Drone Waypoint Navigation Using Mission Planner with Dronekit-Python

Agus Trisanto, Darmawan Hidayat, Nendi Suhendi Syafei, Raflyarka Bagastomo, Peri Turnip, Giraldo Faintfmart J.S., and Arjon Turnip

***Abstract* — Technological developments in the industrial era 4.0 are enormous. One technology that is developing rapidly with a lot of demand is Unmanned Aerial Vehicle (UAV) or Drone technology. The use of drones or UAVs is becoming popular in commercial, private or even governmental activities, and it can be seen that there is a possibility that in the future, people will depend on the use of drones which are more practical in their daily activities. The drone used in this question was a custom drone with the F450 design. This Ramble was equipped with a Pixhawk 2.4.6 Flight Controller (FC) development, which has several sensors such as accelerometer, gyroscope, compass, and others. There was also a Raspberry Pi 4 Scaled down Computer which acts as a command provider for the FC. There were 2 systems, namely the Autonomous Navigation System. This information was obtained from the flight controller, such as ground speed, altitude, latitude and longitude. In testing, the autonomous navigation system includes an altitude deviation of 0.5m - 1m and a normal deviation in taking the path after flying 40.99cm. For the monitoring system, the error values were 4%, 9%, and 0.000001% for altitude, moving speed, and latitude and longitude, respectively.**

***Index Terms* — Drone, Autonomous, Navigation System.**

I. Introduction

In the industrial era 4.0, the use of drones or UAVs became popular in commercial, personal or even government activities shown in Fig. 1, there is a possibility that in the future, people will depend on the use of drones which are more practical in their daily activities [1]. Therefore, knowledge and research regarding drones need to be increased so that it is easier to use or implement by the community.

In the use of these increasingly advanced drones, the complexity and complexity of developing drones also increases. Especially demand and maximization in drone development. One of the most complicated things in the development of this drone is in the inner system, namely the processing of drone software so that it can maximize hardware work on drones to carry out navigation and tasks in developing drone automation. Therefore, one way to address this issue and improve drones is to create a sophisticated application that runs on the Onboard Companion Computer and communicates with the ArduPilot flight controller using a low-latency link. Drone-Kit is an answer that can help in making the application and also help in achieving missions in navigation using waypoints.

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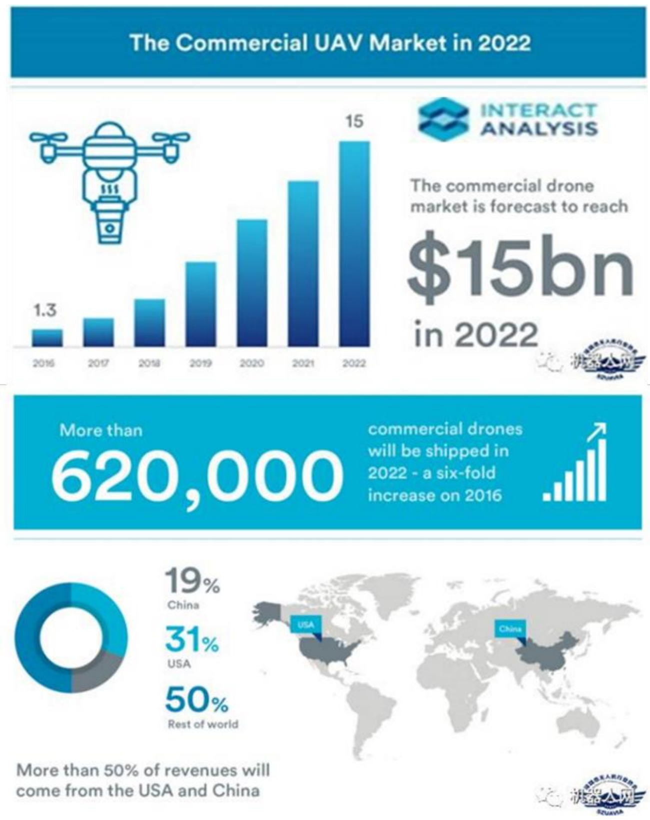
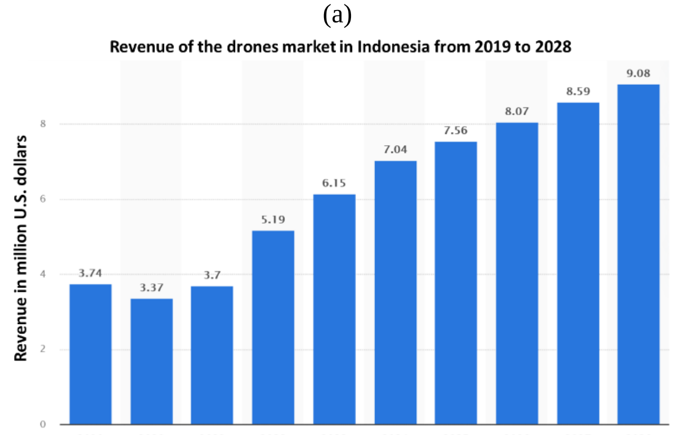


