An Autonomous UAV for Spraying Pesticides

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ABSTRACT

For mass-produced goods to retain their quality, pesticides are an important tool for farmers. Aircraft spraying of these compounds both expedites the process and keeps the soil from being compacted. But bad weather (such the wind's speed and direction, for example) might make pesticide spraying in a specific agricultural area less effective. Therefore, the herbicide might potentially travel to nearby agricultural areas. Some estimate that just a tiny fraction of the world's pesticides really work to keep pests at bay, while the vast majority simply evaporate before reaching their intended agricultural fields. But with more accurate spraying, we can reduce the quantity of pesticides needed, boost crop yields, and lessen the likelihood of environmental harm. Unmanned aerial vehicles (UAVs) have found widespread application in farming in recent years. Nevertheless, pesticide contamination is still a problem and the efficiency is still low compared to expectations. Specifically, these two issues are to blame: 1) Current unmanned aerial vehicle systems have a low level of autonomy. Actually, remote control is still the primary method of operation for the majority of them. 2) In close proximity to the plants, the UAV's flight control is inaccurate, resulting in an operational precision that is inadequate. This article discusses how contemporary farming makes use of a variety of innovative methods and technology. Views and advantages of UAV use in various agricultural contexts, using the "Aero Drone" spraying drone project as a foundation

KEYWORDS: Aeroplanes; Pesticides; Unmanned Aerial Vehicles (UAVs).

INTRODUCTION

Agricultural crop fields often make use of pesticides, often called agrochemicals, to boost yields, enhance quality, and decrease production costs. However, a number of human ailments, including malignancies, respiratory system issues, and neurological disorders, may be brought on by extended exposure (directly or indirectly) with these chemicals. An ever-increasing 2.5 million tons of insecticides are applied annually around the globe. Because of the methods used, a lot of pesticides go to waste when they are sprayed. Research indicates that pesticide drift often occurs between 48 and 800 meters from the intended crop area, with a deviation that may extend up to 32 kilometers downstream. The utilization of unmanned aerial vehicles (UAVs) for pesticide spraying has numerous potential advantages. Firstly, it lessens the likelihood of humans coming into touch with the chemicals, which is good for their health. Secondly, UAVs can enhance the efficiency of the spraying operation by preventing the chemicals from entering non-designated areas, which is good for nearby fields, whether they contain other crops, natural areas, or water sources. The development and fine-tuning of sets of control rules for use in autonomous UAVs is a challenging task. Therefore, the parameters of the algorithm need to be fine-tuned in light of the fact that each UAV has its own unique mechanical properties, as well as the crop kind and pesticide type that will be employed. The authors of this work provide an evolutionary technique for optimizing control rule sets for use in a virtual unmanned aerial vehicle (UAV). We lay up the plans for the building and the research into how the evolutionary parameters may be tweaked. Utilizing a UAV equipped with a linked spray system and capable of communicating with a Wireless Sensor Network structured in a matrix-like manner on the agricultural field constitutes the suggested architecture. The goal of this WSN is to report back on the current weather conditions as well as the actual spraying results in the designated field of crops. The UAV then applies a policy to its flight path accordingly, taking into account the data it has received. So, basically, this study has four main contributions: (i) it looks into an evolutionary methodology that can reduce pesticide contact with humans, (ii) it assesses an evolutionary approach that can reduce pesticide spraying errors in vegetable and fruit growing areas, (iii) it looks into techniques that can maximize agricultural production quality, and (iv) it helps make the proposed architecture more autonomous by setting policy parameters empirically and applying them regardless of weather. Existing unmanned aerial vehicle (UAV) systems in agriculture may be categorized according to their degree of autonomy: execution,

Fig 1. UAV used for pesticides spraying

coordination, and organization. Assuming the UAV can take flight, the most fundamental need is the execution level, the lowest level. According to references [9, 11], the execution level receives the correct sequence of control and identification algorithms from the coordination level. An efficient autonomous freight transportation system is introduced at the organizational level, which is the highest level and includes features like mission management and an environment awareness system [12, 13]. This study introduces a research platform for interior and outdoor search and rescue using completely autonomous UAV technology.

