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Development of an Autonomous Agricultural Drone and Real - Time Monitoring Interface for Aerial Seeding

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***Abstract* - Applications of Unmanned Aerial Vehicles (UAVs) or commonly known as drones, have been considerably growing during the past few decades in various fields such as agriculture, aerial mapping, surveillance, disaster management, and military applications. Drones are used in agriculture to monitor, harvest, and apply pesticides and fertilizers [1]. An autonomous agricultural drone (quadrotor) was developed for aerial seeding and a web interface using IoT technology with a raspberry pi microcontroller. A low-cost and open-source flight controller was used [2]. The real-time unmanned aerial vehicle monitoring system was developed using PHP/MySQL as the backend technologies on the website and Bootstrap, AJAX, JQuery for the frontend and to communicate with the Pixhawk and Raspberry Pi, Python was used. To enhance the continuous flying time with load, proper weight calculations were done before it flies with the load. CAD software was used to design the drone from the top, bottom, right and left views with exact calculations [3]. The design calculations, along with thrust values, also calculated for payload.**

Keywords - Agriculture, Drone, IoT, Pixhawk, Raspberry Pi, RPA, UAV, Quadrotors

Abbreviations: BEC (Battery Elimination Circuit); *BLDC, Brushless Direct Current Motor; CAD, Computer-Aided Design and drafting; ESC, Electronic Speed Controller; IoT, Internet of Things; RPA, Remotely Piloted Aircraft;* UAV, *Unmanned Aerial Vehicle.*

I. INTRODUCTION

UAVs or UAS and RPAs popularly known as drones. Normally these referred, as UAVs, are principally connected with the military, industry, and other specific activities, yet with ongoing improvements in the space of sensors and data innovation over the most recent twenty years the extent of drones has been augmented to different areas like Agriculture [4]. UAV will soon be an important applicable tool for conservation and revegetation practices. A drone can provide efficient and effective methods and low-cost and low-impact solutions to environmental managers working in a variety of ecosystems. Their agility, image quality, and logistic abilities make them become valuable tools. Cutting-edge drones are getting more astute by incorporating open-source innovation, intelligent sensors with better mixes of the most recent invention and more flight time [5]. These drones can have used for a vast range of applications. Here, some of them reported as forest-fire fighting, police surveillance and protection, environmental factors, such as radiation and infectious diseases, monitoring and control, search and rescue missions, ecological research studies, oil and gas industry security. In addition, mapping and surveying, weather monitoring, seismic and geothermal monitoring, to deliver medical supplies and products in times of critical demands across both accessible and inaccessible or dangerous locations. and other calamities the board applications [6].

Concerning the agricultural economic sector, replacing large and unwieldy aerial or land vehicles for UAVs in agricultural operations is now a reality. The use of UAVs in advanced agriculture meets Eco-innovation requirements helping to reduce the negative impact that agricultural activity causes in ecosystems, in particular by reducing the use of fossil fuels and their replacement by electric energy that can be provided from renewable sources [7][8]. UAVs present greater operating flexibility, lower initial and operating investment costs, reduced size and increased profitability by reducing expenses related to the reduction of human resources since a single operator can control several simultaneous UAVs in a safe and comfortable way [9][10].

The drone has been applied in many agricultural operations such as the prediction of fungi appearing and movements weed mapping and control, application of fertilizers, insecticides, pesticides, fungicides spraying, or other spraying chemicals. This research intended to extend the application of drone technology in agriculture by proposing an autonomous drone for aerial seeding and customized web interface. The proposed drone consists with an on-board microcomputer to communicate with the flight controller and the web interface [11][12]. As compared to existing unmanned vehicles, this drone has the capability to real-time monitoring and analyze visually the data in a later time to understand the performance and the behavior on a web portal which could be accessed via a smartphone [13].

Fig. 1. Completed drone attached with the Raspberry Pi, seed dispenser and the transmitter.

II. OBJECTIVES

Development of an autonomous drone with a seed dispenser to hold the seeds and drop the seeds accordingly. Also connecting the drone with a microcontroller such as raspberry pi to communicate with the internet and display analytics of the drone via a web portal with real-time drone path tracking.