(a)



(b)

Fig. 1. a) an information based on commercial UAV market in 2022 [2], b) an Information of revenue market drones in Indonesia [3].

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DroneKit-Python enables developers to create applications that run on the Onboard Companion Computer and communicate with the ArduPilot flight controller using a low-latency link. Onboard applications can significantly enhance autopilot, add greater intelligence to vehicle behavior, and perform computationally intensive or time- sensitive tasks [4] (for example, computer vision, path planning, or 3D modeling). DroneKit-Python can also be used for ground station applications, communicating with vehicles over a higher latency RF link.

The API communicates with the vehicle via MAVLink. It provides programmable access to connected vehicle telemetry, state and parameter information, and enables mission management and direct control over vehicle movements and operations [5]-[9].

Therefore, we need a navigation system that can fly the drone according to the point that has been given. So, a monitoring system is also needed that can monitor the parameter values of autonomous drones in real time. The system can be accessed by users using various types of devices such as PCs, laptops, tablets and cellular phones that have an internet connection through the media website [10]-[12]. The use of a monitoring system in real time on drones is expected to be a place to make it easier for ordinary users without having to use special software [13]-[16].

II. Methodology

This study was conducted in the University of Universitas Padjadjaran PPBS Parking Area with subjects recorded using the Ardupilot application called Mission Planner. In conducting this study, several stages such as literature study (to find an efficient way to navigate waypoints using a python drone kit). The second stages was an application of drone kit-python using software called Mission Planner which can assist users in carrying out tasks or missions on drones.

The drone used in this problem is a custom drone with an F450 outline. It uses Electronic Speed Control (ESC) to direct the incoming current to the brushless engine to control the engine's rotational speed. The Ramble is equipped with a Pixhawk 2.4.6 Flight Controller (FC) to control the development of drones that have several sensors such as accelerometers, gyroscopes, compasses, and others. There is also a Raspberry Pi 4 Scaled Down Computer which acts as a command provider for the flight controller. The drone is also equipped with a GPS sensor to determine drone development area settings. The following is an autonomous drone block diagram which can be seen in Fig. 2.

A. *Planning a mission with waypoints and events*

To navigate waypoints on mission planners, researchers must open planners to carry out mission planning, where in this section researchers will determine the points in making waypoints. In carrying out mission planning, the home position is needed to determine the starting point for take-off, this position is used so that the drone can return to its starting point again. Mission planning is the most important thing in determining navigation because in mission planning, waypoints will be determined. The Mission Planner can also create a mission for the user, which can be used as a mapping mission, where the drone should just go back and forth in a lawnmower pattern over an area to collect photographs. The map of 6 waypoints on mission planer is shown in Fig. 3.

