Dizzy-n-Copter: A Lightweight Spinning Tricopter for Stable Indoor Flight and Telemetry

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Abstract — **Dizzy-n-Copter is a lightweight tricopter designed to maintain controlled flight while continuously rotating about its (Z) axis. Unlike conventional multirotors that attempt to eliminate yaw rotation during hover, this project intentionally sustains a target spin rate while preserving stable indoor flight and collecting real-time telemetry. The system integrates a compact flight controller, brushless motors, an electronic speed controller, a custom ESP32-based support board, and wireless communication for command and status reporting. Telemetry including battery voltage, rotation speed, distance-to-ground, and system status is transmitted to a ground application through Bluetooth Low Energy (BLE). The design emphasizes low weight, enclosed-prop safety considerations, indoor maneuverability, and autonomous safety behavior such as low-battery response and loss-of-signal protection. The project demonstrates a novel low-cost aerial platform that combines stable spinning flight with sensing and wireless monitoring. In addition to serving as an original senior design platform, Dizzy-n-Copter illustrates how a rotating aerial vehicle could support future mapping, environmental sensing, and compact robotics applications.**

I. Introduction

Conceived as a novel approach to multirotor flight control, Dizzy-n-Copter is a complete electrical and computer engineering design project that explores stable flight under continuous rotational motion. Traditional drone systems are designed to minimize or eliminate yaw rotation during hover; however, this project investigates the inverse problem of maintaining a controlled and sustained rotation about the vertical axis while preserving stable flight and controllability.

The system is implemented as a lightweight tricopter platform consisting of three brushless motors driven by an electronic speed controller and managed by a compact flight controller running embedded firmware. In addition to standard flight functionality, the system incorporates a custom-designed ESP32-based support board that enables wireless communication and telemetry processing. This allows real-time transmission of key system data, including battery voltage, rotational speed, altitude estimation, and operational status, to an external user interface via Bluetooth Low Energy.

The originality of the Dizzy-n-Copter lies in its ability to intentionally sustain rotational motion during hover while maintaining system stability and providing useful telemetry. This capability presents unique control challenges, including drift correction, power management, and maintaining consistent rotational velocity. The system is designed for indoor operation, emphasizing safety, compactness, and efficiency.

By integrating embedded control, wireless communication, sensor feedback, and lightweight mechanical design, the Dizzy-n-Copter demonstrates a new class of aerial platform. This rotating flight concept has potential applications in low-cost environmental sensing, spatial scanning, and compact autonomous systems where continuous rotational coverage is beneficial

II. System Components

The system is best presented in terms of system components; that is, the individual physical modules—whether purchased or designed—that are interfaced to create the final product. This section provides a semi-technical introduction to each of these components.

A. Flight Controller & Electric Speed Controller (ESC)

The flight controller used in the Dizzy-n-Copter system is the SpeedyBee F405 Mini, which is responsible for stabilizing the drone and managing overall flight behavior. It processes onboard sensor data and generates control signals to maintain stable flight. Paired with the flight controller is a SpeedyBee BLS 35A 4-in-1 electronic speed controller (ESC), which regulates the power delivered to each brushless motor. The ESC receives digital control signals and adjusts motor speeds accordingly, enabling precise thrust control and coordinated flight.

B. Microcontroller

An ESP32-WROOM microcontroller is used as a support system for communication and telemetry processing. The

ESP32 provides Bluetooth Low Energy (BLE) capabilities, allowing the drone to transmit real-time data and receive user commands. It acts as an interface between the flight controller and the ground system, enabling monitoring and control during operation.

C. Brushless Motors and Propellers

The propulsion system consists of three LANNRC 1505 2650KV brushless DC motors, each paired with an HQProp T3.5x2x3 tri-blade 3.5-inch propeller to generate lift and thrust. These motors are driven by the electronic speed controller and respond rapidly to control signals, enabling precise adjustments in thrust during flight. The selected motor KV and propeller combination provides a balance between efficiency, responsiveness, and thrust output, which is critical for maintaining stable hover and controlled rotation in a tricopter configuration.

