Article

Drone simulation for agriculture and LoRa based approach

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Abstract: Spraying appropriately and regularly will help develop rice plants' growth and development to produce superior rice. These pesticides' spraying is sometimes uneven because of the vast land, limited human labor, and several other factors. that appropriate technology is needed that helps in the process of spraying rice pesticides using drones. Drones are deemed appropriate in spraying its advantages, among others, more effective, reducing the involvement of humans in work. Drones help track consistently and in detail the part of agricultural land that will be sprayed with pesticides, unlike humans. It is more automatic in monitoring, with the camera used on the drone can see the growth of rice plants directly and do recording or real-time connecting to the application server or IoT. Besides spraying pesticides, regular monitoring of plants can be done with drones. This study uses a UAV simulation for mapping the location of pesticide spraying, the results of contributions to large areas, and analysis of drone power consumption, which means allocating Drones to the area of land being managed.

Keywords: Automatic Spraying, drone, internet-server, monitoring, power consumption

1. Introduction

A Rice paddy is the core crop of Indonesian society. Rice paddy is one of the essential needs for Indonesian people; regulation and management in rice cultivation are necessary. Rice growth and development need to be monitored continuously to obtain the qualification. So we need the correct medicine for the growth and development of rice plants, one of which is using pesticides. The use of technology in spraying to date has been done manually, which uses a tool containing a container and sprays on rice plants; the rice plant area can be up to 1 hectare. Moreover, 1 hectare of rice can produce 15 tons of rice. Farmers in Indonesia in the dry season can have 35 million rupiahs per hectare to affect the economy of Indonesian society in general. With the correct management of pesticides for maximum results in the quality of rice, plants can significantly increase rice production.

Furthermore, One of the technologies used is drones. The drone is modified to carry at least 1 liter of Pesticide and can spray automatically at a certain distance in the case of the age of rice that has raised dense green rice leaves. Moreover, Drones, also are known as Unmanned Aerial Vehicles (UAVs) [1,2,3,4,5], are aircraft with autopilots. Amount types are based on the use or function of the drones, e.g., photography, capturing objects to obtain photos and videos, and measuring radio waves in the air. In this research, the focus is on the simulation from the developing drone technology based on the weight and size of the drone and its ability to provide load (kg or liter). In this research, pesticides are liquid. This liquid is placed in a particular container in liters. And spray by the drone automatically when the drone moves from point 0 to a certain point precisely on all plant parts. As for the sprayed crop is rice, this paper is divided into several sections, i.e., the basis of rice cultivation, drone technology, and its communication system and the arrangement of the prototype drone, and mathematics on the movement of Unmanned Aerial Vehicle (UAV) or Drone [7, 8, 9, 10, 11, 12, 13].

An unmanned Aerial Vehicle (UAV) [15, 16, 17, 18, 19], quadcopter, or drone has the capacity of at least 2 kg ability to carry loads and fly up to 5000 m (use LoRa). Spraying rice doesn't need a high flight ability, and the load factor is water. Drones must be able to carry and spray pesticides automatically. Drone for pesticides spraying is equipped with four hoses attached to the 4 UAV or drone vanes connected to the mini pump valve.

2. Supporting Data

2.1 Paddy Characteristics

Pest and disease control is carried out by spraying insecticides and fungicides. Moreover, The insecticides used were 250 ml Bestox 50 EC and 25 EC Hamasid for rice plants. The fungicides used were 400 g of Victory Mix 8/64 WP and 250 g of Fitokarb 50 WP. Spraying of insecticides and fungicides is carried out every ten days or seeing symptoms that arise due to pests and diseases in the field (Yoshida 1981). The rice plant classification is as follows: Kingdom: Plantae; Division: Spermatophyta; Subdivision: Angiosperms: Class: Monocotyledoneae: Order: Poales; Family: Poaceae: Genus: Oryza; Species: Oryza sativa L.(Luh 1980). Rice plant roots have a fibrous root system. There are two kinds of root systems: seminal roots that grow from the radicles' primary roots when germinating and are temporary—secondary adventitious roots that branch and grow from the young lower stem nodes. Rice plant roots also play a role in the absorption of nutrients and minerals in the soil.

The rice plant (Oryza sativa L.) is included in the Gramineae group, characterized by a branch composed of several segments. Each segment of the rice plant is not the same length and is covered by leaf books. In the lower part of the book, from the vertebrae grow leaves that bind the knot to the knuckle's top (Makarim 2009). The characteristics of rice leaves are scales and earlobe, as for the parts of rice leaves, namely: 1. The strands of rice are located on the rice stem and are elongated like ribbons. The length and width of the rice depending on the variety. 2. Rice midrib is the leaf covering the branch. Leaf midrib serves to provide support to the soft tissue segment. 3. The leaf tongue is located on the border between the leaf blade and '*upih*.'. The length of the leaf tongue varies depending on the variety.

