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Application of UAV Communication Using An Antenna Tracker based on a Global Positioning System (GPS)

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ABSTRACT

An Antenna Tracker is a system that automatically directs an antenna toward a specific signal source like a satellite or moving object, commonly used for communication, weather monitoring, or controlling drones. The study aims to develop a GPS-based antenna tracker to improve accuracy and speed. It uses GPS coordinates to ensure precise tracking. Challenges in data processing arise when not in mission mode, such as interference from high-rise buildings when manually operating the UAV. The GPS module showed a standard deviation of 0.7 for the average distance value. By using the GPS Positioning method, the antenna tracker can perform accurate rotation with Pulse Width Modulation (PWM) signals on the pan servo, namely RC1_Min = 800, RC1_Max = 2200, RC1_TRIM = 1500, and the tilt servo, namely RC1_Min = 1100, RC1_Max = 1900, RC1_TRIM = 1500. The pan servo rotates 180 degrees and the tilt servo rotates 90 degrees.

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1. INTRODUCTION

In modern times, network and communication technology are integral parts of human life, making our lives much easier [1]. Over the past 60 years, antenna technology has played a crucial role in the evolution of networks and communications [2]. One example is the Antenna tracker, which converts electromagnetic waves into a tool for providing information and communication in the field of unmanned aerial vehicle [3].

The Antenna Tracker is a system designed to detect moving signal sources [4]. It can move horizontally and vertically [5]. The main components of the tracking antenna are a GPS module and a height sensor, which are used in the process of detecting unmanned aerial vehicles (UAVs) [6]. The movement system on the tracking antenna follows the coordinates produced by the Global Positioning System (GPS) to enable the antenna to communicate and receive real-time data from the Ground Control Station (GCS) [7]. This responsive movement ensures that the data obtained is accurate, as the antenna constantly follows the GPS coordinates [8].

The current antenna tracker operations still rely on a control system that uses a mini USB cable directly connected to the antenna tracker [9]. Communication works well, but it has one drawback: the distance between the tracker antenna and the connected one is limited [10]. On the plus side, it reduces the delay in attitude value connected to the antenna tracker for the software used [11].

A telemetry system is used for measuring distances remotely and reporting information to software. Telemetry refers to wireless communications, such as radio, ultrasonic, or infrared systems [12]. For example, telemetry can receive real-time data from the vehicle, such as height, speed, and horizontal and vertical angle data. This allows the antenna tracker to follow the vehicle's movement [13].

In a data transmission system, a crucial component is the 433 MHz telemetry antenna. The antenna needs to be capable of detecting the direction of the UAV signal [14]. This allows the tracker antenna to track the UAV signal's direction and retrieve height and speed data from the UAV [15]. Various types of antennas are commonly utilized, including dipole antennas, skew-planar antennas, cloverleaf antennas, and patch antennas [16]. The choice of antenna type significantly impacts the construction of a communication system between the antenna tracker and the UAV [17].

This antenna tracker, constructed to replace the GCS, utilizes mission planner software. The software displays data including speed, telemetry signals, and horizontal and vertical angular attitude responses to track the UAV [18]. The communication between the antenna tracker and the UAV is facilitated by a 3DR 433Mhz Radio Telemetry module [19].

2. RESEARCH METHOD

2.1 Antenna Tracker Design

In the process of designing the antenna tracker, several steps are involved. The first step involves printing an acrylic sheet cut to the required size. The size of the acrylic sheet is adjusted to fit the inner and outer circumference according to the bearing size. The next step is to install a spacer to create distance between the top mount and the bottom mount of the bearing. This same process is repeated for the servo mounting holder and antenna pole. This design allows the servo to move freely and ensures that the resulting data values are maximized. Figure 1 shows the design of the tracking antenna.

