Flying Pipe Inspection Robot Report

Jan 2024 – April 2024

Overall Handsketch Design

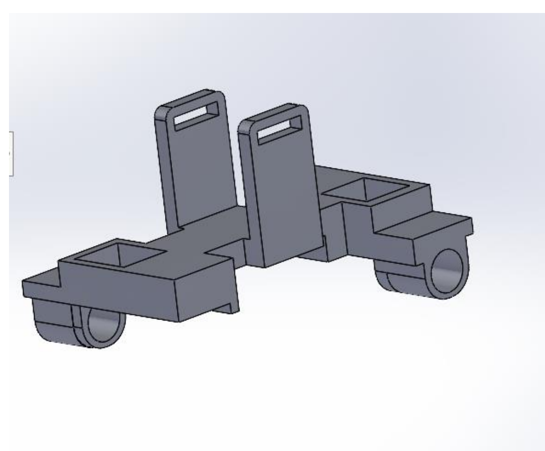
This design prioritizes simplicity for ease of construction and adherence to deadlines. The robot consists of two main parts: a chassis and a drone body.

- **Chassis**: The chassis is the base of the robot and houses the two wheels. It should be sturdy enough to support the weight of the robot and be designed to allow for easy attachment of the drone body.
- **Drone Body**: The drone body sits on top of the chassis and houses the brushless motors and propellers that will enable the robot to fly. It will also house other components such as the battery, sensors, and any electronics necessary for control.

Body and Chassis Design

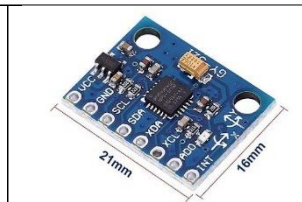
Your design uses a Betaflight Meteor85 drone kit for the main flight body. The chassis should be designed to connect securely to the Betaflight Meteor85 body. Here are the key considerations:

- **Dimensions:** Measure the Betaflight Meteor85 body to ensure your chassis design fits it exactly.
- **Connection Points:** Design the chassis to have mounting points that match the Betaflight Meteor85 body for a secure connection.
- **Material:** Choose lightweight, strong material like ABS or PLA filament for the chassis.



List of components.

Part	Components	Weight (1 piece)	Dimensions	Price (1 piece)	Amount	Reference
1.	Betaflight Flight Controller F4 AIO 1-2S 12A V2.2	4.23 g	5.5L*5.5W *2H centimeters	39.99 USD	1	
2.	ABS 3D Printing Case Betafpv Meteor85 Whoop Frame kit	11.32 g	15.5L*15.5L *3H centimeters	7.99 USD	1	
3.	Propellers Gemfan 2015 2-Blade	0.5 g	2” Diameter 1.0mm Shaft 1.5” Pitch	1.00 USD	4	
4.	1103 11000KV Motors	3.3 g	14mm Height 1.5mm Shaft M1.6 Hole 8.5mm Dia	9.99 USD	4	
5.	LAVA 2S 450mAh 75C 7.4V Lipo Battery	28.8 g	60.8L*15.2W 14.5H millimeters	12.99 USD	1	

6.	ESP32 Node MCU	10 g	6L*3W*2H centimeters	5.66 USD	1	
7.	3.3Vdc Brushed Motor	11 g	3L*1.2W*1H centimeters	8.49 USD	2	
8.	Other, IC, Voltage Regulator, PCB etc.	< 30 g	In One Board ~15L*15W *0.2H centimeters	< 5 USD	TBA	  
9.	GY-521 MPU6050 3 Axis Module	2.7 g	21mm * 16 mm	1.48 USD	1	
10.	BLHELI 12A Brushless Motor ESC BEC Output	9 g	25L*20W*7H millimeters	6.97 USD	4	
	total	164.25g		156.8 USD		

Testing Components

This report details the testing and integration procedures conducted for a mobile robot with both wheeled and flight system functionalities. The testing focused on evaluating individual components and resolving encountered challenges to achieve a stable and controllable robot.