Rice also has flag leaves. Flag leaves are the top three leaves that are located close to rice panicles. Flag leaf morphology significantly affects yield, seed quality, and production. Rice flowers that grow as a whole are called panicles. The panicle consists of 8-10 nodes, which produce primary branches then have secondary branches. In general, from the root of the panicle, only one primary branch will appear, but the book can produce 2-3 primary branches (Luh 1980). The grain consists of seeds wrapped in husks.

2.2 Paddy Characteristics

The Rice Field mapping is used to determine the direction of the drone and how wide the paddy field will be sprayed with pesticides, here there needs to be managed, i.e., the ratio between the number of liters of pesticide fluid the area of land. Figure 1 shows paddy fields that are not square but have different angles to form a rectangular shape with amount points or squares with different angles. The line formed in figure 1 is the drone's direction in spraying automatic pesticides. Moreover, The land in figure 1 and figure 2 is taken using Google Earth in the village area of Dukuhseti Pati, Central Java, famous for rice paddy fields. Furthermore, Figure 3 shows alternating movements of the drone at a distance of 1 or 1.5 meters when the drone is flying.

Figure 1. The Ricefield rectangle mapping

Figure 2. The Rice Field Free form mapping

Moreover, drones move based on the shape of the paddy field. The wider the battery or power consumption of drones will quickly run out, for this research will discuss how long the battery usage (%). Moreover, a factor besides mileage is power consumption or Battery; in this research, a simulation using Universal Ground Control Software (UGCS) is based on how to manage Altitude, i.e., AGL Altitude, Raw, and AMSL Altitude. Then in Battery (Volt) and percentage of Battery (%), and telemetry (%).

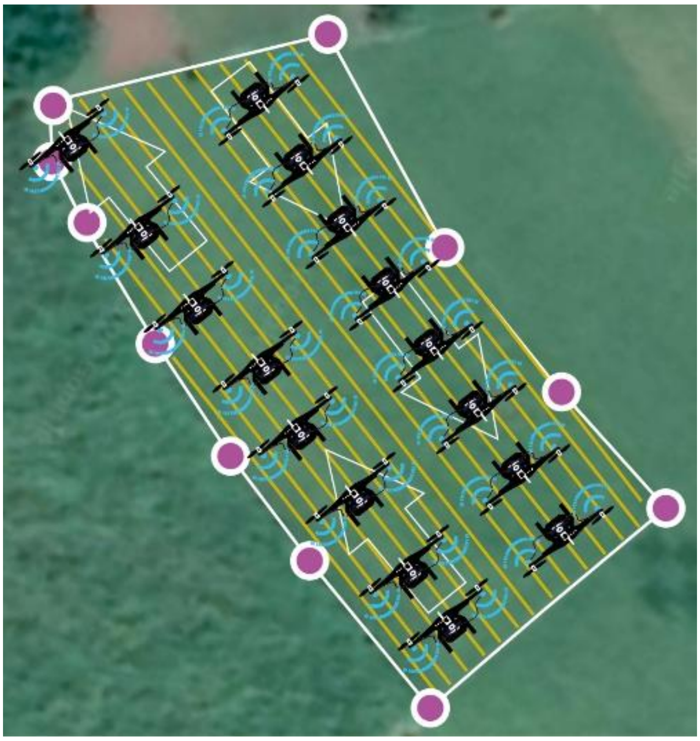

Figure.3. Drone Direction on the rectangle mapping

Figure.4. Drone Direction on the free form mapping

The drone's Altitude for rice plants is 1.5 meters so that water sprayed on parts of the plant can spread more widely. (Figure 5).

2.3 Parameters on Flight

One of the parameters used in this research is elevation, and there is UgCS software. The term elevation is used to measure the height of the drone to be flown. Besides the hill, it is also called Altitude. Altitude is shown in figure 5, i.e., the size of drones and objects such as rice plants, this Altitude is used to measure the level of water spray from the drone to rice plants to ensure that the water sprayed is not too biased or does not focus on the object point. Table 1 shows the parameters used for the flight (Altitude). This parameter is used in the UgCS software used in this research.

