Advances in Computer Science and Information Technology (ACSIT)
p-ISSN: 2393-9907; e-ISSN: 2393-9915; Volume 11, Issue 1; January-March, 2024, pp. 9-13

http://www.krishisanskriti.org/Publication.html

Intelligent Spraying Application of UAV for Continuous Evenly Distributed Crop in Horticulture

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Abstract—*Unmanned aerial vehicle (UAV) integration in precision agriculture has demonstrated encouraging possibilities for improving crop management techniques. The intelligent spraying UAV application for horticulture, which is based on UAV and aims to manage nutrients and protect crops discretely and uniformly by applying image processing, IoT and AI/ML Technology is presented in this study. The precise spraying systems on the UAVs include adjustable nozzles and variable-rate technology. This guarantees modification in spraying parameters in response to the unique needs of various trees in the field. By utilizing UAV technology for intelligent spraying applications in horticulture, the suggested method marks a substantial improvement in precision agriculture. It provides a workable and scalable solution that enhances yields, promotes sustainable agricultural methods, and lessens ecological imprint.*

INTRODUCTION

The art and science of growing plants is known as horticulture. It includes development, support, soil the board, scene reconstruction, plant protection, and garden structure. Enhancing knowledge about plants and their use for different human needs, as well as restoring the environment and personal sense, is socially crucial. In addition to increasing plant growth, quality, and yields, it also entails enhancing plant defense against diseases, pests, and environmental stresses. Remarkably high quality and substantial yields are managed via horticulture.

It includes the plants, soil-derived products for flavorful applications, or aesthetic appeal. In addition, parkways, professional flowerbeds, and recreation centers use it. The field size in horticulture is frequently less than in arable production. Trees or areas of tree squares can be targeted with horticulture in a way that responds appropriately to their current state, allowing for necessary pruning. UAVs can operate covertly and behind clouds that prevent larger, more elevated aircraft and satellites from engaging in a similarly vital role.

Horticultural applications are generally found in areas where diseases and pests are controlled, as well as in crop creation for superior quality, higher yields, greater advantages, biology, and well-being [1]. Drones may fly autonomously when they have dedicated programming, which enables them to establish a flight plan, transmit the GPS framework, and input various parameters including height, speed, POI (Point of Interest), geofence, and safety modes. Due to their cheap activity cost, ease of triggering, combination of high spatial targets and rapid turnaround capacities, drones are preferred over full-size flying vehicles. These highlights are necessary for precision farming, when large zones must be examined and inspections must be completed in the shortest amount of time.

Because of all the environmental benefits that drone technology offers, horticulture is becoming a big sector. Growers are able to prevent issues before they get out of hand with their assistance. Enhancing the efficiency of resources like water and fertilizer is a major benefit of using drones equipped with agricultural sensors. Farmers can scan crops from above with the help of cameras mounted on drones. Enhancing potential yield is made possible by having access to high-quality pictures and high-resolution spectral data.

By automating and streamlining a variety of processes, drones provide a wonderful chance to decrease the need for professional labor. Drones, for instance, may easily shade greenhouses or apply fertilizer to crops precisely in fields that are considered too damp for tractors to maneuver through. Operationally, drones provide for smooth, safe workflow. Unmanned aerial vehicle technologies have made incremental advancements in time and cost-saving applications.

LITERATURE SURVEY

The research and advancements in UAV-based pesticide spraying systems are covered in this section. In many regions of the world, traditional techniques continue to be the predominant approach for applying pesticides. The most popular equipment for applying conventional pesticides is the manual mechanical sprayer. Humans are impacted by the manual application of pesticides, which can result in conditions including cancer, hypersensitivity, asthma, and other illnesses [2]. Conventional techniques also have a number of other drawbacks, including the need for more chemicals, a lack of farm labor, less regularity in the spraying process, damage to the environment, and a smaller coverage area. These traditional techniques are less successful in managing illnesses and pests and result in greater pesticide treatment costs. One solution to these drawbacks is the use of a sprayer placed on a drone. Drone-mounted sprayers have improved chemical efficacy, improved coverage, and sped up and simplified the spraying process in the field. These days, drones may carry up to 40 liters of insecticide and can fly along pre-mapped paths to spray fields as needed. Drones are shown a lot of promise for covering fields that are hard for tractors and airplanes to access [3]. The first unmanned aerial vehicle (UAV) for the spraying of pesticides was created in 1983 by Yamaha Motor Co. Ltd. in Shizuoka, Japan. This helicopter's stability and controllability made it unfit for use in the field. Numerous studies have focused on the spraying systems and stability and controllability of UAVs.

For UAV-based pest control in small fields, Y. Huang et al. had constructed a sprayer in this sequence [4]. The control mechanism for this UAV was based on pulse width modulation, or PWM. It might also be used at difficult-to-reach locations. A PWM regulator-based remotely controlled, pre-programmed helicopter for pesticide application in agricultural fields was proposed by Zhu et al. [5]. A method for adaptive control of pesticide spraying using unmanned aerial vehicles in dynamic situations was presented by Bruno S. Faiçal et al. [6]. According to the experiment's findings, the suggested pesticide sprayer system now operates better in the evaluated environment. It was necessary, therefore, to create a less expensive automated spraying system.