1. Introduction

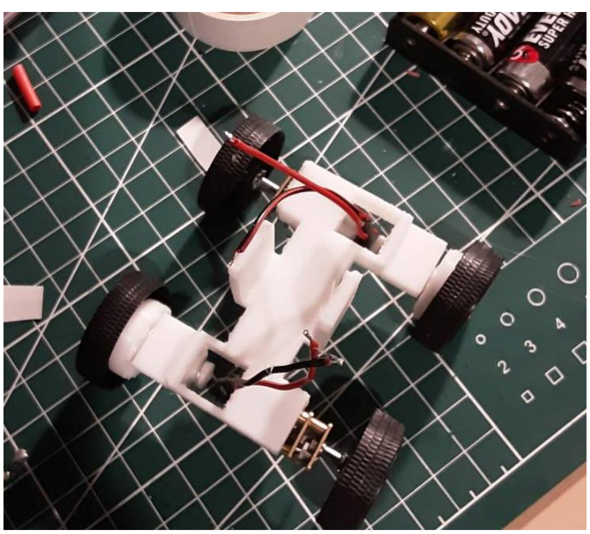
The experiment aimed to develop a mobile robot capable of ground and aerial movement. This report details the testing processes for the key components in each system:

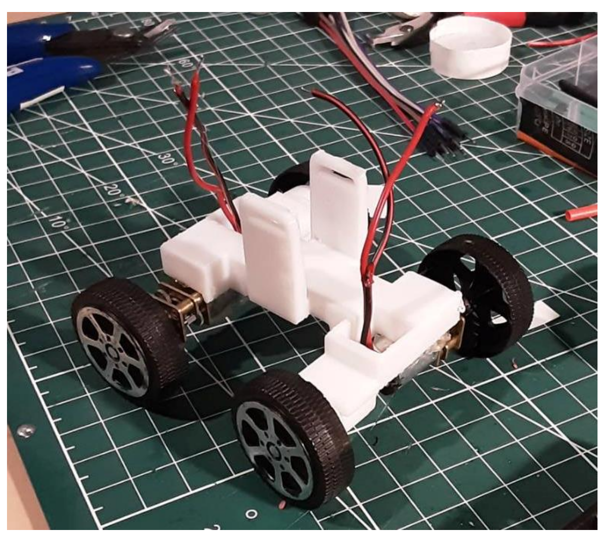
- **Wheel System:** DC motor, chassis structure, and wheel structure.
- **Flight System:** Brushless motors with ESCs (Electronic Speed Controllers), gyro sensor, communication protocol, and control method.

2. Wheel System Testing

2.1 Observations

Initial testing revealed instability in the front wheel, causing the robot to veer off course and travel in a curved path.





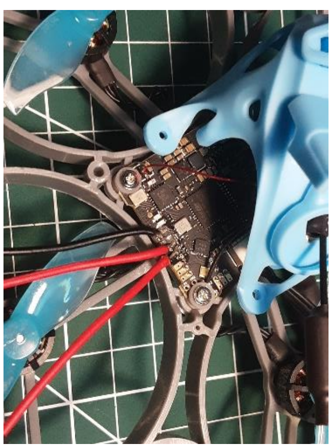
2.2 Solution

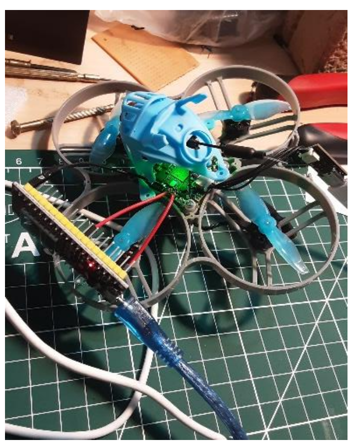
The front wheel was secured using glue to enhance its stability. This intervention resulted in straighter travel for the wheeled system.

3. Flight System Testing

3.1 Communication Protocol

The initial approach involved using an ESP32 microcontroller to communicate with the flight controller board via the SBUS protocol. However, after numerous attempts, configuring the flight controller board for successful SBUS reception proved challenging and time-consuming.



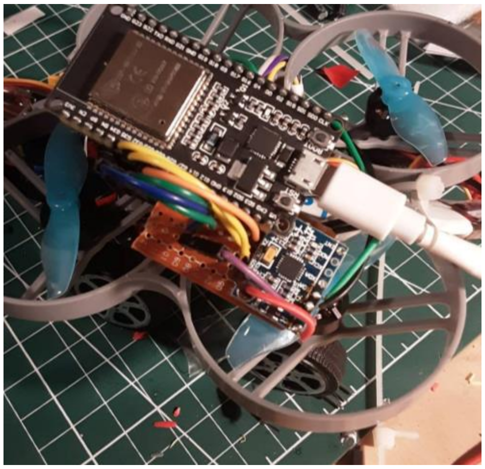


3.2 Control Method

Given the difficulties with SBUS communication, an alternative control method was adopted. This involved sending PWM signals directly to the ESCs for controlling the BLDC motors.

