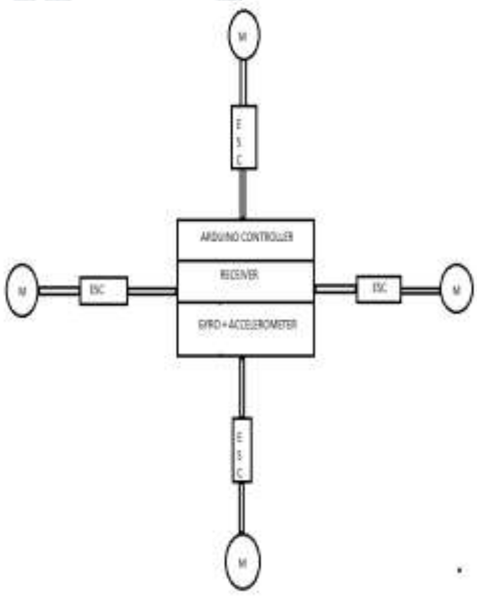

Fig. 1: Block diagram of working process

2.4 Components used

2.4.1 Motor

In certain drones, the outer runner BLDC motors are engineered to function without the need for brushes. Instead, they employ a permanent magnet system for operation. These motors present a range of benefits when compared their brushed counterparts. One notable advantage is their higher efficiency, as they eliminate the friction and energy loss typically associated with brushes this improved efficiency translates to longer flight time and improved total performance.

Additionally, the absence of brushes in these motors reduces the need for maintenance. Since the brushes are prone to wear and tear, their removal eliminates the need for periodic replacements or requirements This enhances the durability and longevity of the motor, making it a reliable choice for extended use.

Controlling the rotational speed of these BLDC motors is achieved by adjusting the input current. By regulating the amount of current supplied to the motor, the rotational speed, measured in revolutions per minute (RPM), can be effectively controlled. This enables the pilot to customize the speed and responsiveness of the drone to suit various flight scenarios, offering greater flexibility and control during operation.

Fig. 2: A2212/10T 1400 KV MOTOR

2.4.2 Propeller

The propeller is constructed using carbon fiber, a material renowned for its exceptional strength-to-weight ratio, surpassing that of plastic propellers. This means that despite its lightweight nature, carbon fiber possesses remarkable strength, making it an ideal choice for propeller manufacturing. With a length of 10 inches, this carbon fiber propeller is designed to deliver optimal performance while maintaining durability and efficiency. Its composition ensures a balanced combination of strength and low weight, enabling it to efficiency propel various devices or vehicles, such as drones or small aircraft, with improved agility and maneuverability.

Fig. 3 1045 Propeller

2.4.3 Electronic speed controller

The ESC stands for electronic speed controller, which serves the purpose of regulating and controlling the revolution per minute (RPM) of a motor. It plays a crucial role in managing the speed and power output of the motor based on the desired requirements. In the context of motor and battery specifications, a 30AMP rated ESC is employed. This indicates that the ESC has been chosen in accordance with the specific motor and battery requirements to ensure compatibility and optimal performance. By using a properly rated ESC, one can effectively control the speed and performance of the motor within the designed limits, ensuring efficient operation and preventing any potential damage that may arise from overloading the system.

Fig. 3: 30A simonk ESC

2.4.4 Battery

The available battery for use is lithium-polymer (LI-PO) battery with a capacity of 2200 mah and a voltage of 11.1 Volt. This battery configuration consists of three LI-PO cells connected in series. When cells are connected in series, the positive terminal of one cell is linked to the negative terminal of the next cell, effectively increasing the overall voltage output. In this case, the three LI-PO cells are connected in a chain, resulting in a combined voltage of 11.1 Volt. This battery configuration allows for higher voltage output while maintaining the same capacity as a single LI-PO cell.

Fig. 4: 2200 Mah LI-PO Battery

2.4.5 Radio Transmitter and Receiver

The Fly-sky CT6B 2.4GHz 6CH transmitter and FS-R6B receiver are being utilized in this setup. This particular combination offers a range of approx. 1000 meters, allowing for communication between the transmitter and receiver over considerable distances. The transmitter provides up to 6 channel options, which means it can control and transmit signals for up to six functions or devices. The receiver, on the other hand, is designed to receive these signals and translate them into actions or commands for the connected devices. Together, the transmitter and receiver system offer reliable and versatile wireless control capabilities with a range up to 1000 meters

Fig. 5: Radio Transmitter and Receiver

2.4.6 Arduino UNO

Arduino Uno is a popular open-source platform for physical computing. It allows you to create interactive devices and objects that can sense and control the physical world. The Uno uses the ATmega328P microcontroller and provides 14 digital input/output pins and 6 analog inputs. It also has a USB connector, a 16 MHZ quartz crystal, a power jack, an ICSP header, and a reset button. The Arduino board includes everything necessary to work with the microcontroller. The Arduino IDE is used to upload programs to boards enabling them to perform specific tasks.