To optimize pesticide spraying tasks, He Luo et al. suggested a multi-UAV system based on genetic algorithms [7]. The model was only evaluated on a rectangular field; its applicability to other shaped fields was not confirmed. For consistent spraying operations in the field, Spoorthi et al. created a drone called Freyr [8]. An Android app with a Wi-Fi interface that is easy to use was created. For semi-professional farming, it was helpful. But in order for the farmers to use the built Android app, they needed to grasp some technical stuff. To make agricultural technology more user-friendly for farmers, B. Balaji et al. created a hexacopter using a Raspberry Pi controller [9]. Python programming was utilized in agricultural monitoring apps to detect weeds and diseases. However, the drone's payload has to be improved for this arrangement. An artificial neural network (ANN) served as the foundation for the UAV integrated variable spray system developed by Sheng Wen et al. [10]. The UAVDDPS software was created to forecast droplet deposition. Less than 20% separated the actual droplet deposition from the expected droplet deposition. AeroDrone, a drone created by Kislaya Anand and Goutam, is intended for chemical spraying and field monitoring [11]. The integrated system of quadcopters proved to be efficient in its work, as seen by the nearly identical mission times of each drone. However, it was only tested on rectangular farms. Martinez-Guanter et al. created an airborne pesticide spraying system while taking payload constraints into account [12]. According to the trial results, the proposed method outperformed the previously in use technology, saving around €7/ha.

A lighter weight spraying system octocopter has been devised by Karan Kumar Shaw et al. [13]. The payload was calculated by taking into account the pump, tiny spray nozzles, fluid density, and tank capacity, which was six liters. Although the design of this octocopter was useful for agricultural surveillance, in order to enhance its performance, the manually operated system had to be replaced with an AI-based autonomous system. By analyzing the real-time data, a completely automated pesticide spraying system may do spot spraying [14].

In this paper, the application of spraying drone for the horticulture is presented. The designed strategy helps to optimize the quantity of pesticide and covers maximum canopy of tree. The rest of the papers is organized as section 3 presents the various components used in UAV. Section 4 describes the methodology for experimentation and assumptions carried out during the measurement. Section 5 is about the results and discussion and section 6 is conclusion.

COMPONENTS OF UAV

Frame: The physical framework of the UAV that connects all of its parts is called the frame. The structure, which can be built of plastic, aluminum, or carbon fiber, affects the mobility and stability of the UAV. The frame serves as the basic structure upon which the other components of the construction are built. In a sense, it acts as the UAV's skeleton. To reduce power consumption during flight, it should be as light as possible, but robust enough to sustain jerks and accidents and increase the UAV's payload. The way the motors and other equipment are supported by the frame helps to keep the vehicle level and stable during the flight. The many frame types characterize the multicopter. The most common frame types are the hexacopter, quadcopter, octocopter, single copter, and tricopter kinds.

Propeller: The propellers are responsible for lifting the UAV. The two important parameters of the propellers are their diameter and pitch. Pitch is the distance a propeller travels in a single revolution. A propeller with a lower pitch value can lift big loads because it generates more torque and requires less effort from the motors to push heavy loads. The motors will use less power from the batteries as a consequence, extending the UAV's flight endurance. Higher pitch propellers would create less torque, which would cause turbulence, but they would also provide less thrust. The amount of air that makes contact with the propeller surface governs the UAV's flying efficiency. Larger propellers will make more contact with the air than smaller propellers hence larger propellers are more efficient. Low pitch propellers are preferred for the optimum stability and vibration reduction.

Motor: High-quality motors are one of the key parts of a UAV and influence the selection of the complete power system, hence it is selected very carefully while purchasing the UAV. The most common type of motor used is a brushless motor. The advantage of brushless DC motors over brushed DC motors is that the former are electronically commutated, eliminating the need for brushes. As a result, they provide outstanding torque-to-speed characteristics, great efficiency and silent operation, and a long lifespan and wide speed range.

Flight Controller: The flight controller, which processes information from several sensors and sends control signals to the motors, is the brains of the UAV. It supports the UAV's ability to stabilize and carry out pilot or autonomous system.

Power Source: The propulsion system and electrical components of the UAV are powered by batteries or other power sources. Because LiPo batteries have a high energy density, they are frequently utilized in Unmanned Aerial Vehicles (UAVs).

Sensors: Numerous sensors are installed aboard UAVs to aid in data collection, navigation, and stabilization. Gyroscopes, accelerometers, magnetometers, barometers, GPS, and occasionally more sophisticated sensors like cameras, LiDAR, or multispectral sensors are examples of common sensors.

Communication system: Data interchange between the UAV and the ground control station (GCS) is made possible via communication technologies. This covers antennas, receivers, and radio transmitters.

Onboard Computer: An onboard computer runs control algorithms and analyzes sensor data. It might also be used for data processing, computer vision, and autonomous navigation.

