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# Pesticides Spraying Using Non-GPS-Based Autonomous Drone

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***Abstract*—Technological use in agriculture has a greater impact on efficient farming that elevates crop yield. The use of drones in the agriculture field helps farmers to a greater extent. This paper demonstrates the development of a non-GPS-based autonomous pesticide spraying drone, which is particularly useful for farms with limited land sizes and in areas where GPS is inaccurate. Because of poor GPS positioning and mapping, GPS became unreliable. This autonomous drone creates an optimized navigation path around the mapped field spraying pesticides uniformly over the crops. This agriculture drone carries a fluid pesticide tank to spray evenly all over the crop, reducing the time and effort of the farmer and preventing harmful effects caused by pesticides. This drone can adjust the altitude, liquid flow rate and speed depending on the type of crop. This drone included with the monitoring application platform provides real-time information. The web application is user-friendly, ensuring that drone performance is manageable and understandable by the user. With the help of these features, the farmer is able to comprehend the field's spray in real-time.**

***Keywords—Autonomous Drone, Non-GPS, Pesticide Spraying, Monitoring***

## I. Introduction

Now a day, autonomous drones and UAVs are not only used for military purposes viz. spying, surveillance, inspection, payload carrying, and other military-grade missions but also in the agriculture sector which plays a crucial role in crop production as well as in the country's economy. The application of fertilizers, pesticides and insecticides is of prime importance for crop yields. With the advancement in technology, the use of UAVs or a drone is becoming more common in modern agriculture fields. Manual spraying of pesticides requires a lot of time and effort. An autonomous drone maintains a certain speed, liquid flow rate and altitude so that it covers the maximum area and sprays evenly all over the field.

Currently in India, conventional methods of pesticide spraying have led to excessive use of chemicals and reduced spray consistency, deposition and coverage, which raises pesticide expenditures and pollutes the environment. Also, drudgery in field application leads to reduced area coverage, an increase in the cost of inputs and reduced effectiveness in controlling pests and diseases.

Object avoiding, pesticide spraying and aerial drone do not require any human activity. A fully autonomous drone maps the field, sets an optimized path and studies the entire field. The autonomous drone will maintain a certain speed while it is flying. This Autonomous Drone can avoid obstacles by using depth sensor cameras and image processing. The drone captures crop images and examines plant health and also it can complete the task even in poor light and at night with intelligent mapping and autonomous flight.

UAVs are deployed in spraying operations more frequently due to their speed and accuracy. Crop regions overlapping and some areas of the crop field not being completely covered by spraying are two examples of factors that reduce crop quality. To tackle these challenges, UAV was deployed for agricultural operations, where unmanned aerial aircraft spray pesticides. Pesticide application to the crop is managed by the autonomous drone that has been deployed in the field. In bad weather, an unmanned aerial vehicle's trajectory is kept constant using a control loop. UAV control loop algorithm also helps to reduce pesticide waste. For the designed quadcopter-mounted sprayer, both laboratory and field research is done on the liquid pressure and discharge rate, spray uniformity, liquid loss, and also with solution concentration.

## II. Drone Architecture

The size of the agricultural field determines the type of drone to be used. The design of the drone depends on the following factors, we must first estimate the weight of the payload, and then select a motor, propeller, electronic speed controller, pump, first-person view camera, depth-sensing camera and onboard control system based on the weight of the drone. The battery must be chosen with the current and voltage requirement of the components. The thrust need must be estimated, and ultimately the frame of the copter must be designed by establishing the required arm number, arm length, and payload application. A drone's body frame and flight controller, which serve as its control system, are the most expensive components. The overall cost of the UAV can be significantly reduced by designing the body of the UAV with recycled plastic. All of the drones are built similarly and carry nearly identical payloads.