METHODS OVERVIEW

A. Precision Agriculture and It's Tasks

Precision agriculture has been a buzzword in the unmanned aerial vehicle (UAV) sector for the last several years. The reason for this is because data acquired by drones is increasingly being used as a basis for decision-making by farmers throughout the globe. Thus, one definition of precision agriculture is the study of the interplay between various decision-making factors and the development of crops. In order to preserve crops and increase their yield, several different procedures and chemicals are used. It is common practice to spray chemicals across a whole area or farm. By using precision agriculture, one may pinpoint trouble spots and selectively administer pesticides there. Huge savings will be possible as a result of this. Precision agriculture makes extensive use of UAVs for a variety of tasks. Jobs that fall under their purview include: I am monitoring the Normalized Difference Vegetation Index (NDVI). Plant Diseases Keeping An Eye On Index for Crop Water Stress (CWSI) Keeping An Eye On Applications of Pesticides, Liquid Fertilizers, and Entomological Material (Trichogrammatid) via Spraying Flying Maps.

B. Detailed Description of Precision Agriculture Methods B.1. Plant Health Monitoring

Several ratios, or indices, that are sensitive to various physiological and environmental factors have been developed using the Normalized Difference Vegetation Index concept, which is based on evaluating the amount of incident light absorbed and reflected at different wavelengths. NDVI only relies on optical and infrared sensor readings. One way to find places with inadequate soil fertility is to utilize the Normalized Difference Vegetation Index. At now, NDVI is determined using satellite imagery. Poor management choices are made using outdated data, and it takes a lot of time. This is why it makes sense to use UAVs for these kinds of tasks. Drones using optical and Near Infrared (NIR) sensors provide several benefits, including improved picture quality, less latency, and a much more affordable operation.

The primary goal of a UAV is to save expenses and provide decision-making data swiftly in the event that the typical farmer applies fertilizer consistently throughout his whole field. Considering that fertilizer costs 800 horn per hectare and the average farm size in Ukraine is 200 hectares, the total cost to apply the fertilizer to the whole farm would be around 160,000 horns. The farmer stands to save 48,000 horns, assuming moderate savings of 30%. This computation is only related to the NDVI fertility monitoring approach. A lot of money may be saved by using other ways. The study of infectious diseases in plants is known as plant pathology. Viruses, bacteria, fungus, nematodes, and parasitic higher plants are the several types of plant pathogens. Our attention here will be directed on the detection of leaf rust. Plants like wheat, rye, and oats may have leaf rust from fungi. Over expansive regions, it may cause losses between 1% and 20%. Visual inspections for leaf rust are now standard practice. Hyperspectral Imaging (HSI) helps farmers find dead spots in their crops. As a non-invasive approach, HSI has great promise. After then, UAVs may be equipped with Hyperspectral Sensors as a payload.

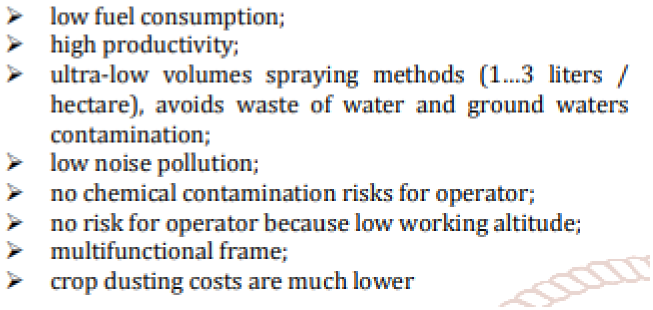
Among the many devastating plant diseases is Hangdogging (HLB). Hundreds of thousands of hectares of citrus crops are infected and devastated all over the globe. Hydrogen LB may be detected using both near-infrared and thermal infrared detectors. With their unique spectral signature, these sensors may identify diseases before they manifest in leaves or fruits. The method for monitoring agricultural water stress index is based on the water needs of individual crops during irrigation. The CWSI may be determined by comparing the air temperature differential between the plant and surrounding air with the vapour pressure deficit, which measures the relative humidity of the air. Relative humidity is a key variable in determining the Vapor Pressure Deficit. It is possible to plan irrigation using CWSI. Crops require watering when the CWSI value reaches 0.6. An unmanned aerial vehicle (UAV) equipped with a thermal sensor and a relative humidity monitor may provide a thermal picture that can be used for CWSI evaluation.