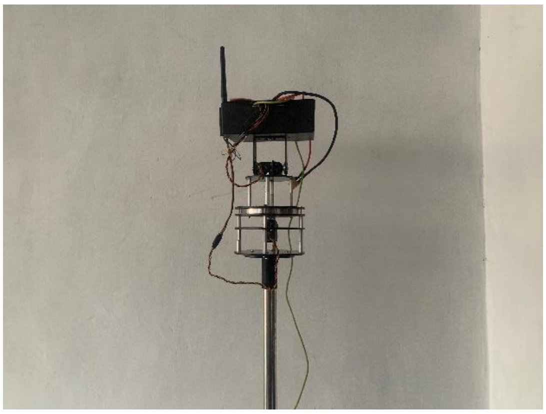

Figure 1. Design shape of the antenna tracker

2.2 Wiring Design

After designing the antenna tracker, the next step is to carry out the wiring design for the tracking antenna system. This wiring includes several components: a flight controller, GPS module, telemetry radio, power supply, pan and tilt servo. The flight controller used is the Mateksys F765-WING, which has a special port for connecting a GPS module, enabling features such as Return-to-Home and automatic navigation [20]. The GPS module used is the Ublox M10Q-5883, and it plays a crucial role in the data collection process by allowing researchers to read the coordinate points between the tracking antenna and the UAV. Additionally, the 433MHz 100mW radio telemetry module, with its output power of 100mW and a frequency of 433MHz, supports various communication protocols for airplanes, drones, remote control cars, and tracking antennas. During the wiring process, it's important to refer to the instructions for use and specifications of each component to ensure proper integration [21].

Table 1. Rescue the wiring of antenna tracker

No	Component	Addres
1	Pan Servo	Channel 3
2	Tilt Servo	Channel 4
3	LiPo Baterry	Power
		Ground
		DA
		CL
4	GPS	Rx
		Tx
		VCC
		Ground
		RTS
		CTS
5	Telemtry Radio	Rx
		Tx
		VCC

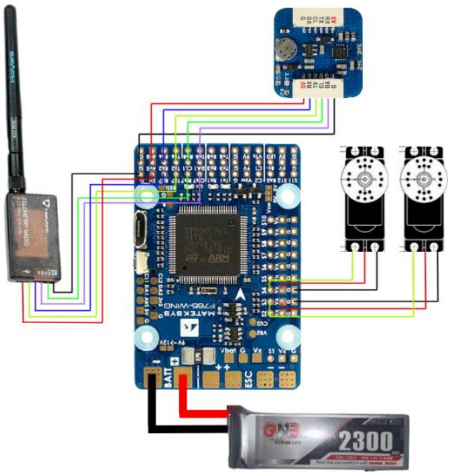

Figure 2. The antenna tracker wiring display

2.3 Block Diagram Design

The design of this system requires the creation of a system block diagram to provide an overview of how the antenna tracker works. It is expected that the device can function properly [22]. They allow us to analyze how a circuit works and to design general hardware.

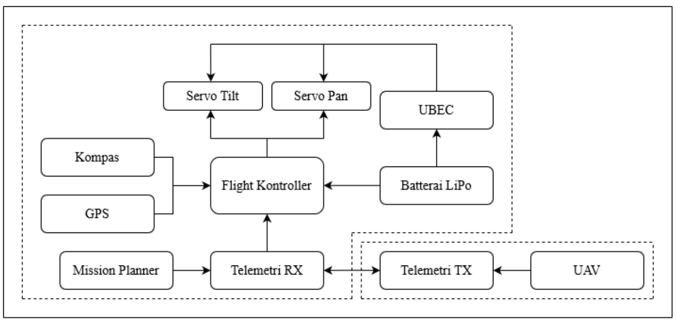

Figure 3. Block diagram system

2.4 Software Design

The program is designed to track and adjust the position of the UAV automatically based on coordinate information from the GPS system on the antenna tracker [23]. In this process, the flight controller receives information from various components, which is then converted into the output values for the two servos [24].

The software utilized in this study is Mission Planner, an open-source program employed for mission planning and control on UAVs or drones.

Mission planner is used to design and organize UAV flight missions. It has an easy-to-understand user interface and supports applications such as aerial surveying, mapping, and environmental monitoring [25]. Figure 4 is a flowchart of the antenna tracker software system.