Table 1. Parameters on Flight (Altitude)

No.	Parameter	Description
1	AGL	Above Ground Level
2	AMSL	Above Mean Sea Level
3	HAE	Height Above Ellipsoid
4	HAAT	Height Above Average Terrain
5	AFE	Above Field Elevation
6	TDZE	Touchdown Zone Elevation
7	TH	Threshold Height
8	MSL	Mean Sea Level

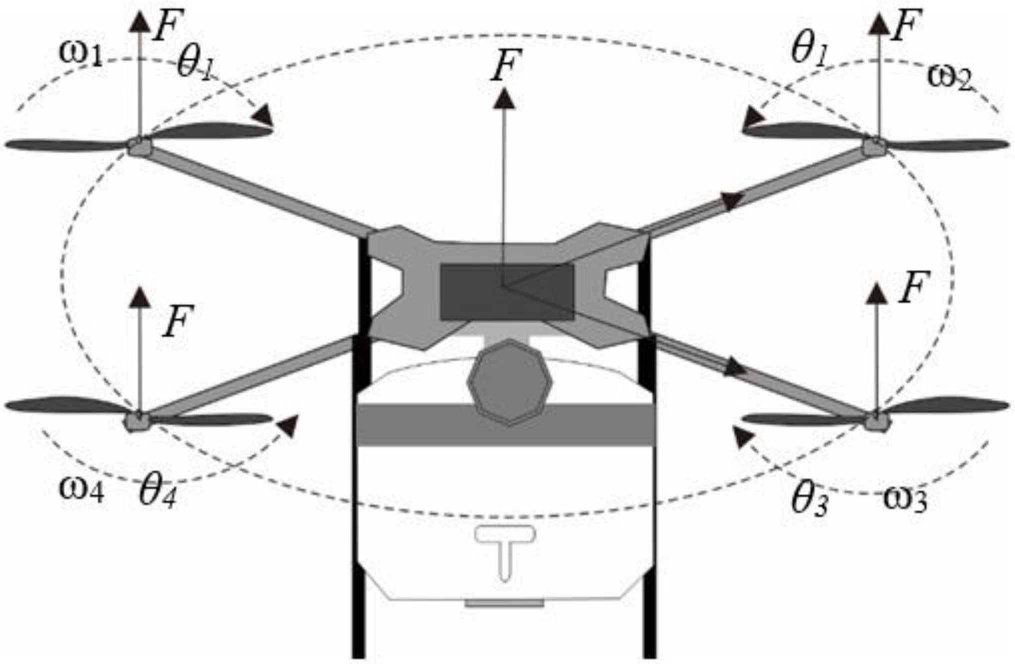

Figure 6. motion, position, and propeller on the drone

In scientific development in the Drone field, the level of analysis is increased by knowing Trajectory and error analysis that can be seen on the server or Web Server [6], in other research Drones are combined with Radio Frequency (RF) devices such as Long Range (LoRa), ZigBee, and Bluetooth Low Energy, and other RF devices analyzed in research [14, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 39].

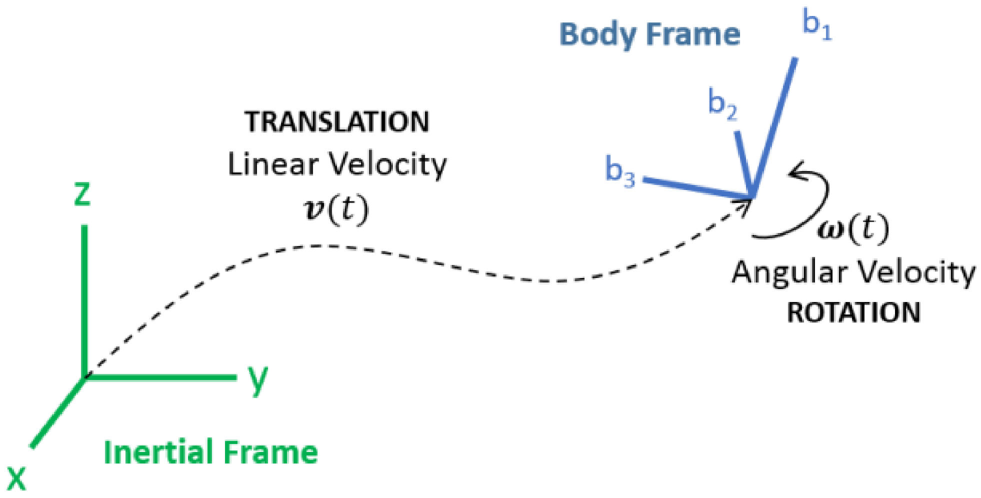

Figure 7. Angular velocity Rotation and Translation Linear velocity

Equation 1, 2, 3, 4 is a math equation that represents the movement of the quadcopter propeller, which is then calculated at the time of the quadcopter [30, 31, 32, 33, 34, 35, 36, 37, 38, 40]. And the matrix of these parameters can be analyzed as in equation 5. The results of this mathematical analysis will vary based on the speed of the propeller the position of the quadcopter that forms an angle of theta value.