3.3 BLDC Motor Control

Initially, the BLDC motors encountered stuttering issues. This problem was resolved through adjustments and tuning of the ESC settings.

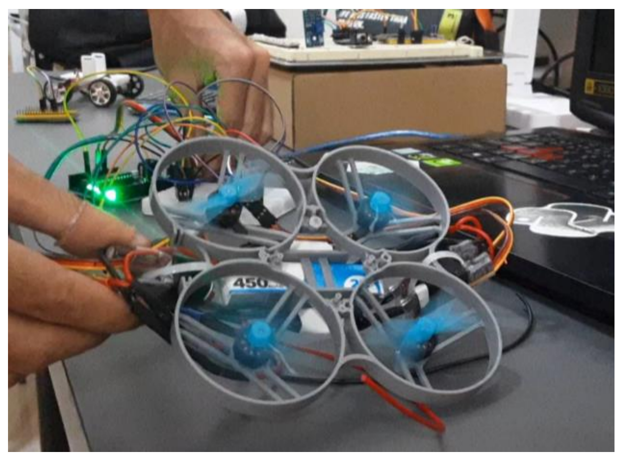


3.4 Flight System Stabilization

A GY-521 MPU6050 sensor was integrated for the PID (Proportional-Integral-Derivative) control method to further enhance the stability of the flight system. This sensor functioned without any errors during testing.

4. Results

While all components functioned individually, the challenges encountered with the initial SBUS communication method highlighted the need for alternative approaches for flight system control.