B.2. Crop protection Crops

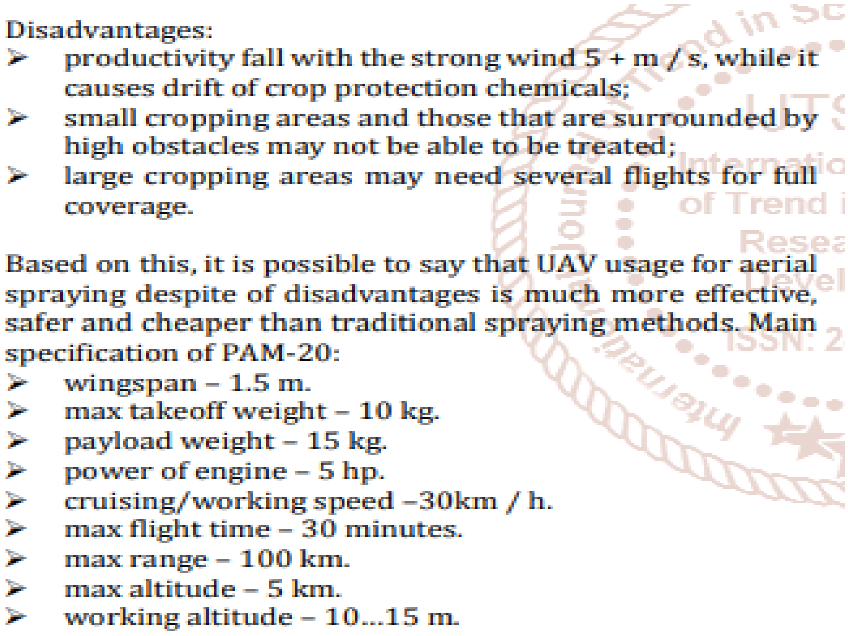
One crucial aspect of precision agriculture is spraying. This is a typical job for agricultural planes and ground-based sprayers. However, currently UAVs may be used for this purpose; for example, Japanese farmers spray 40% of their rice fields with drones, and they deploy unmanned helicopters for this purpose. Due to reduced fuel consumption and expenses, the aforementioned approach is much more cost-effective than conventional agricultural aviation. When it comes to spraying crops, unmanned helicopters and fixed-wing UAVs are both viable options. But they're not the same in practice. Helicopters are a lifesaver for vineyards, tiny farms, and farms with challenging terrain. Normal fixed-wing tractor aircraft and fixed-wing vehicles are not mutually exclusive. It is not effective to use UAVs to spray liquid fertilizer. Five to seven kilos of fertilizer per hectare is the standard for a typical field. Most UAV sprayers have a payload capacity of less than 50 kg. This kind of work may only be done by a select few UAVs that are comparable in size to current agricultural planes. Unmanned Aerial Vehicles (UAVs) have the capability to spray various chemicals that protect plants. Today, you can find a wide variety of plant protection solutions on the market. Precision agriculture mostly use the following pesticides:

SOLUTION OVERVIEW

Great amounts of unmanned aerial platforms for agriculture exist around the globe. Most of them are small drones, equipped with different types of special cameras and sensors for agricultural fields monitoring. Exceptions are small UAVs and multicopper systems that are used for entomological material (Trichogrammatid) “dusting” and only sometimes for classical dusting designations. Ukraine based start-up “Aero Drone” develops a unique project that has no analogues worldwide. As far as it is known, this project is the first working prototype of fixedwing spraying UAV. It has many advantages, comparing with traditional crop protection methods, realized by means of big aircrafts and ground tractors. Main of them are:



- low fuel consumption;
- high productivity;
- ultra-low volumes spraying methods (1...3 liters / hectare), avoids waste of water and ground waters contamination;
- low noise pollution;
- no chemical contamination risks for operator;
- no risk for operator because low working altitude;
- multifunctional frame;
- crop dusting costs are much lower



Disadvantages:

- productivity fall with the strong wind 5 + m / s, while it causes drift of crop protection chemicals;
- small cropping areas and those that are surrounded by high obstacles may not be able to be treated;
- large cropping areas may need several flights for full coverage.