Moreover, Figure 7 is the equation used when the drone moves from point A to point B so that the transition or linear velocity (v(t)) and angular velocity (ω(t)) or rotation parameters appear. The drone's take-off position is 2 m above the ground, and the maximum Altitude is 120 m. Other parameters are Latitude, Longitude, Altitude AGL, AMSL, and Raw. Figure 8-10 shows the drone's direction when spraying land on rice plants. Drone movement, every 1 meter turns and points straight by the area and turns back at a distance of 1 meter and so on. This drone movement is made using simulation software.

$$\emptyset = k\,((\omega_1 + \omega_4) - (\omega_2 + \omega_3)) = k\omega_1 - k\omega_2 - k\omega_3 + k\omega_4 \quad (1)$$

$$\emptyset = k\,((\omega_1 + \omega_2) - (\omega_2 + \omega_4)) = k\omega_1 - k\omega_2 - k\omega_3 + k\omega_4 \quad (2)$$

$$\Psi = k\,((\omega_1 + \omega_3) - (\omega_2 + \omega_4)) = k\omega_1 - k\omega_2 + k\omega_3 - k\omega_4 \quad (3)$$

$$F = k\,((\omega_1 + \omega_2 + \omega_2 + \omega_4)) = k\omega_1 + k\omega_2 + k\omega_3 + k\omega_4 \quad (4)$$

$$\begin{pmatrix} \emptyset \\ \theta \\ \Psi \\ F \end{pmatrix} = \begin{pmatrix} k & -k & -k & k \\ k & k & -k & -k \\ k & -k & k & -k \\ k & k & k & k \end{pmatrix} \begin{pmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{pmatrix} \quad (5)$$