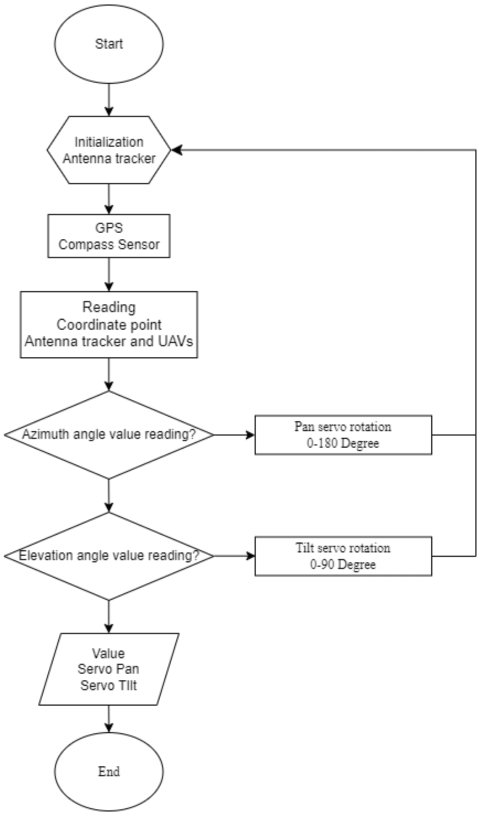

Figure 4. Flowchart diagram system

3. RESULTS AND DISCUSSIONS

3.1 GPS Module Testing

This test involves the Ublox M10Q-5883 Module. Before conducting performance experiments, the module's specifications are recorded by reviewing its datasheet [26]. The GPS test aims to determine the distance, longitude, and latitude between a antenna tracker and a UAV coordinate point. The Mission Planner Software is used for the GPS Module reading [27]. The test was conducted to assess the GPS module's capability to periodically read coordinates and distances. The test results are shown in Table 2:

Table 2. Distance comparison testing of antenna tracker

Antenna Tracker		Unmanned Aerial Vehicle		Calculation Distance (m)	Module Distance (m)	Distance Difference (m)
Latitude	Longitude	Latitude	Longitude			
-7.8345036	110.3832519	-7.8344221	110.3833132	11.3	10	1.3
-7.8345107	110.3832914	-7.8343584	110.3833955	20.4	20	0.4
-7.8344949	110.3832834	-7.8342848	110.3834576	30.2	30	0.2
-7.8344931	110.3832722	-7.8342090	110.3835038	40.6	40	0.6
-7.8344967	110.3832710	-7.8341161	110.3835074	49.6	50	-0.4
-7.8344900	110.3832680	-7.8339571	110.3833476	59.9	60	-0.1
-7.8344891	110.3832767	-7.8338625	110.3833757	70.5	70	0.5
-7.8344931	110.3832685	-7.8337916	110.3833913	79.2	80	-0.8
-7.8344943	110.3832643	-7.8337365	110.3835535	90	90	0
-7.8345026	110.3832580	-7.8336236	110.3836129	104.8	100	4.8
-7.8344991	110.3832652	-7.8335979	110.3836990	110.6	110	0.6
-7.8344868	110.3832639	-7.8335517	110.3838139	120.3	120	0.3
-7.8344921	110.3832498	-7.8334821	110.3838751	131.3	131	0.3
-7.8344913	110.3832668	-7.8334613	110.3839604	137.6	140	-2.4