Based on this, it is possible to say that UAV usage for aerial spraying despite of disadvantages is much more effective, safer and cheaper than traditional spraying methods. Main specification of PAM-20:

- wingspan – 1.5 m.
- max takeoff weight – 10 kg.
- payload weight – 15 kg.
- power of engine – 5 hp.
- cruising/working speed –30km / h.
- max flight time – 30 minutes.
- max range – 100 km.
- max altitude – 5 km.
- working altitude – 10...15 m.

The "Aero Drone" is seen in Figure 2. It can spray up to 10 hectares in a single flight, has a fuel consumption of 0.2 litters per hectare, and comes with a 5-liter fuel tank and two 10-liter chemical suspension tanks. In a different mode, fuel tanks are used instead of the hanging tanks. This increases the flight duration and range and allows for the installation of a specialized video unit with sensors and cameras. With this mode, the UAV may be used for any kind of surveillance, however precision agriculture is its main purpose. Autopilot, modems, measuring devices, sensors, and other electronics are housed in the "Aero Drone"'s" hanging portable control unit. Other unmanned aerial vehicles (UAVs) may also use this control unit, however the operator will need to upload other configuration files before takeoff. With autopilot, you can automate every step of your flights, from takeoff to landing, and it works with up to a thousand GPS locations to plot your course.

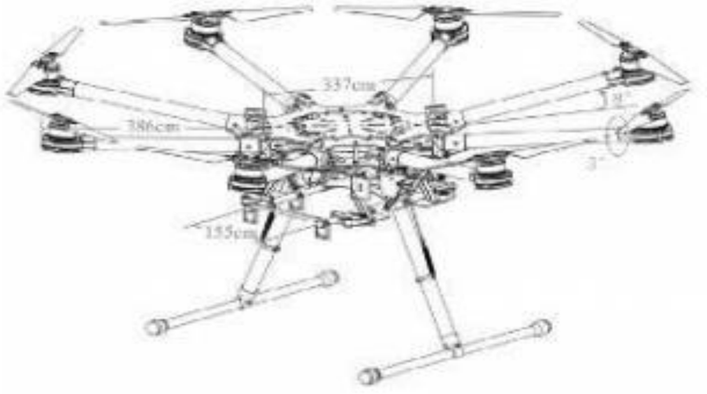


Fig. 2. UAV Aero Drone.

SIMULATION PLATFORM ESTABLISHMENT AND RESULTS ANALYSIS A. Simulation Platform Establishment

An MATLAB-based simulation environment is set up and a battery of simulations are run to confirm that the best mission assignment system is reasonable and accurate. Initialization of parameters, assignment of missions, control of quadcopters, and charting are the four primary components of this simulation platform. You can see the inner workings of this simulation platform in the block diagram in Figure 2. Figure 2 shows that the user inputs the values of m, r h, war, and w0, but the parameter initialization module sets the following values: base, current point, current velocity, destination point, last point, way point, current way point, maximum electric quantity, charging rate, consuming rate, control parameter, control precision, control model, and quadcopter states. Based on specified parameters, the mission assignment module executes the best task assignment scheme, generates waypoints, and plans the itinerary. The cooperative control of the quadcopters, as well as the quadcopter attitude control and state determination, are implemented by the quadcopter control module. Using the mission assignment scheme and the route points created by the mission assignment module, the plotting module plots moving paths in the "Mission display" portion of Figure 3.