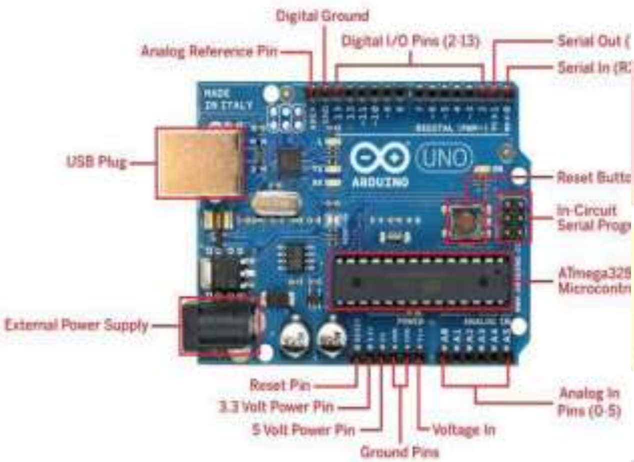

Fig. 6: Arduino Development Board.

2.5 Thrust calculation

In order to enhance the maneuverability and climbing capabilities of a drone, it can be beneficial for the thrust generated at 100 % RPM (revolution per minutes) to be significantly greater than the total weight of the drone. By doing so the drone provided with greater surplus of thrust, which allows for improved control and agility in flight.

Having a thrust three times larger than the drone's weight means that the drone's weight means that the propulsion system is capable of producing a substantial force that surpass the gravitational pull acting on the drone. This excess thrust empowers the drone to execute maneuvers more effectively, change directions swiftly, and respond promptly to control units.

Additionally, a higher rate of climb is achievable when the thrust greatly exceeds the drone's weight. The surplus thrust enables the drone to overcome gravity with greater ease, resulting in a steeper ascent and a quicker climb to higher altitudes. This capability can be particularly advantageous in scenarios such as search and rescue operations or aerial surveillance, where reaching higher altitudes swiftly is crucial.

Overall, having a thrust that is three times larger than the total weight of the drone offers improved maneuverability and a higher rate of climb. These benefits contribute to the drone's ability to perform precise movements, navigate challenging environments, and reach elevated positions rapidly.

Thrust produced by one propeller with one motor = 1000 gm
Overall thrust = 4 x 1000 = 4000 gm
Thrust to weight ratio = thrust produced / total drone weight
= 4000/1100
= 3.63 N/m^^{2}.

2.6 Weight build-up

TABLE 2:
COMPONENTS WEIGHT DATASHEET

Parts	Weight (grams)
Frame	300
Battery	175
Motor (4)	248
ESC (4)	92
Propeller	56
Arduino	25
MPU unit	2.1
TOTAL	898.1

Total weight of the drone is calculated by adding total weight of the components and payload weight.
Overall weight = payload weight + components weight
250 + 898.1
1148.1 grams (approx).

2.7 Battery Drain Time Calculation

To ensure a safe and efficient operation, the drone's battery drain time should exceed 5 minutes. This allows the drone to deplete its entire battery capacity, return safely, and be refuel or recharged for subsequent missions. Calculations should consider factors such as distance, time required for the drone to complete its mission, and ensure a safe return to its base.

Current output from battery = 2200 mah
Total current consumption of all components = 29.31 A
Battery endurance = Current output from battery / total current in amp
Consumption of all components = 2200 Mah /29.31 A
= 75.059 MINS.

TABLE 3:
CURRENT REQUIREMENT TABLE

Component	Current Required (Amp)
Motor	12
Receiver	0.1
ESC (4)	12
Pump	5
Arduino	0.2
MPU unit	0.01
TOTAL	29.31

2.8 Structural Description

The choice of a quadcopter frame depends on various factors such as the configuration, balancing, application, materials, stiffness, and component integration to ensure proper balance and component placement, a base plate in the shape of regular square was designed, with all components positioned at the centre of gravity. The dimension in mm are mention on fig 7

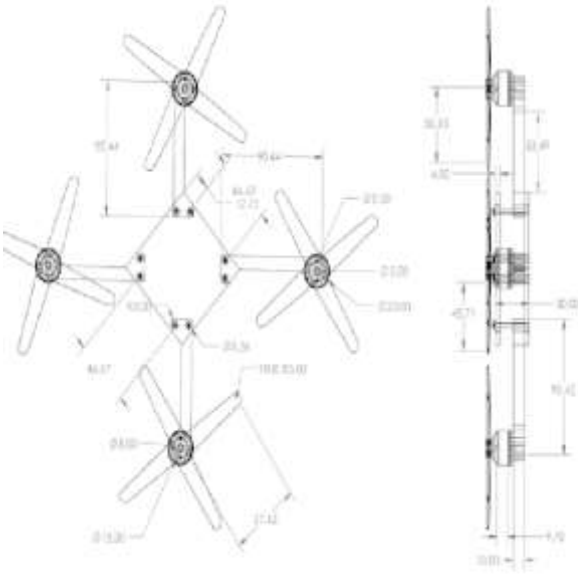

Fig. 7: quadcopter dimensions.