III. MATERIALS AND METHODS

The drone plays a significant role in the project, and the drone designed according to the X-frame type since the X-frame type provides more balance. To align with the project's objective, the drone must have the ability to lift heavy weights and be portable and light (which are some attributes of X-frame type drones) [14]. This section describes the peripherals, application software, and seed dispenser unit used to conduct this project. Following Fig. 2. is the detailed CAD drawing of the drone with the seed dispenser.

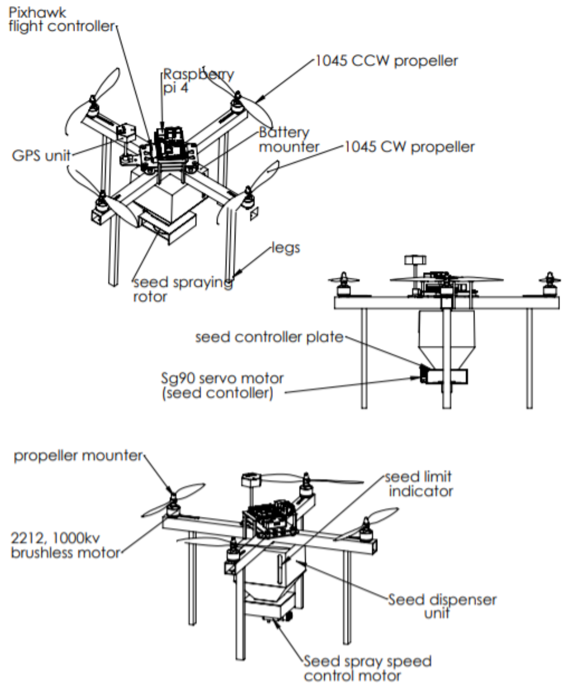

Fig. 2. Detailed drone with the seed dispenser

A. *Components selected for the drone*

Four brushless motors (A2212/13T 1000Kv), four electronic speed controllers (40A), four 10inch carbon fiber propellers with 45-degree pitch angle, Pixhawk flight controller with SE 100 GPS unit and 11.1V, 5500mAh Lithium polymer battery. Also, X-type drone frame, Raspberry pi 4, 4G dongle to provide the internet connection for the Raspberry Pi Microcontroller, one servo motor(5v) and one DC gear motor(5v), seeds dispenser unit, seed dispenser unit mounter [15].

B. *Hardware Implementation*

An aluminum bar used in order to minimize costs. In addition, the landing gear been made with plastic that will be used to land the machine softly and spread the landing force over the body. In addition, there are two aluminum bars that were been linked together in the X-shape and on top of the bars in each corner, and a brushless motor was mounted. The middle part of the body contains all the payloads (ESC, Controller, RF receiver, battery and mobile device) [16][17].

C. *The Drone Thrust Calculations*

The total weight and the thrust calculations done to make sure the user could have the drone under proper stability.

Table 1. Weights of the individual components.

Drone part	Weight
Drone frame	200g
5500mah battery	288g
Flight controller	40g
40A ESC (4 pcs)	(38 * 40) 152g
A2212 1000kv motor (4 pcs)	(64 * 4) 256g
Seeds caring unit	200g
Raspberry Pi 4	50g
Other payload	100g
Total	1286g

When calculating the thrust of the drone, two times of the drone's weight used to hover the drone in the air by half thrust, which enables the remaining thrust for stability and control movements of the drone. [18]. Therefore, the calculation is for the thrust is as follows,

$$T = 2 * (Wd + Wpl) \quad (1)$$

Where, (T) thrust, (Wd) weight of the drone, (Wpl) payload.

$$Total\ trust = T + [T * 0.20] \quad (2)$$

According to the calculation, the required thrust is 2572g to get it off the ground. An additional 20 % (514 grams) added to that total to ensure that the drone could hover. After dividing the total thrust by the number of motors, the drone requires.

771.6g (3086.4/4 = 771.6) of thrust per motor.