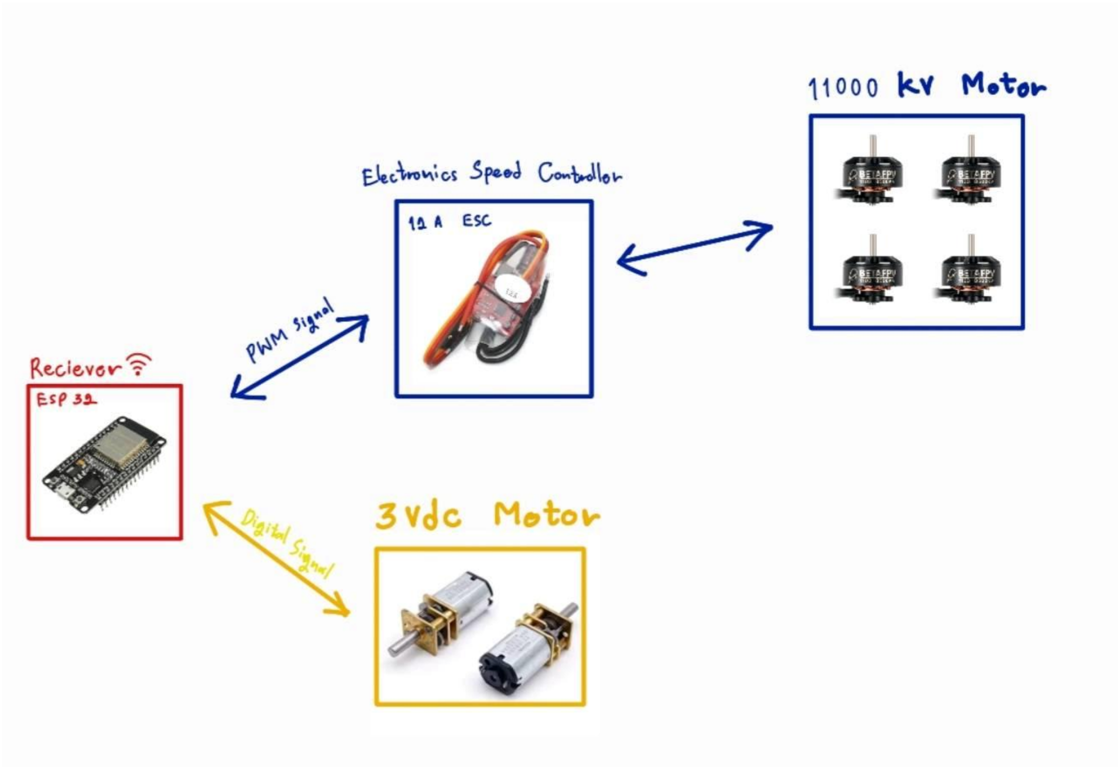


5. Conclusion

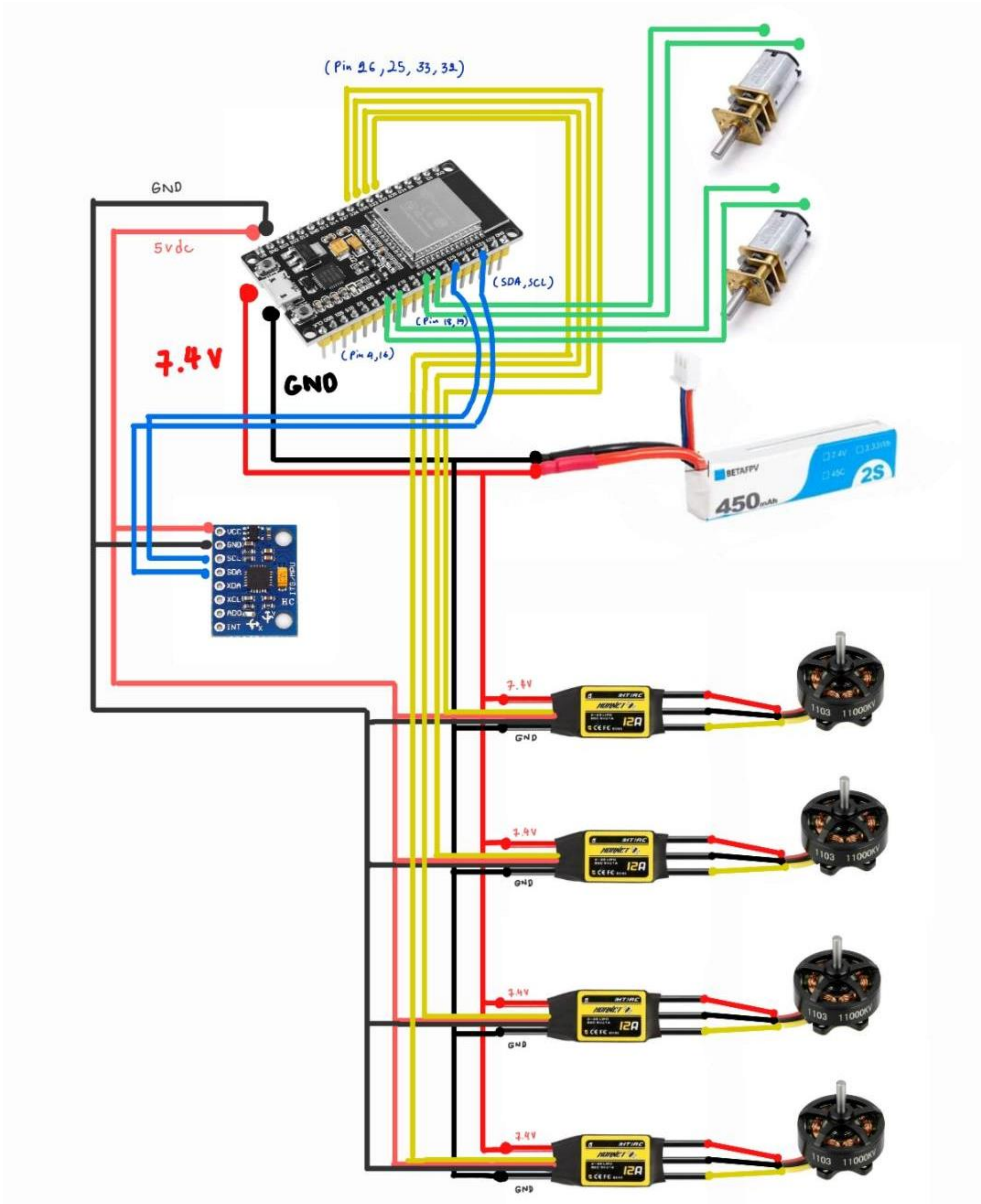
Component testing identified flight system improvements needed. Securing the front wheel stabilized the wheeled system. We'll explore alternative communication methods for a more efficient and reliable flight control system. Future work includes implementing a viable communication protocol and refining the PID control system for optimal flight stability. optimal flight stability.