## III. Control System

A UAV's onboard intelligence system is its heart. The onboard control system's intellectual component offers real-time information about the external environment. It also evaluates and compares data, resulting in decision-making for the implementation of applicable algorithms. The following methods and algorithms are used to solve these problems: reference-oriented methods and algorithms for detecting, recognising, and selecting objects in the scene and determining their coordinates, and algorithms for analysing the states. The control loop system is used for solving the situational awareness problem during flight.

### *A. Flight Controller*

ArduCopter APM is a professional quality Inertial Measurement Unit (IMU) autopilot which is based on the Arduino Mega platforms. The ArduCopter is a quadrotor system with manual remote control, automated stabilisation, and waypoint navigation. This APM 2.5 board includes a 3-axis gyroscope, accelerometer, magnetometer, and high-performance barometer. APM 2.5 gives control commands to the electronic speed controller (ESC). ESC lowers or raises the voltage to be given to motors using pulse width modulation (PWM).

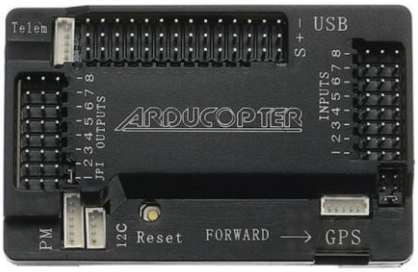


Fig. 1. ArduCopter APM 2.5 board

### *B. Raspberry pi*

The embedded system used is Raspberry pi 4 to make the drone autonomous. Power consumption in Raspberry Pi 4 is also a major reason to choose in developing autonomous drones as it consumes 3.8W to 4.0W it can also handle 24/7 runtime depending on the battery we choose. It works about as fast as Intel Core 2 processor, and it also has an average lifespan of 7-10 years. It is better than Arduino as it has its operating system. Also, it can provide significant processing capacity to drones, giving them access to hugely complicated yet exciting technologies like AI. This additional functionality allows you to interact with the drone using Python while it is flying.

### *C. Raspberry pi communication*

The RPi (Raspberry Pi) performs on-board processing and various algorithms based on path planning, controlling, field mapping etc. Based on these onboard processing and algorithms set of instructions and commands are sent to the flight controller via the MAVLink (Micro Air Vehicle Link) protocol. MAVProxy, a Python-based MAVLink ground station, is installed in the RPi OS (Raspbian) to transform understandable commands into MAVLink command messages. RPi performs tasks such as picture recognition, which the flight controller simply cannot handle due to image storage and memory limitations.

### *D. Depth sensor camera*

To determine the range of the objects from the drone in three dimensions (3D), depth sensor cameras are used. A depth sensor camera gathers multi-point distance data over a large field of view (FOV). The drone's depth sensor aids in field analysis through mapping, object recognition, calculating distance, avoiding obstacles, and real-time object tracking. It is critical for drones to avoid colliding with obstacles. Depth cameras allow the drone to see its surroundings. The depth is compiled from one or more depth cameras used in the obstacle avoidance algorithm. These depth measurements are then transformed into 3D voxel positions. We update the chance of that voxel being occupied for the value and use the voxel map to compare the drone's heading and velocity to potential obstacles in that direction. If any are found, the path is rerouted to avoid collisions.