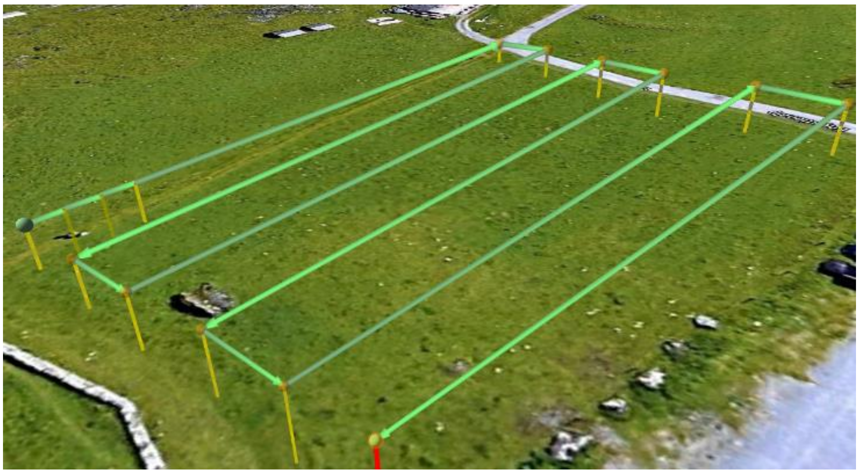

Figure. 8. Motion, position, and propeller on the drone

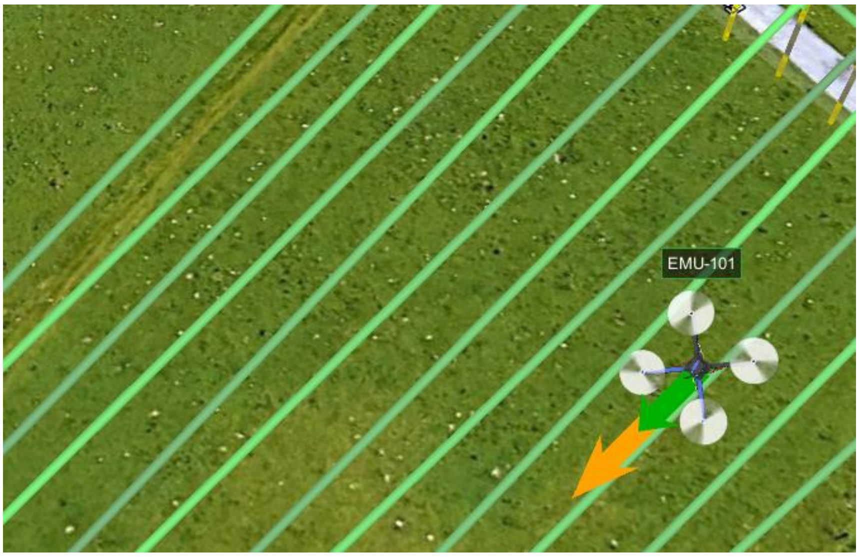

Figure. 9. Emulator Drone Movement

Figure.10. Emulator Drone Movement with the different Altitude

Figure 11 and Figure 12 are the types of routes taken by drones, namely normal routes, and multi-point route conditions that the drone will use to complete the mission. A route like this is seen from the multi-point and diameter distance (meters), which determines the battery percentage (%).

Figure 11. Normal route

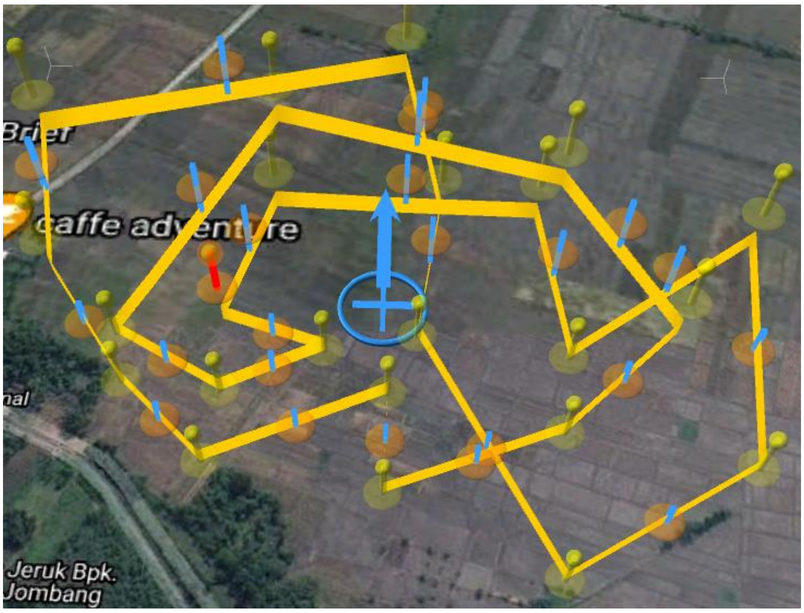

Figure.12. Multi-point route

This section will discuss the relationship between land area or distance (meters) with the Power Consumption of Drones. Table 1 shows the relationship between Battery (%) and length (m). Dan dapat dilihat pada Figure 13. Relationship Flight time and Battery Capacity.