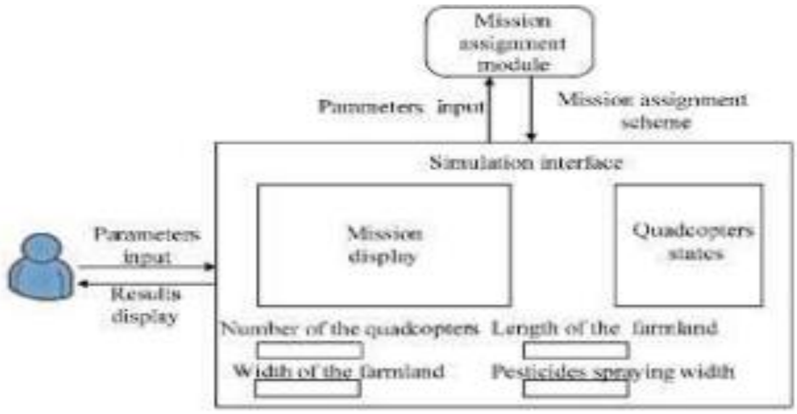


Fig. 3 A block diagram of the simulation platform

Results Analysis

The values of m, r h, war and w0 are given as 3, 60 meters, 300 meters and 10 meters, respectively, and so n is 30. In order to verify the reasonability and correctness of the optimal mission assignment scheme, two kinds of simulations have been carried out. One is to divide all tasks equally without optimization, and the other is to use the optimal mission assignment scheme to assign the tasks. Then, the time for each quadcopter to complete its mission is recorded. Fig.4 is the path diagrams showing the time for the first quadcopter to complete its mission when the tasks are divided equally without optimization, and Fig.5 is the path diagrams showing the time for the first quadcopter to complete its mission when use the optimal mission assignment scheme to assign the tasks.

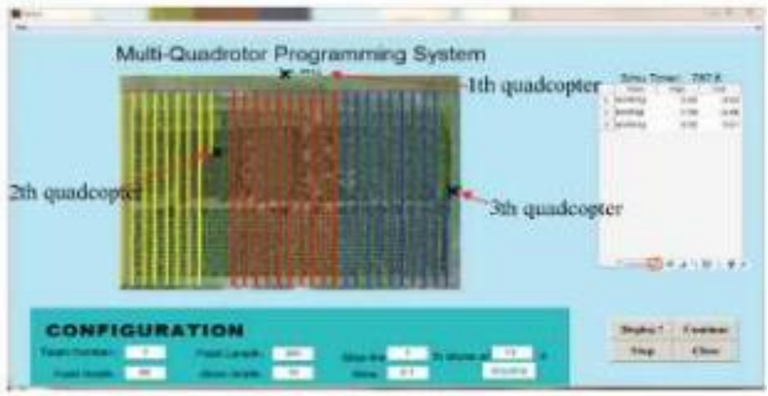


Fig. 4 The time for the first quadcopter to complete its mission when the tasks are divided equally

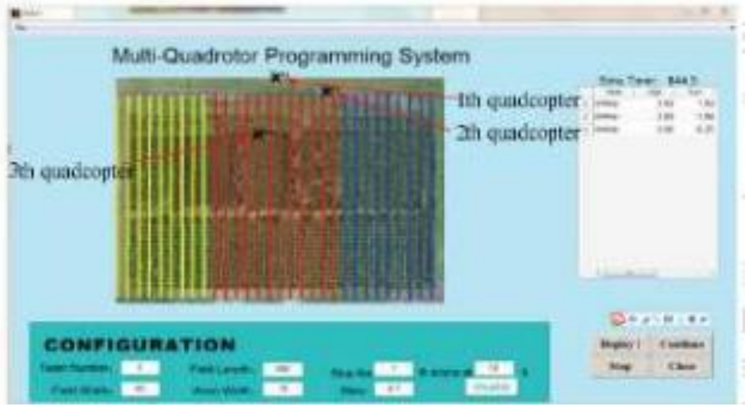
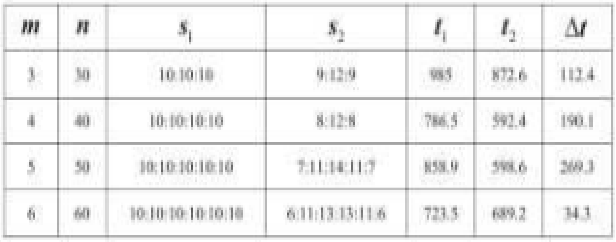