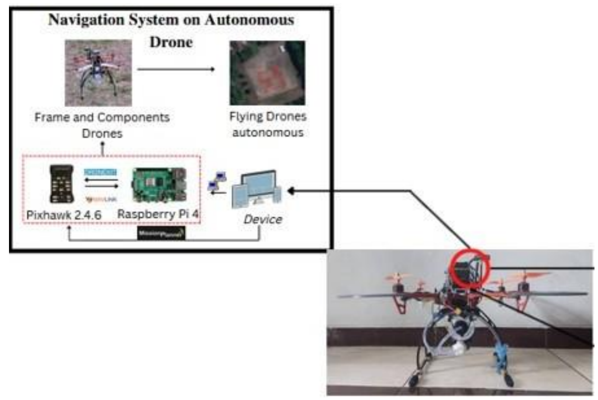

Fig. 2. Autonomous Drone Block Diagram.

Fig. 3. Making 6 Waypoints on Mission Planner.

B. *Mission Commands*

When creating a waypoint for the planner, operator must first connect the drone to the firmware that the mission planner will read. Determination of the waypoint is carried out after determining the home-point. In this case the researcher made 6 waypoints where the 6th waypoint tracked back to the home point. As can be seen in Fig. 3, waypoint input is carried out independently, where the researcher must fill in the altitude or height of the drone when it flies and passes through the waypoint area. As can be seen in the Fig. 4, apart from just forming waypoints, it can also make drones perform other missions such as making rotations on a scale and so on.

Fig. 4. Making Waypoints Settings on Mission Commands.

During the flight of an autonomous drone there are several variable differences between the data generated by the GPS, the position of the drone, and the mission [17]-[19]. The data seen in this navigation system is latitude and longitude data from various sources, namely GPS and drone position [20]-[21]. From this data will be analyzed whether the drone is in accordance with the mission or has a high error value when compared to the flight plan. Then the data that is seen is drone altitude data by comparing altitude data sourced from AHR2, GPS, POS and sourced from Barometer, Control, Throttle and Altitude Information (CTUN). From these data it will be seen the error value of each variable.

This study was conducted in the Basic Science Service Center (PPBS) field as a place for developing and testing tools as shown in Fig. 2. The assembly and integration of the tools will be carried out at the PPBS Laboratory Building C, 3rd floor in the area of the Basic Science Service Center Building, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor Campus, shown in Fig. 5.

Fig. 5. Pusat Penelitian Basic Science (PPBS) field.

III. Results and Discussion

In this study experiment, drones can fly autonomously using predetermined navigation waypoints. Just like the previous statement, the researcher uses 6 coordinates as waypoints that will be passed by the drone. In the mission planner application, this drone flight has been set at an altitude of 3 meters with a speed of 2 m/s and a maximum acceleration of 1.25 m/s2. Drone flight data with predetermined waypoints is shown in Fig. 6.

Fig. 6. Determined 6 Waypoints.

Numerous sensors, including an accelerometer, gyroscope, compass, barometer, and others, are located on the flight controller. The x, y, and z axes of the drone's displacement are measured in translational speed by the accelerometer. When the drone is navigating, the gyroscope will determine the tilt of the drone. When the drone is flying and navigating, the compass is helpful for determining direction. While the drone is in flight, the barometer will gauge air pressure. Several parameter data from sensors on the Pixhawk flying controller will be displayed in graphs for analysis in this study. Altitude, ground speed, latitude, and longitude make up the parameters. Additionally, some data will be filtered out in advance to lessen noise. Fig. 7 shows the plotted graph made with the Pixhawk flight controller.

The results of plotting altitude data from AHR2, GPS, and POS sources are displayed in Fig. 7. The Pixhawk flying controller has this information on it. There are some discrepancies between each data source from the graph. The measurement from each source differs significantly enough in the first 10 seconds, by about 0.5 to 1 m. Additionally, as of 03.10, the variables' value differences are getting less. The three variables then differ by between 1 and 3 m once the data has been averaged. After that, after 3.16 minutes, there was a significant variance; each variable had a difference of 2 meters, and the GPS height had a 4-meter divergence from the POS height. The altitude sourced from AHR2, GPS and POS are the height of the drone when measured from sea level not to ground level.

Fig. 7. GPS, AHR2, POS altitude data.