Ground Control Station (GCS) or Remote Control: Unmanned Aerial Vehicles (UAVs) can be remotely controlled manually or remotely controlled by a ground control station. The operator may design routes, keep an eye on the UAV's status, and manage its movements with the help of the GCS.

Payload or Camera: In order to gather pictures, videos, or data for a variety of uses, including aerial photography, mapping, surveillance, or agricultural, UAVs frequently carry cameras or other payloads.

Positioning and Navigation System: Accurate location data is provided by GPS and other positioning systems, allowing the UAV to navigate and adhere to predetermined flight patterns. Both autonomous and manual activities depend on this.

Safety Features: To minimize mishaps and guarantee safe operation, UAVs can be equipped with safety features including obstacle avoidance systems, fail-safes, and return-to-home capabilities.

Telemetry System: Telemetry systems provide the ground control station with real-time data on the state of the UAV, including battery voltage, altitude, speed, and other pertinent information.

4. METHODOLOGY

We have used UAV that are outfitted with cutting-edge sensing technology, such as sensors for environmental variables and high-resolution cameras. The field image is first taken at a height of 50-75 feet and waypoints are plotted for the entire field. Boundary is determined after connecting the waypoints. The tree traversing as well as discrete spraying path is determined based upon analysis of horticulture field image. To assess the health and trees in the field, real-time data gathered by UAVs and machine learning has been applied. This intelligence analysis serves as a guide for the decision-making processes involved in effective spraying operations. The UAV may now fly at a suitable height to spray pesticides/fertilizers in the second phase. The optimal amount of insecticide is applied to each tree in the entire field in following manner.

For the applicability of above methodology following assumptions are made:

1. This method is applicable for orange, pomegranate, mango etc gardens in which there is sufficient distance between trees.
2. There is need to cover maximum spherical surface of tree.
3. For the plantation of tree minimum 20×20 feet distance is used.
4. The height of the tree is not above than 15 feet.

RESULTS AND DISCUSSION

The experimentation is carried out in two ways i.e. Conventional (Continuous spraying) and Discrete Continuous.

In conventional method, first the area is selected and the way points are marked with front and side overlap from particular height. After that a mission is created with the help of mission planning software which will follow the terrain which minimizes the chances of collision. It will execute the path created as shown in figure 1.

In this method, once the path is decided the drone follows this path for spraying the pesticide in to the field. But the drawback of this technique due to uniform spraying is that it will cover only the upper part of the canopy of the tree. The spraying is required only on the trees but not on the field in between trees. Conventional method uniform autonomous spraying will lead to wastage of spray liquid.

Figure1: Conventional method of spraying

To overcome this problem, we have devised a discrete continuous spraying technique. In this technique, area has been selected with the above mentioned procedure and the way points are marked. First way point is selected at the top of the tree and then it is supposed to cover the upper surface of the tree. In second phase, it will traverse along the way points marked and cover entire periphery of the tree such that the entire side canopy is sprayed uniformly. The procedure will continue for the trees in the rest of the field as shown in figure 2.

Figure 3 shows the detailed view of figure 2. The novelty of this technique is that, the spraying is off during the gap between trees (as shown in figure 3, between the way points 8 and 9) and the entire surface area of the tree is sprayed with optimum quantity of pesticide.

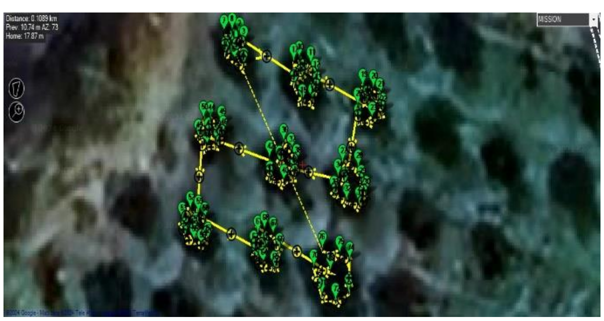

Figure 2: Discrete–continuous intelligent spraying system

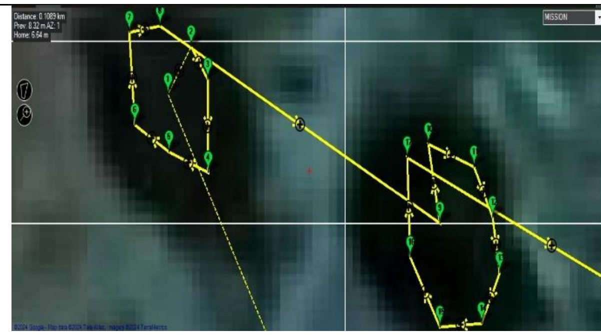

Figure 3: Detailed view of figure 2.

CONCLUSION

In this paper intelligent spraying application of UAV for continuous evenly distributed crop in horticulture is discussed for the orange crop. The experimentation is carried out with conventional method and discrete continuous method. It has been found that the discrete continuous method is more efficient as tit optimizes the pesticide quantity and covers the entire surface area of tree, which helps in better growth of the plant and minimizing the yield.

ACKNOWLEDGEMENT

This work was supported by a grant from the IITI Drishti CPS Foundation.

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