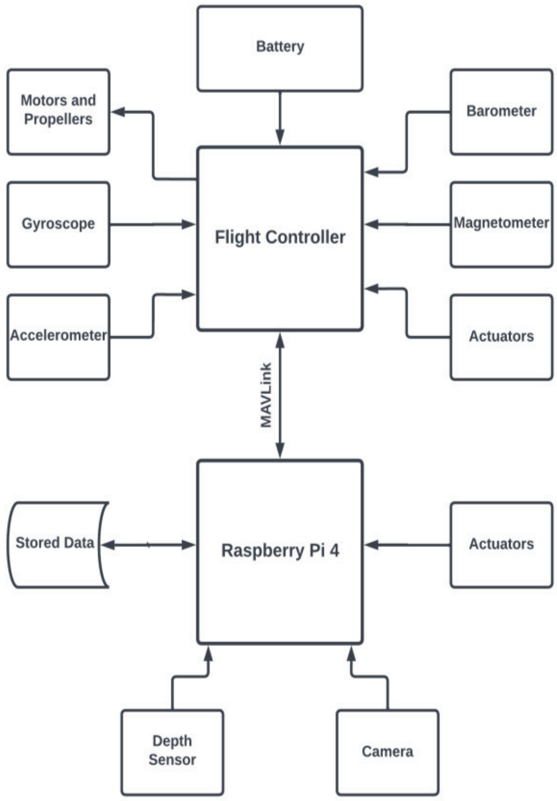


Fig. 2. Control System of the Drone

## IV. Methodology

### *A. Field Mapping*

Autonomous drone navigations require a map of the entire field. The map gives a clear idea of the workspace and helps to store and keep track of the informative data and the plant location across the field. Initially drone take-off to a particular height which covers the entire field and captures the view through the camera figure (3) and (4). Through web application farmer need to mark the field boundary by creating a contour around the field on a web application. This data is stored and processed by an image processing algorithm creating a 3D map using the SLAM algorithm. This data is used for drone navigation within the boundaries and performing path planning.

Fig. 3. Illustration of drone view covered by the camera.

Fig. 4. Outline of field collected by the farmer

## B. *Positioning of Drone*

Pesticide spraying is one of the agricultural applications of drone technology. Drone navigation over the field without GPS location plays a significant role in positioning the drone accurately over the specific location of the field. To perform efficient spraying, the spraying must be coordinated and combined with the previously mentioned image processing, and automated analytics capabilities in order to precisely spray over the plants. A method like this would not only improve the health of the plants in the affected area, but it might also maintain the total amount of pesticides used in the area. To solve the issue an accurate map for locating has been created by stitching together several aerial pictures.

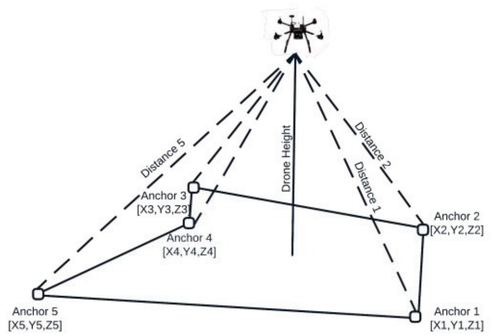


Fig. 5. Calibration method for precise drone positioning on the field.

When the drone locates these photographs in the field, the inaccuracy of the coordinates will be computed. The image was stitched using the relative coordinates of the ground features, and the ground control points shown in figure(5) were utilised to adjust the absolute coordinates of all scanned areas. This calibration is done before each drone flight.

## C. *Path planning*

The effective path for drone navigation reduces damage caused by uneven pesticide spraying in the agriculture field. The complete coverage path planning algorithm finds the efficient path of spraying pesticide keeping in mind of spraying distance covered and also the spraying rate to maintain the uniform distribution throughout the crop field. This paper applied the A* algorithm which is a popular heuristic search algorithm to improve the efficiency of the complete coverage path planning.

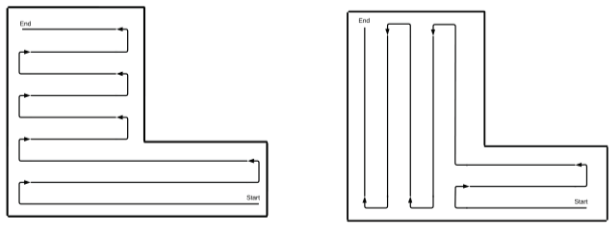


Fig. 6. (a)Non-Optimized Path planning (b) Optimized Path Planning

Fig. 7. Optimized path generated for pesticide spraying.