The results of plotting altitude using the barometer and POS HOME ALT are displayed in Fig. 8. Fig. 8 is the altitude measured above the ground, as opposed to Fig. 7, which has a different altitude. While the altitude as measured from sea level is shown in Fig 7. There are variations in the consistency of the data, as you can see from the graph. Data obtained from the barometer has a tendency to fluctuate because it is unfiltered and is obtained directly from the barometer sensor. However, because it has been filtered, the altitude data obtained from POS HOME ALT data has a tendency to be more consistent. The results of plotting altitude using the barometer and POS HOME ALT are shown in Fig. 8.

The plotted latitude and longitude values are displayed in Fig. 9. Latitude and longitude data are essentially the drone's earth coordinate position. Using this information, we can determine how the drone travels to each waypoint and how it returns to its starting place.

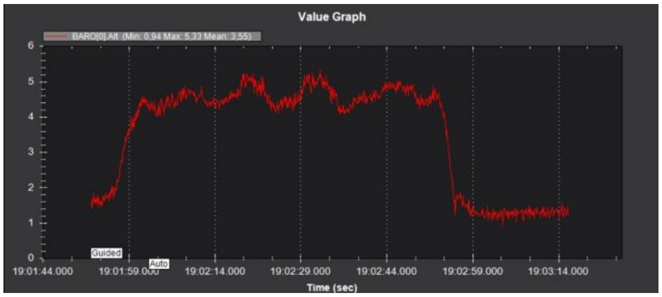

Fig. 8. Barometer altitude data.

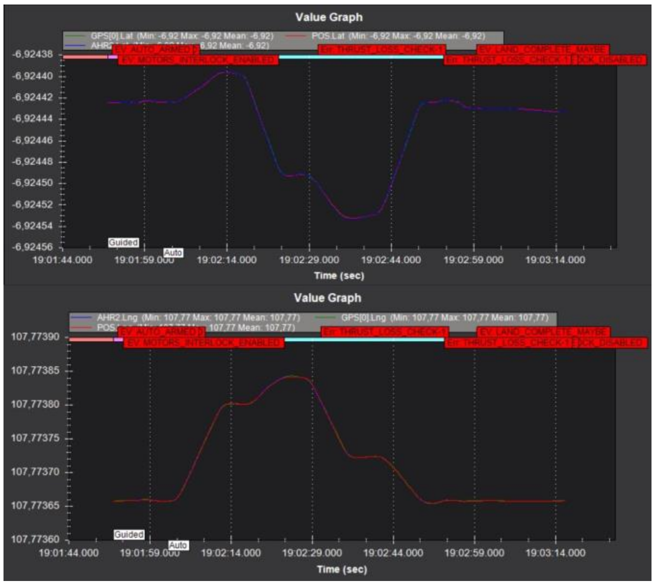

Fig. 9. a GPS, AHR2, POS latitude data, b GPS, AHR2, POS longitude data.

The results of graphing ground speed data are displayed in Fig. 10. Ground speed is the speed of a drone relative to the surface of the earth, calculated by dividing the distance between the drone's starting point and its destination by the time traveled between the two points. The graph demonstrates that there is a fourfold increase in ground speed. This is because the drone will linger at the waypoint in order to rotate its location, after which it will take off again with a greater ground speed.

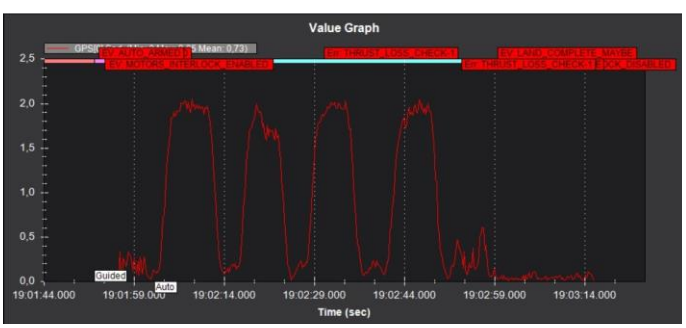

Fig. 10. Ground speed data of GPS.