Block Diagram

The picture shows the electronic parts of a robot. The transmitter (Blynk IoT) sends signals to the receiver, which tells the motor controller how fast to spin the motor. The motor controller also powers a steering motor.



Circuit Design



Estimate Thrust Generated by Brushless Motors

This section estimates the lift force (thrust) generated by the four brushless motors in your robot.

Motor Specifications:

- Motor KV rating: 11000 KV
- Operating voltage: 7.0 V (adjusted for safety from 7.4V)
- Estimated efficiency: 60%

Calculation

The motor's rotational speed (RPM) is estimated using the formula:

- RPM = Kv * Voltage * Efficiency
- RPM = 11000 KV * 7.0 V * 0.6 ≈ 46200 RPM

[T-Motor F1103 Motor 8000kv 11000kv 2s 3s (quadcopters.co.uk)]

Type	Propeller	Throttle	Thrust (g)	Voltage (V)	Current (A)	RPM	Power (W)	Efficiency (g/W)	Operating Temperature (℃)
F1103 KV11000	HQ 65MMLB	50%	79.85	8.15	3.62	35040	29.52	2.71	79 (Ambient Temperature:19℃)
		55%	95.55	8.13	4.42	38213	35.97	2.66	
		60%	109.98	8.11	5.43	40490	44.05	2.50	
		65%	119.31	8.08	5.88	42072	47.55	2.51	
		70%	131.34	8.06	6.66	43995	53.69	2.45	
		75%	146.27	8.03	7.69	46290	61.69	2.37	
		80%	159.56	7.99	8.71	48210	69.63	2.29	
		85%	172.84	7.96	9.83	50076	78.19	2.21	
		90%	184.82	7.92	10.98	51674	86.93	2.13	
		95%	196.48	7.87	12.20	53183	96.05	2.05	
		100%	208.73	7.83	13.59	54641	106.41	1.96	
	HQ 65MMR	50%	74.77	8.19	3.25	35790	26.58	2.81	78 (Ambient
		55%	91.43	8.17	3.98	39250	32.51	2.81	
		60%	107.10	8.14	4.80	42110	39.09	2.74	
		65%	120.11	8.12	5.53	44224	44.87	2.68	
		70%	130.46	8.09	6.15	46101	49.73	2.62	
		75%	142.84	8.06	6.94	48125	55.95	2.55	

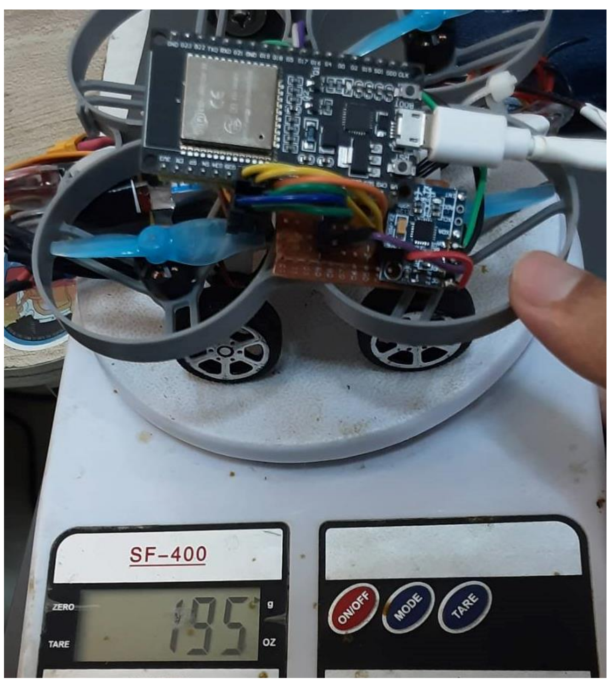
Calculation

The lift force using the formula:

- Force = Thrust * Number of motors
- Force = 130.46 * 4 = 521.84 g

Conclusion

Based on an estimation of the lift force generated by four brushless motors, The robot can be lifted with 100% throttle. Because of the weight of the robot does not exceed to 521.84 grams.



Programming

Testing confirmed functionality of all components:

Wheel System: DC motors, chassis structure, and wheel structure.

Flight System: Brushless motors, ESCs, and GY-521 MPU6050 sensor.