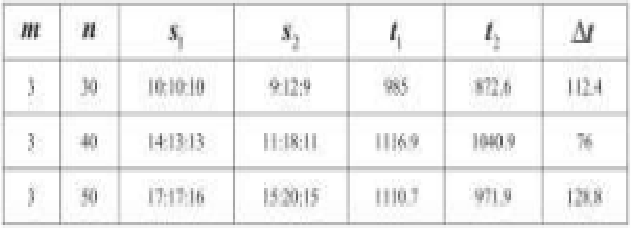
Fig. 5 The time for the first quadcopter to complete its mission when the optimal mission assignment method is used to assign the tasks

It is clear that the overall time required to do the spraying job differs from one simulated route diagram to the next. The number of subtasks given to each quadcopter is 10, and when the subtasks are split evenly, it takes 787.6, 956.6, and 985 simulation time intervals for three quadcopters to accomplish their mission, accordingly. The three quadcopters are given 9, 12, and 9 subtasks, respectively, and the simulation time intervals for completing their missions are 844.5, 855.6, and 872.6 when the optimum mission assignment technique is employed. Based on the comparative findings, it is clear that the best task assignment method will result in more efficient mission execution and close mission times for each quadcopter. Additional simulations are run to bolster the credibility of the findings. These include 1) the same number of quadcopters with varying farmland sizes and 2) various numbers of quadcopters with varying farmland sizes. Tables Č and Nj show the outcomes of the simulations. This parameter The best mission assignment method saves time (at), the average allocation strategy takes 1s, and the average mission assignment scheme takes 2s. The completion times of the two schemes are 1 and 2t, respectively. The units of 1 t, 2t, and At are based on the simulation time period.**TABLE I. RESULTS OF THE DIFFERENT NUMBER OF THE QUADCOPTERS WITH THE DIFFERENT SIZE OF THE FARMLAND**



m	n	s_1	s_2	t_1	t_2	Δt
3	30	10:10:10	9:12:9	985	872.6	112.4
4	40	10:10:10:10	8:12:8	786.5	592.4	190.1
5	50	10:10:10:10:10	7:11:14:11:7	858.9	598.6	269.3
6	60	10:10:10:10:10:10	6:11:13:13:11:6	723.5	689.2	34.3

TABLE II. RESULTS OF THE SAME NUMBER OF THE QUADCOPTERS WITH THE DIFFERENT SIZE OF THE FARMLAND



m	n	s_1	s_2	t_1	t_2	Δt
3	30	10:10:10	9:12:9	985	872.6	112.4
3	40	14:13:13	11:18:11	1116.9	1040.9	76
3	50	17:17:16	15:20:15	1110.7	971.9	128.8

As can be observed from TABLEs I & II the effect of saving time by using the optimal mission assignment scheme is significant whether when the number of the quadcopters is the same but the size of the farmland is different or when the number of the quadcopters is the different and the size of the farmland is different.

CONCLUSION

In order to solve the issue of spraying farms, this research suggests a new task assignment mechanism. To ensure this plan is reasonable and accurate, we build a simulation platform and run a battery of simulations. This scheme's primary goal is to reduce the time it takes to accomplish a spraying mission using plant-protection quadcopters in a rectangular area by solving the mission assignment issue. This paper's findings demonstrate that the best mission assignment method leads to more efficient mission execution and relatively close mission times for all quadcopters. This study presents some perfect simulation results using this technique, but there is still room for improvement. Firstly, this plan is only applicable to rectangular farmland, which is not the majority of the real farming. Therefore, in order to apply this plan to the uneven farmland, it has to be modified. Second, a quadcopter may be unexpectedly broken and rendered useless during flight. Thus, in future studies, this strategy should also take quadcopter failures into account.

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