Fig. 11 depicts the deviation of actual flight paths from the anticipated flight patterns. The purple line shows the optimal flying pathways, the blue line represents the actual location of the drone as determined by GPS, and the red line indicates the drone's predicted position as determined by AHR2. To determine the deviation, the distance between the blue line perpendicular to the purple line, representing the ideal flight route, is measured. Maximum variation from point 1 to point 2 is 23.08 cm, from point 2 to point 3 is 15.38 cm, from point 3 to point 4 is 46.15 cm, from point 4 to point 5 is 40.85 cm, and from point 5 to point 6 is 38.46 cm. In point 6, the drone hovers for approximately 2 seconds with a variance of 30.76 cm. After hovering, the drone will return to its initial position and land. The drone itself lands 92.3 cm away from where it took off.

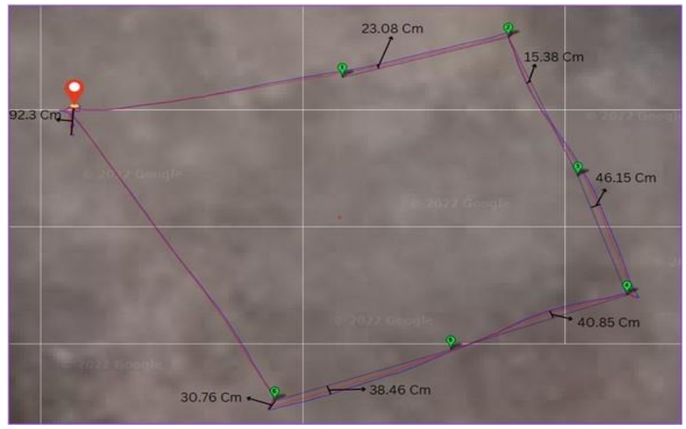

Fig. 11. Flight path deviation.

Various causes may contribute to these variances. Strong gusts of wind can force the drone's flight route to deviate, and the drone cannot maintain its optimal flying path. Considering that the drone we are utilizing is rather small and sensitive to wind gusts. In addition, the state of the drone itself can influence the deviation of the flight route. The state of the drone consists of the health of the motor and electronic speed controller (ESC), the weight it carries, and the configuration of the internal parameter. The numerical data of ground speed, altitude, longitude, and latitude data which obtained from GPS log are given in the Table I.

TABLE I. DATA LOG OF GROUND SPEED, ALTITUDE, LONGITUDE, LATITUDE

t (s)	Ground Speed	Altitude	Longitude	Latitude
1	0.003	0.048	107.7736568	-6.9244200
3	0.072	0.293	107.7736582	-6.9244200
5	0.161	2.220	107.7736585	-6.9244250
7	0.064	2.967	107.7736572	-6.9244220
9	1.678	2.810	107.7736832	-6.9244230
11	1.916	2.840	107.7737545	-6.9244070
13	0.165	2.910	107.7738009	-6.9243970
15	0.338	3.030	107.7738005	-6.9243980
17	1.494	3.170	107.7738229	-6.9244540
19	0.188	3.020	107.7738414	-6.9244910
21	0.327	2.990	107.7738398	-6.9244910

23	1.801	2.970	107.7737841	-6.9245100
25	0.563	2.966	107.7737249	-6.9245320
27	0.204	3.039	107.7737230	-6.9245310
29	1.622	2.980	107.7737198	-6.9245250
31	1.990	3.120	107.7736542	-6.9244560
33	0.145	3.080	107.7736573	-6.9244250

IV. Conclusion

In this paper, the drone that is capable of traveling independently by following a six-way itinerary has been created. The programmed drone can depart and return to its point of origin without significant errors. In the flight sequence, the drone has flown past the waypoint at an altitude of approximately 3 meters above ground level with an initial time of 1 second. The primary drone has been at an altitude of 0.048 meters above the ground and has reached a maximum altitude of 3.170 meters for 33 seconds out of 3 flight minutes, according to the data collected. For future studies, ideally, it can be redeveloped with a higher degree of precision.

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