1. Control Software Development

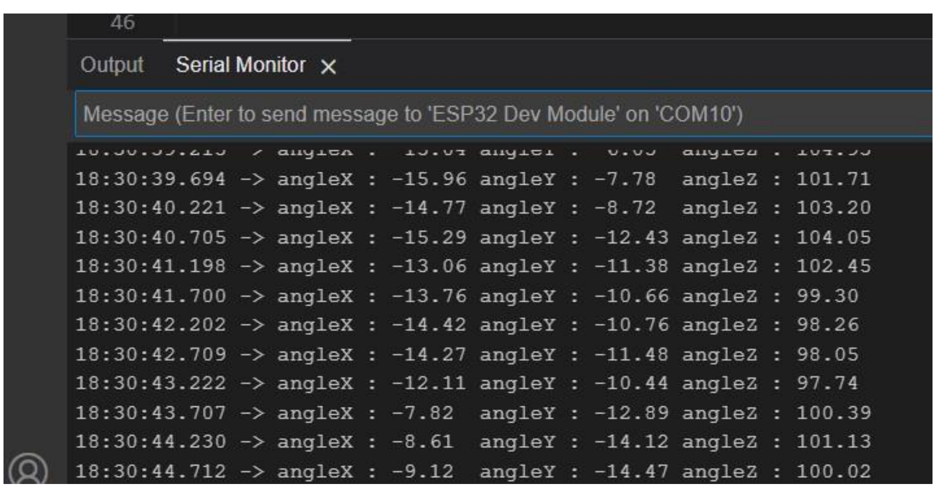
Two software classes were created:

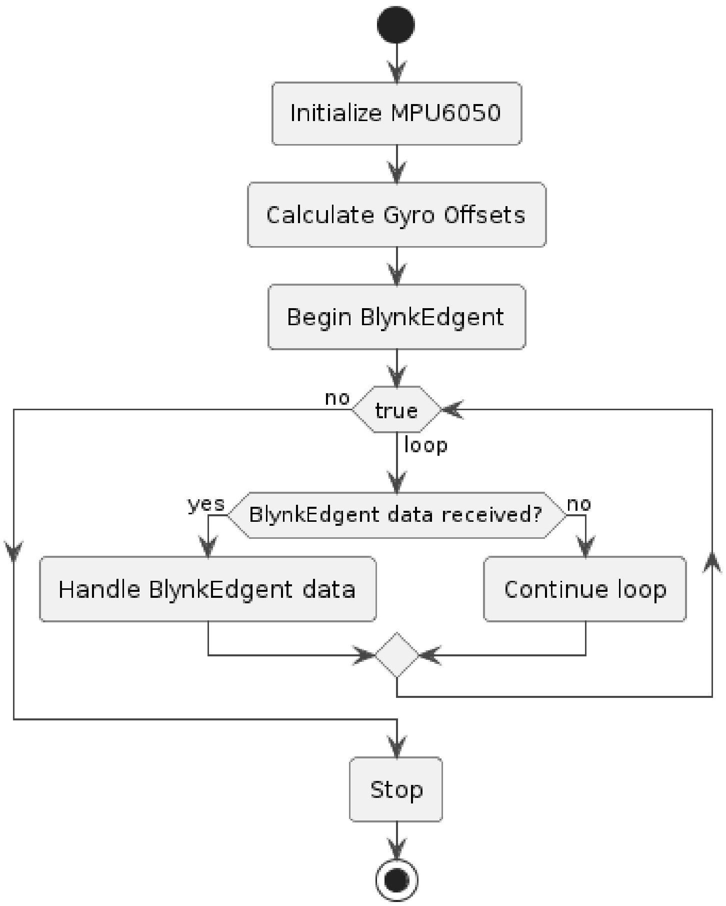
1.1 Motor Control: Provides functions for forward, backward, left, and right rotations.

1.2 Flight Control: Utilizes the MPU6050 sensor data for PID control of the four brushless motors.

4. Flight Control Optimization

Initial testing of the flight control system highlighted the need for sensor calibration and PID parameter tuning. The MPU6050 sensor requires constant calibration to maintain accurate readings. Additionally, the PID controller's proportional, integral, and derivative gains need further adjustment for optimal flight stability.