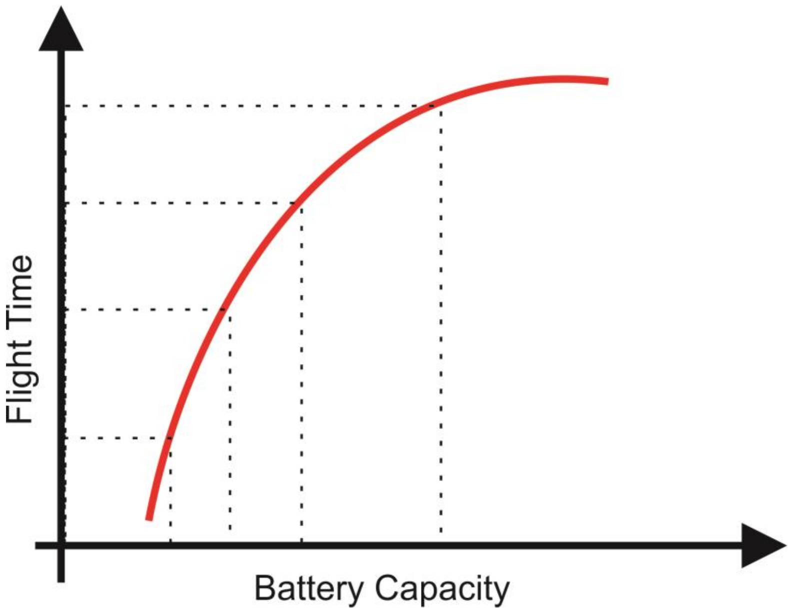

Figure 13. Relationship Flight time and Battery Capacity

3. Method

The method used is the drone spraying pesticide efficiency method, namely by adding the part of the watering stalk that is on the drone as a pesticide spraying stalk to save power consumption. Accordingly, figure 14 is a spraying pesticide with a normal drone and an Altitude of 1 meter; moreover, figure 15 is a spraying pesticide with an Extention stalk drone and Altitude of 1 meter. The advantage of this method of changing the shape of the drone is in the number of plant areas sprayed with pesticides. If the drone typically only has two rows of plants, the extension stalk drone can water three rows of plants in one round, with the addition of a spraying nozzle in the middle of the drone. This technique can save battery energy on the drone, making it more effective.