Drone weight = 1286g

Double weight with seed dispenser = 2572g + 514g

When dividing it into four motor = 3086.4/4

So, one motor trust =771.6g

So A2212 1000kv motors with 1045 propellers and 40A ESC have been used for each motor [18].

(Each motor can carry 800g approximate weight, finally, able to get 800*4 = 3200g trust).

D. Assembling

As the first step, the project developed by using a designing tool (i.e., engineering drawing software). Then the box bar cut and assembled in the shape of "X" to create the drone frame. The speed controllers and the four motors nailed to the box bar to tighten the grip. After that, the flight controller and other related GPS units installed to the frame. After finishing the wiring works flight controller was programed and run pilot tests.[14]. In addition, the following Fig. 3. shows the assembled drone.

Fig.3. Completed drone attached with the Raspberry Pi and the transmitter

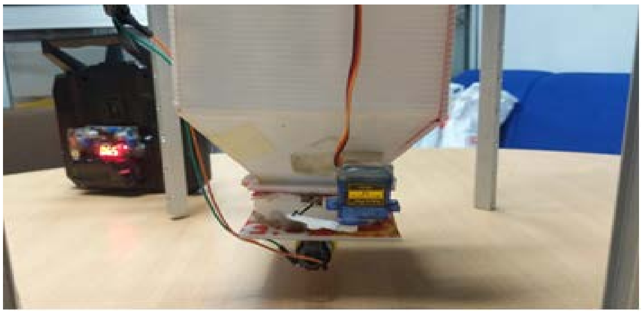

Fig. 4. Speed Dispenser

According to the 3D design, the PVC foam board (5mm) cut to the relevant measures and chambers created to enter the seeds and display the level. The cutting sketch glued as a funnel shape according to the above Fig. 4. Then, the seed control mechanism was created using a servo motor and aluminum plate (2in*2in)[19]. The bottom part of the seed dispenser unit created to spread the seeds widely using a gear motor. Servomotor and gear motor connected to the flight controller and tested. To switch on the gear motor, a relay (transistor embedded) used. The seed dispenser unit attached to the drone (which also can be detached easily). Moreover, tested the flight with seeds. Then a stand placed under the drone to protect the seeds dispenser unit. A test run conducted to measure the seeds' flow rate prior to connecting the raspberry pi to the flight controller.

E. Internet of things

To read the flight controller's data, a raspberry pi installed. Raspberry pi was linked to a website using the python programming language[10] [20]. The flight data history of the drone and the accuracy followed according to the given instructions checked through the website. Here for the data communication JSON API requests will be used and those data will be sent to the web site and once the web page captured the data, those data will be saved in the database and those data will be processed and later on, displayed on a web site [21].

IV. Results

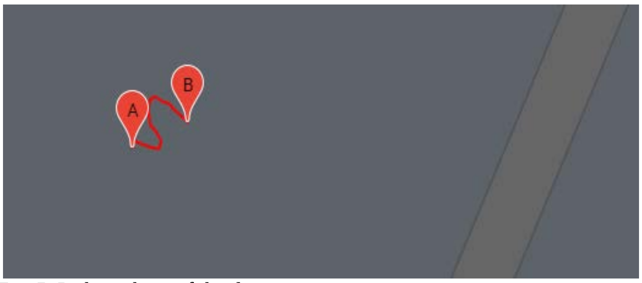

Fig. 5. Path tracking of the drone

The above Fig. 5. displays a sample movements of the drone which is plotted over Google Maps using google APIs, which was live tracked when the drone flew to drop seeds. In addition, the following Fig. 6. is a dashboard that shows the summary of the paths that the drone been traveled.

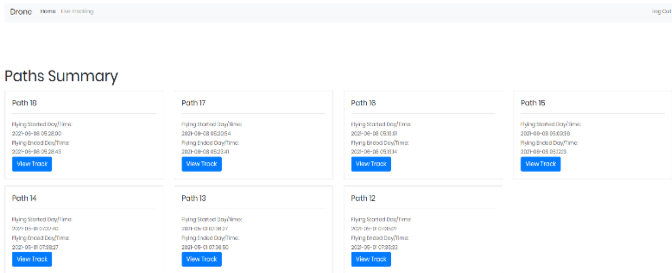

Fig. 6. Website Homepage with paths traveled history

Fig. 7. Drone way point. (Drone planner) Location – University of Kelaniya, Ground.