5. Conclusion

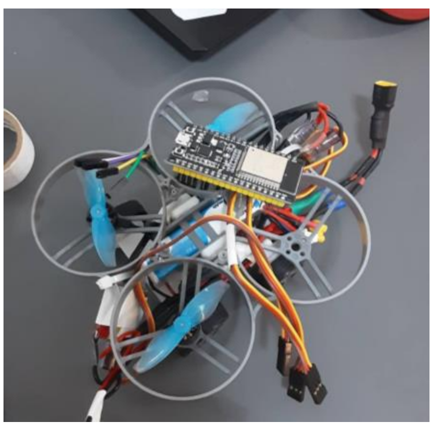
The experiment successfully developed control software for both wheeled and flight systems. However, the flight control system necessitates ongoing calibration and PID tuning to achieve desired stability.

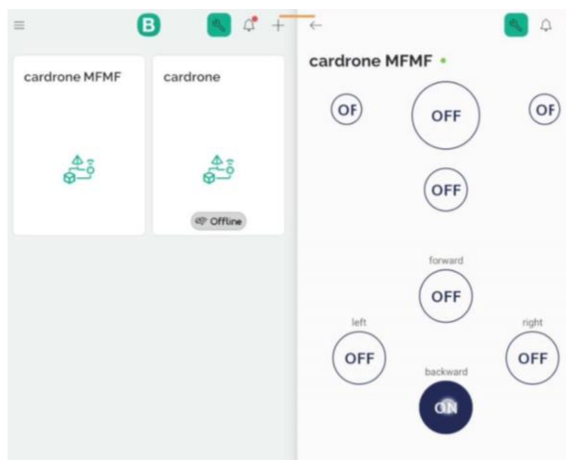
Final Conclusion

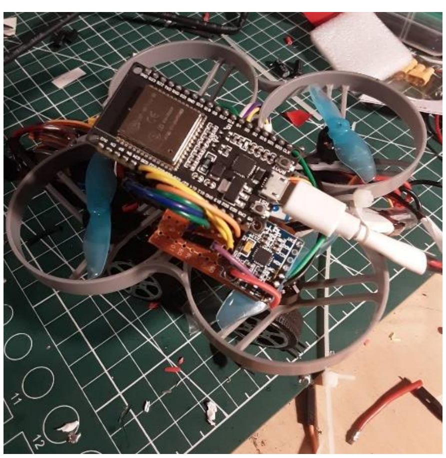
The mobile robot development achieved functionality in both wheeled and flight systems, demonstrating the potential for a versatile mobile platform. However, several key areas require further development:

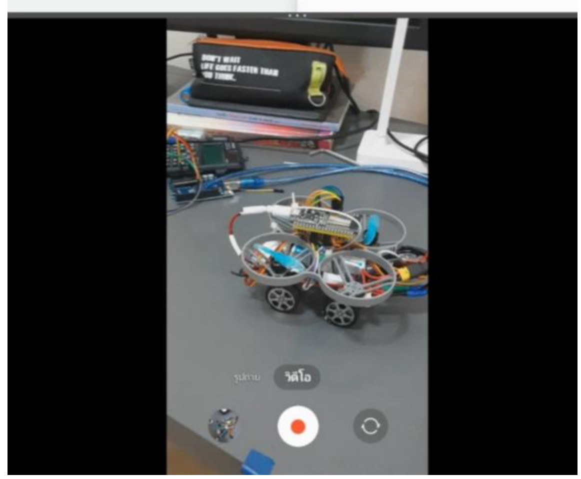
Wheel System: While operational, the robot's movement speed is limited by the low 3.3V power supply. Upgrading to a higher voltage battery will significantly improve performance.

Flight System: Software development successfully established basic control functionalities using the MPU6050 sensor and PID control. However, hardware limitations emerged as two ESCs were found to be malfunctioning, restricting operation to only two BLDC motors.









Despite these limitations, the robot's ability to rotate with high acceleration using just two functional BLDC motors highlights its potential for aerial maneuvers. Additionally, successful integration with Blynk IoT for Wi-Fi control demonstrates a foundation for remote control capabilities.

Moving Forward:

Replacing the faulty ESCs will enable full utilization of all four BLDC motors, potentially achieving sufficient thrust for liftoff.

Continued software development will focus on sensor calibration, PID tuning, and potentially incorporating additional sensors for enhanced flight control.

Upgrading the power source will address the limited speed of the wheeled system.

By addressing these areas, the mobile robot development can progress towards achieving its full potential for combined ground and aerial movement.