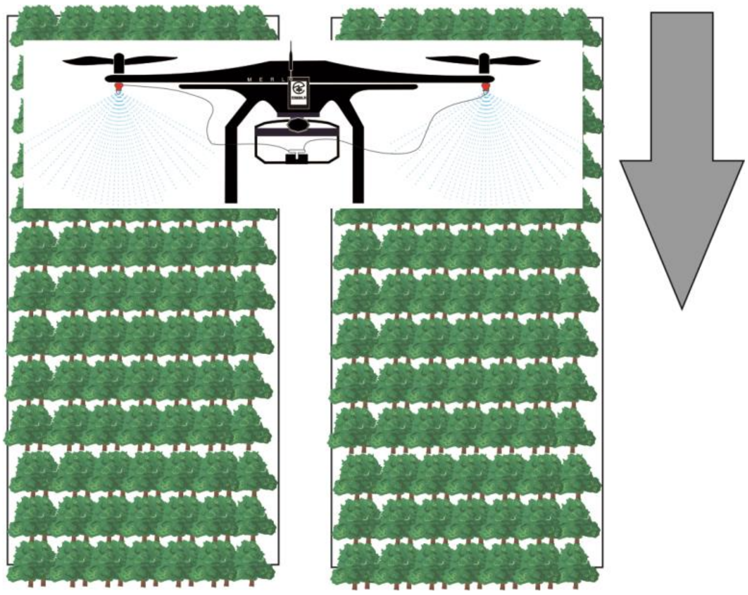

Figure 14. Spraying Pesticide with a normal drone and Altitude 1 meter

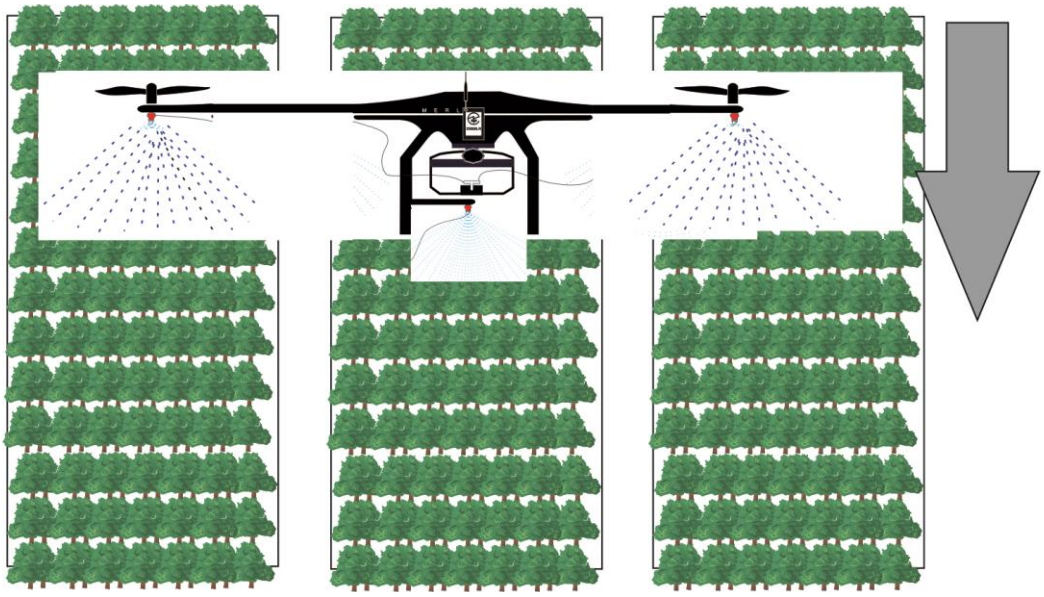

Figure 15. Spraying Pesticide with extension stalk drone and Altitude 1 meter

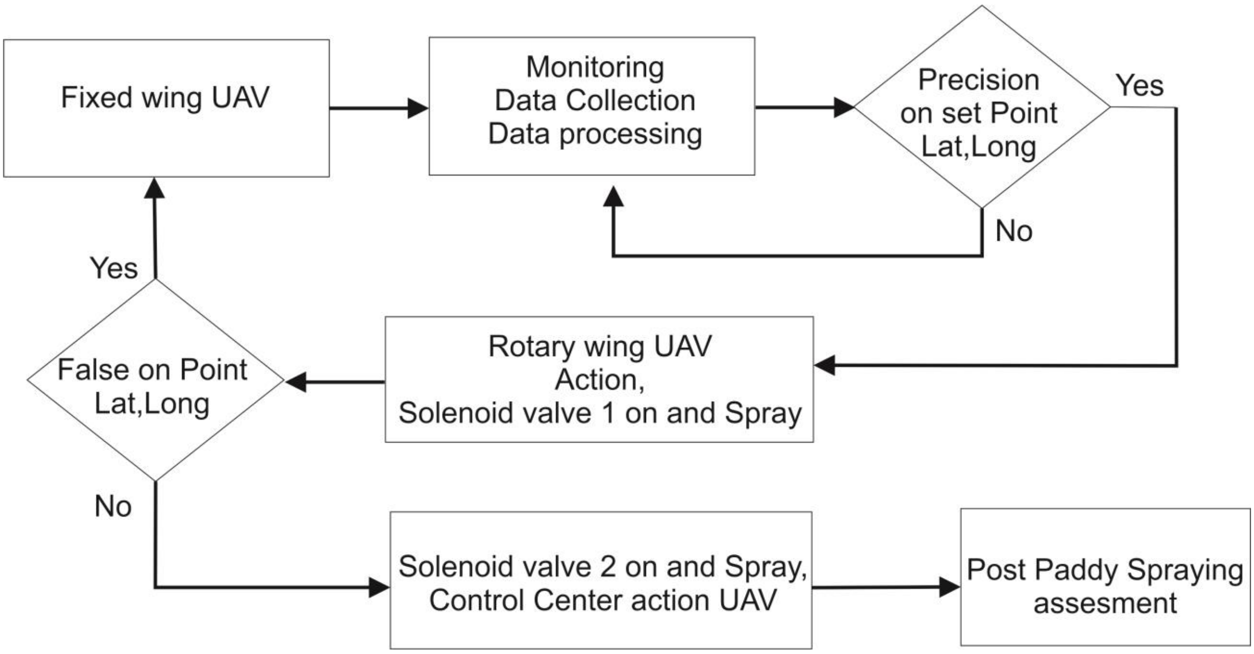

Figure 16. Flowchart a Spraying method of UAV

Figure 16 is a Flowchart of the Paddy spraying system as a whole, and the initial drone system is a fixed-wing UAV after the condition is declared fixed, the next step is to carry out the monitoring process, data collection, and data processing (from this process it is often called a trajectory) and from the monitoring process it can be to see if the flight method of the UAV is in accordance with its Latitude, Longitude, and Altitude points, this trajectory analysis can be seen in Figure 17 [Conte, C [1]]. In Figure 17, errors are found at each point of the comparison between Trajectory Data and Proposed Method Data, but the error value (%) is not significant.