The arms of the quadcopter were dimensioned with a minimum gap of 6.419cm, and they were made up of hollow aluminium rods. The selection of hollow rods was based on their ability to withstand stress comparable to solid rods while offering a better strength to weight ratio. This means that a hollow cylinder is stronger than a solid rod of equal mass and material.

Aluminium was chosen as the material for the arms due to its advantageous properties, including light weight and high strength-to-weight ratio. For the base plate, PVC sheet material was selected. Providing a sturdy and lightweight foundation of the quadcopter. The landing frame was constructed using aluminium rods to provide stability during landing and takeooff the model of our design as shown in fig 8.

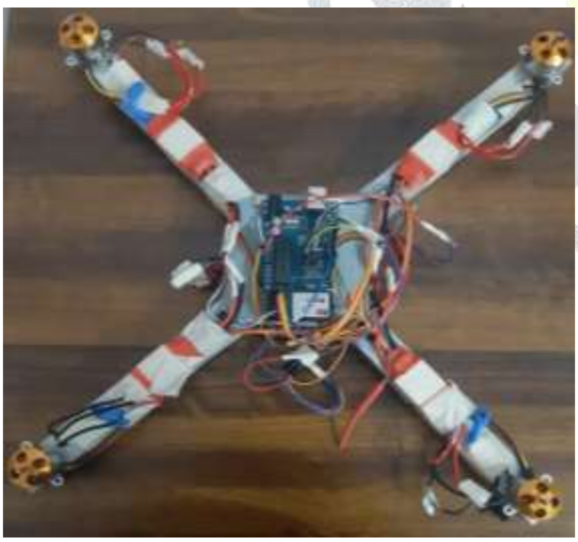

Fig. 8: Model of our design

To accommodate the spraying function, a tank with a capacity of 250 ml was placed at the centre of gravity of drone. The tank made from a 250 ml cold drink bottle was chosen for its common availability and resistance to damage from saltwater. It is important to note that any non-hazardous liquid can be used in the tank for the spraying purpose. Overall the design choices for the quadcopter frame and materials were made with the goal of achieving stability, efficient performance, and proper integration of components.

3. CONCLUSIONS

To summarize, this paper introduces a novel drone-mounted spraying mechanism designed for both agricultural purposes and the application of disinfectants. The proposed method offers several advantages over traditional spraying techniques. By utilizing drones, the need for manual labor is reduced, resulting in time and cost savings. Additionally, this approach minimizes the risks associated with human involvement in spraying operations. Furthermore, the versatility of the drone enables the spraying of disinfectant liquids not only on agricultural fields but also n buildings, water bodies, and densely populated areas. Overall, this innovative solution provides an efficient and effective means of spraying liquids, benefiting various industries and promoting safety and productivity.

4. FUTURE SCOPE

- In the context of the COVID-19 pandemic, this drone-mounted spraying mechanism proves to be particularly valuable. It offers the capability to sanitize large hotspots areas without the need for individuals to physically be present. By deploying the drone, it becomes possible to disinfectant and sanitize highly populated areas without exposing personnel to potential risks. This innovative solution provides a remote and efficient method for sanitizing and ensuring the safety of large areas affected by the pandemic, contributing to the overall containment and prevention efforts.
- The manual control of the drone-mounted spraying mechanism can be transformed into autonomous control by leveraging GPS technology and incorporating an auto return home feature. By integrating GPS capabilities, the drone can navigate and operate autonomously, following predetermined routes and targeting a specific area for spraying. This eliminates the need for constant manual control, allowing the drone to operate efficiently on its own. Additionally, the auto return home option ensures that the drone can safely return to its designated home location after completing its spraying mission or in case of any emergencies or signal loss. This transition from manual to autonomous control enhances the convenience, precision, and reliability of the spraying mechanism, enabling seamless operation and optimizing overall productivity.
- By utilizing image processing techniques, the drone can play a role in surveillance by accessing the pest attacks on plants and monitoring the condition of ripening fruit. With the ability to capture high-resolution images or even use advance imaging technologies such as thermal multispectral imaging the drone can gather valuable data about the health and status of crops. By analysing these images using image processing algorithms, the drone can detect and identify signs of pest infestation, allowing for timely intervention and targeted pest control measures. Additionally, the drone can assess the maturity and ripeness of fruits, providing farmers with crucial information for harvest planning and optimizing yield. This integration of image processing techniques expands the capabilities of the drone beyond spraying, enabling it to contribute to early pest detection and efficient crop management.

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the spray coverage area, known as swath width, as well as the distribution of droplets.

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