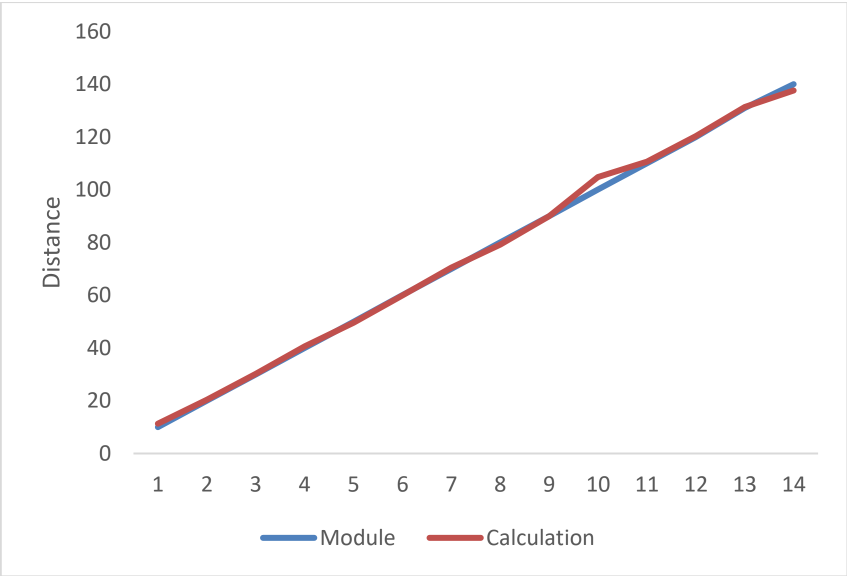

Figure 4. Distance testing

After obtaining the distance, average, and standard deviation values, the next step is to calculate the azimuth and elevation for analysis. In this study, the Omnicalculator application was utilized to streamline and standardize the data analysis process. The azimuth value involves several data processing steps, including calculating the altitude distance, computing the longitude distance, and deriving the two points [28]. The calculated azimuth and elevation angles are detailed in Table 3.

Table 3. Azimuth and elevation angle values

Azimuth Angle (deg)	Elevation Angle (deg)
36.7	0.5
34.1	0.28
39.4	0.18
38.9	0.14
31.6	0.23
8.4	0.38
8.8	0.40
9.8	0.43
20.7	0.38
21.8	0.43
25.5	0.41
30.2	0.38
31.5	0.48
33.71	0.37

The results of the azimuth angle calculation test yielded a range of 8.4 to 39.4 degrees, while the elevation angle ranged from 0.18 to 0.5 degrees. The graph depicting the azimuth and elevation angle testing is displayed in Figure 5.

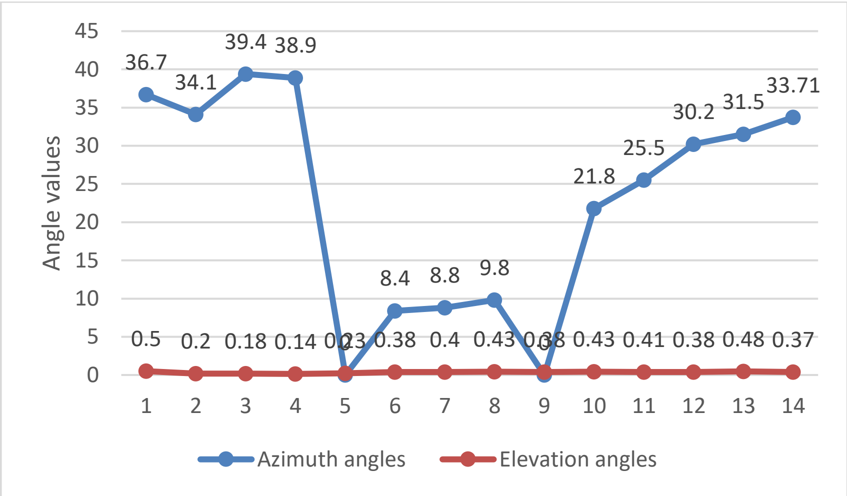

Figure 5. Graph of Azimuth and Elevation angles

3.2 Pan and Tilt Servo Rotary Motion Testing

The test involves a pan servo that moves 180 degrees and a tilt servo that moves 90 degrees. This pan and tilt servo system requires several tests to ensure that the tracking antenna functions properly and can accurately follow the signal source on the UAV.