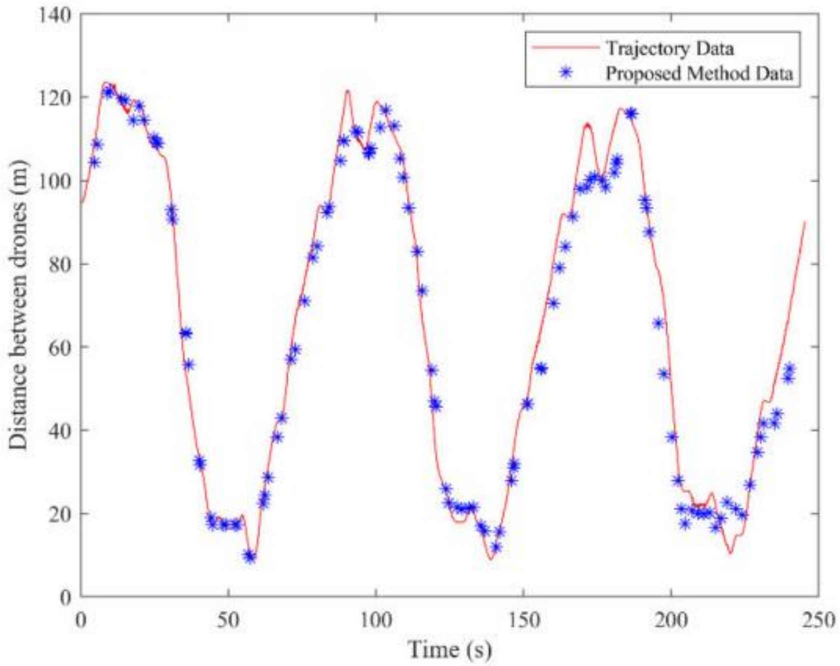

Figure 17. Comparison Trajectory Data and Proposed method Data of UAV

4. Result and Analyzes

Table 1 is Battery (%) with distance Comparison, Flight Speed 5 m/s, Altitude 5 meters. In this condition, it can be concluded that the farther the distance traveled by the drone from 200 meters to 1200 meters or 1.2 km, giving a reduction in battery capacity (%), the decrease is from 91% at 200 meters to 43% at 1200 meters or 1,2 km. Furthermore, Figures 18 and 19 are an example of a Drone Plotter *source:* plot.dronee.aero, which represents the drone position data when flying from point 0 to another point which is data from the Altitude, Latitude, and Longitude points; this facility can use the WEB Browser.

Figure 18. Drone Plotter example

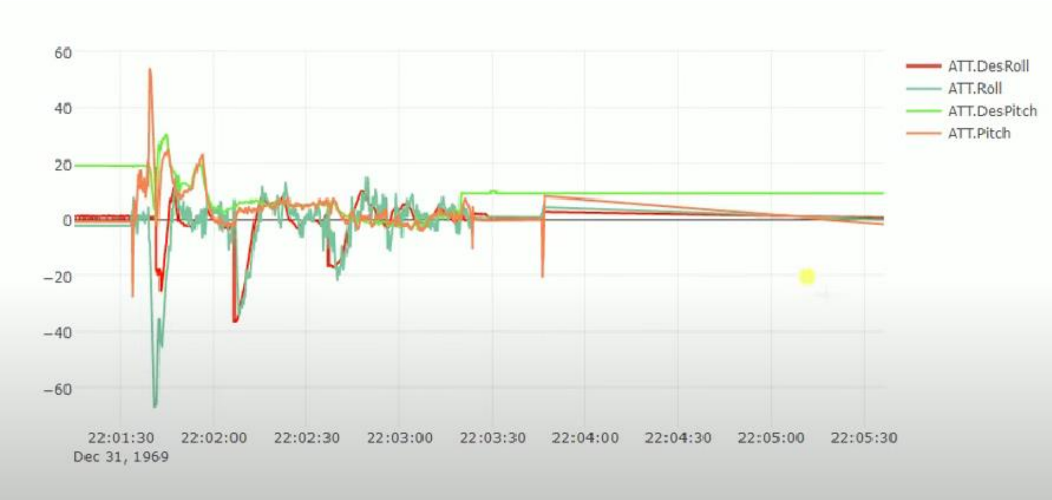

Figure 19. Drone Plotter example

Table 1. Battery (%) with distance Comparison, Flight Speed 5 m/s, Altitude 5 meter

Drone type	**Battery Voltage (V) a**	**Battery Voltage (V) a″**	**Battery (%) b**	**Battery (%) b″**	**Distances (meters)**	**AGL**	**AMSL**
EMU-101	12,4	12,32	100	**91**	**200**	1,3	1841,3
EMU-101	12,6	12,4	100	**85**	**400**	5,2	39,2
EMU-101	12,8	12,6	100	**72**	**600**	5,3	43
EMU-101	13	12,7	100	**63**	**800**	5,0	55
EMU-101	13,6	12,8	100	**54**	**1000**	5,6	65
EMU-101	14	13	100	**43**	**1200**	5,7	78

Source: Experiment and Puput Simulation result

5. Conclusions and Suggestion

In a comparative study between Battery (%) with distance, it was found that Flight Speed 5 m/s, Altitude 5 meters. In this condition, it can be concluded that the farther the distance traveled by the drone from 200 meters to 1200 meters or 1.2 km, giving a reduction in battery capacity (%), the decrease is from 91% at 200 meters to 43% at 1200 meters or 1.2 km. Overall, this system has succeeded in getting the right drone specifications for agriculture. The technique of adding stalks to the drone to take three rows of plants will make drone-based spraying more effective with battery savings (%). The development is carried out with a drone plotter which aims to see the trajectory error of a predetermined route, and this is to improve analysis on the drone.

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Conflicts of Interest: The authors declare no conflict of interest.

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