## D. *User Application*

The web application provides a user-friendly platform and essential information. The User Interface (UI) of this application will instruct the farmer on how to set up the drone. This web application introduces additional modes such as take-off, return to home (RTH), land, and intelligent flight modes that display altitude, distance from the crop, horizontal speed, and vertical speed in real-time. The operator can easily assess the performance of a drone. The user will map the field area and length using this interface and offer the drone with its subdivision platform to supervise before the flight take-off. Map Locator, which is specifically developed for the field overview, sensor parameters, and other drone properties for the region covered, is also included in the application. The field area slide metre is used to double-check the field length and structure.


Fig. 8. Web Application

## V. Workflow

The drone scans the field from the air and creates a 2D map of it. The field's borders are set up so that the drone can recognize them. An ideal flying path is developed after mapping to move through the field and keep an eye on the crop. The state of the plant is documented via image processing. Procedures that are essential are advised based on the data. According to the demands and requirements pesticide is sprayed. With the use of artificial intelligence, the crop's health is analysed. Figure (9) shows the working flow chart of an autonomous pesticide spraying drone.

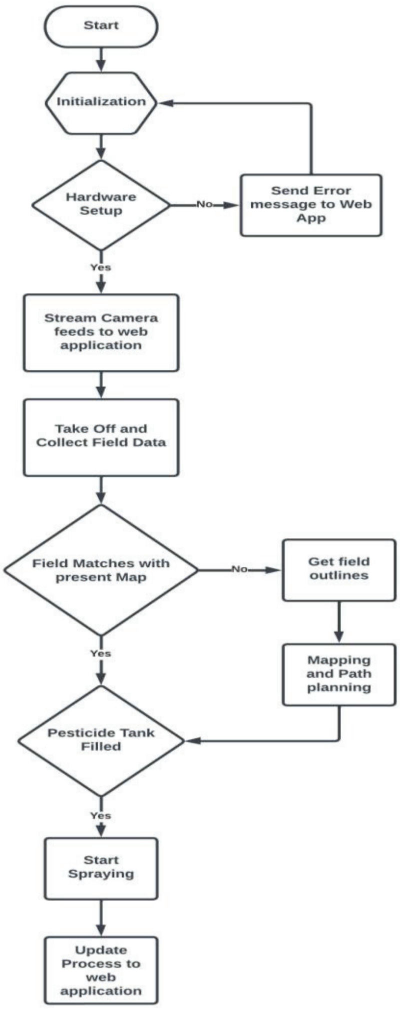


Fig. 9. Working flow chart

## VI. Conclusion

For a country like India where the land size is small and there is no accurate GPS mapping available, the designed UAV can map the field accurately and follow the designated path for pesticide spraying. UAVs with artificial intelligence capabilities. The methodology proposed in this research is novel in comparison to existing unmanned aerial vehicles utilized in agriculture. Additional sensors can make the entire process of field monitoring considerably simpler and easier. There are numerous UAV designs and projects in agriculture, however, the methods mentioned in this article can support you in monitoring fields without the use of GPS. This allows a farmer to monitor his field without having to enter the field and inspect each crop individually. This proposed method provides an overview for field monitoring, and the monitored values can provide the farmer or user with an entire image of the area. The integration of high-definition cameras with machine learning capabilities could improve field surveillance. When the ground is ripe for harvesting, farmers can use smart devices to guide further processes. Monitoring generates standardized data for crop kinds that can be used to compare crops in the future. The operator can utilize this strategy suggested in this research intended to make it easier for farmers to monitor their fields, enhance crop quality, and improve yield.

## VII. Discussion and Future Scope

In this study, we evaluate a large amount of research on drones in the agriculture field and we discovered that there has been a significant increase in publications and a strong need for an autonomous drone in that domain. Drones are also becoming more common in agriculture, and artificial intelligence (AI) on drones that can predict plant disease can provide proper treatment in real-time. Autonomous drone technology will improve agricultural and general uses, with real-time data gathering and processing fueling strategy and decision-making.

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