The initial stage carried out is to determine the servo motion configuration in the form of a PWM (Pulse Width Modulation) signal value. The pan servo has a pwm value of 800 to 2200. While the tilt servo has a pwm value of 1100 to 1900. Furthermore, perform simulations to test conditions on the tracking antenna such as performing servo motion orientation. So that researchers are able to overcome or give orders in these situations. This test is carried out at different coordinate points so as to get accurate pwm values.

This process involves directing the UAV to a specific location so that the tracking antenna can accurately detect the UAV signal source. The data collection results of servo PWM and tilt values are presented in Table 4.

Table 4. Pan and Tilt servo pwm values

Distance	Servo Pan	Servo Tilt
11.3	1445	1200
20.4	1460	1200
31	1542	1200
40.5	1514	1200
49.5	1504	1200
59.6	1424	1200
70.2	1431	1200
78.8	1562	1200
89.7	1453	1200
104.8	1399	1200
110.6	1418	1200
119.9	1549	1200
131.3	1624	1200
137.2	1513	1200

In this test, the rotating movement of the pan servo produces a Pulse Width Modulation (PWM) signal value of 1399 to 1624. However, the tilt servo is unable to respond to the direction of rotation because the test is not in flight mode on the UAV. As a result, the servo tilts produce a Pulse Width Modulation (PWM) value of 1200. The graph of the rotating motion of the pan and tilt servo can be found in Figure 6.

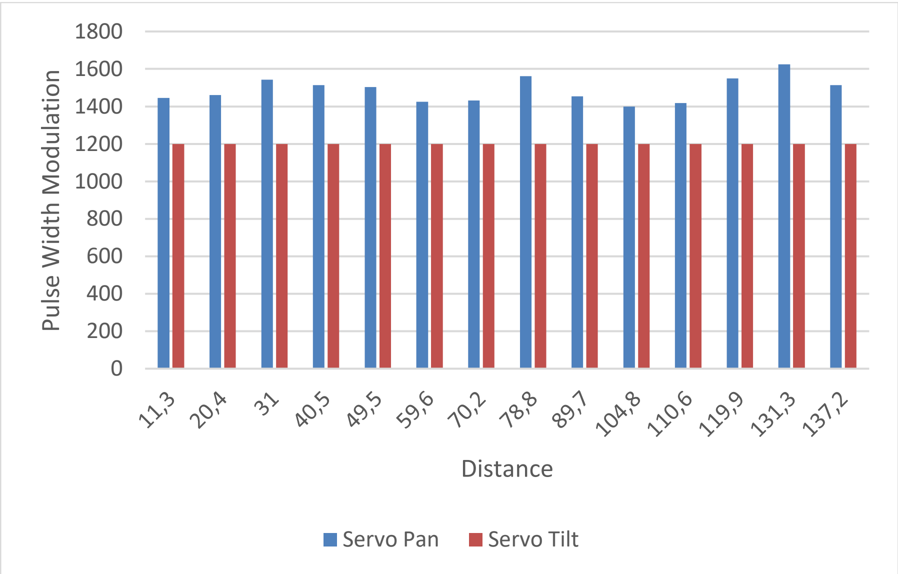

Figure 6. Graph of Pan and Tilt servo rotary motion

4. CONCLUSION

Based on research entitled "Application of UAV Communication Using An Antenna Tracker based on a Global Positioning System (GPS)" it can be concluded that there is a positive and significant influence. In testing the tracking antenna communication with the UAV using the GPS Positioning method which shows that the tracking antenna can follow the UAV well and accurately. The tracking antenna can track the UAV according to Mission Planner commands and can display information between the tracking antenna and the UAV such as data on coordinate point values, distance and servo rotational movements. The GPS Testing Module can produce quite accurate coordinate points and obtain measurements of distance differences with an average standard deviation value of 0.7. From the results of testing the rotational motion of the pan and tilt servo using the GPS positioning method, the tracking antenna was able to perform fairly accurate tracking, with Pulsewidth Modulation (PWM) signal values on the pan servo, namely RC1_Min = 800, RC1_Max = 2200, RC1_TRIM = 1500 and on the tilt servo i.e. RC2_Min = 1100, RC2_Max = 1900, RC2_TRIM = 1500.

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