- Total way points – 14
- Maximum Altitude – 3ft (Feet)
- Latitude measure north-south position, with the equator at 0 degrees and the North Pole at 90 degrees north.
- Longitude measure east-west position, with 0 degrees at Greenwich, England.
- Home location (H) –
  - Latitude - 6.974836
  - Longitude - 79.914406

Table 2. Waypoint table with longitude and latitude.

Waypoint	Flying altitude(ft.)	Latitude	Longitude
H	2.992	0	0
2-3	3.775	6.9747367	79.9144127
3-4	2.551	6.974645	79.9145016
4-5	3.225	6.9746356	79.9144886
5-6	3.735	6.9747278	79.9143992
6-7	3.756	6.9747385	79.9143959
7-8	2.890	6.9746262	79.9144755
8-9	3.560	6.9746168	79.9144624
9-10	3.460	6.97471	79.914372
10-11	2.450	6.9747011	79.9143584
11-12	2.557	6.9746074	79.9144493
12-13	3.330	6.974598	79.9144362
13-14	3.775	6.9746922	79.9143448
14-H	2.545	6.9746545	79.9145147

Here the max altitude has been defined as 3ft, but when the drone actually flying there was a fluctuation been the real value such as around ± 25.83% altitude due to external factors and imbalance due the weight. Also focusing on reducing the altitude percentage and get closer to defined altitude.

V. DISCUSSION

UAVs are flying robots. Even though initially intended for military use, they currently generally utilized in different areas, from sporting games and putting out fires. In this part, a utilization introduced of UAVs on Agricultural businesses. A significant sort of UAV been introduced. However, with its capacity to float on spot and take-off and landing vertical, the multi-rotor UAV may appear to be appropriate for agriculture. Its restricted flight time is a significant impediment. The half-and-half fixed-wing-motor-rotor may be a superior fit. An itemized understanding of the uses of UAVs in crop creation and animal cultivating likewise introduced. UAVs have the benefit of improving and are even more effective when contrasted with people.

A few benefits of applying UAVs in Agriculture introduced, some of which incorporate restricted way requirements, efficiency, and reduced extensive labor. Nonetheless, there are various difficulties restricting UAVs, commonly the incorporated cost. UAVs that are appropriate for agriculture use are costly. Activity and support likewise include some significant downfalls. Thus, it is challenging to persuade ranchers and agriculture related parties to invest in UAVs for their business. One-time cost, battery impediments, security, and legitimate related issues are significant obstacles that should be scaled before UAVs can track down solid traction in agriculture. Following Fig. 8. shows a figure while the drone releases the seeds.

Fig. 8. Aerial Seeding through the drone

VI. CONCLUSION

A UAV designed to spray seeds on the agricultural fields safely. The UAV is a transportation platform that can carry materials from one place to another. Pixhawk selected to control the drone, and the thrust calculations done to understand the total weight the frame holds. Therefore, it can be helpful in enhancing the stability of the drone since the drone should be properly stable in order to have proper control over the drone. Moreover, Raspberry Pi micro controller incorporated in this study as it has an inbuilt Wi-Fi module and USB ports. As USB ports are available, it is easy to connect a dongle for a high-speed internet connection to communicate with the web portal. In addition, the Raspberry Pi has a better processing speed that is useful in this project. Thus, this study proves that the use of drone technology is far more efficient in speed spraying over human labor due to the variable - speed. Therefore, in conclusion it is evident that drone technology creates an effective platform for harvesting without damaging seeds and by maintaining proper records of seed spraying paths.

VII. FUTURE SCOPE

In this project, a prototype of UAV designed to be use in the agricultural field. It is required to improve the flying time of the UAV while increasing the payload by considering the throttle percentage formerly it will be useful for larger agricultural areas.

Also further studying about the aerodynamics in order to make a better body design and better propellers that will help to increase the flying time and make the drone fly under 6-sigma accuracy level. In addition, more precisely, control the drone via the website in real-time.

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