D. Time of Flight Sensor

A custom-integrated VL53L8X time-of-flight (ToF) sensor is used to measure the distance between the drone and the ground. The VL53L8X provides multi-zone distance sensing by emitting infrared light and measuring the time it takes for reflections to return. This enables accurate short-range distance measurements suitable for indoor operation. The sensor is incorporated into the system through a custom PCB design, allowing it to interface with the microcontroller for real-time data processing. This distance information can be used to assist in maintaining a consistent hover height and improving overall flight stability.

E. Servo

An SG90 micro servo is incorporated into the system to provide controlled mechanical actuation within the tricopter design. In this configuration, the servo is intended to adjust the orientation of a motor to assist with yaw control. Unlike traditional quadcopters that rely solely on differential motor speeds, the tricopter design can benefit from mechanical adjustment to improve directional control and stability. The SG90 servo is lightweight and suitable for small aerial platforms, operating through pulse-width modulation (PWM) signals to achieve precise angular positioning. While integration and tuning of the servo mechanism are ongoing, it represents an important component for enhancing maneuverability and control.

F. Audio Amplifier

The audio amplification subsystem utilizes an LM386 low-voltage audio amplifier integrated circuit to generate audible feedback during drone operation. Under normal conditions, the amplifier is activated by control signals corresponding to key system events such as takeoff, landing, and low battery warnings. The LM386 is a compact, low-power device designed for battery-operated applications, capable of directly driving small speakers while operating over a typical supply range of 4V to 12V. It features an internally configurable gain, which in this design is set to the default value of 20 V/V. The circuit incorporates two capacitors and a resistor to form a filtering network that stabilizes the output and reduces noise. This configuration allows low-level audio signals to be amplified to an audible level without significant distortion. The purpose of this subsystem is to provide clear auditory cues to the user, improving situational awareness and enhancing overall system safety.

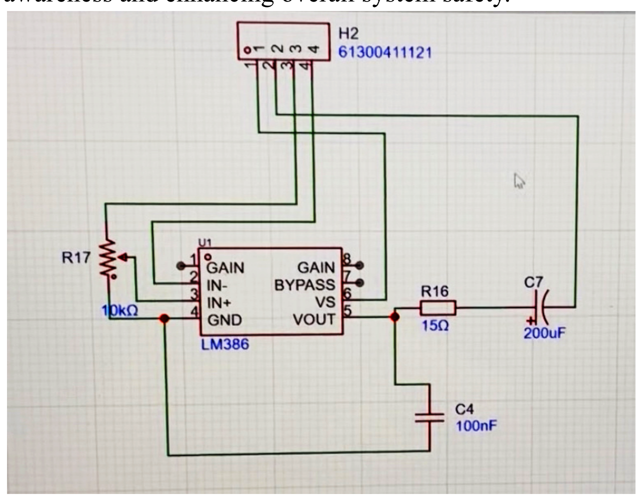


Figure 1: Audio Amplifier Schematic

G. Power System

The power system utilizes a Gaoneng GNB 11.4V 3S 850mAh 60C LiHV micro battery to supply energy to all onboard components. This battery was selected for its high discharge capability, lightweight design, and ability to provide sufficient voltage and current for sustained flight. The power system must support the demands of the brushless motors, flight controller, microcontroller, sensors, and auxiliary electronics while minimizing total system weight. Efficient power delivery is critical to achieving stable operation, maintaining hover, and maximizing flight time within the design constraints of the tricopter platform.

H. Mechanical Frame

The mechanical frame design initially considered the use of 3D-printed carbon fiber due to its favorable strength-to-weight ratio and suitability for lightweight aerial systems. However, after evaluating material availability, cost, and manufacturing practicality, an alternative approach was adopted. The design process transitioned to using a standard PLA-12 filament for prototyping and final fabrication. The frame components were printed with a thickness of approximately 4 mm, providing a balance between structural rigidity and overall weight. Following multiple iterations and print evaluations, it was determined that the PLA-12 material offered sufficient strength to withstand the mechanical stresses of flight while maintaining the sub-250 gram requirement. Additionally, the use of PLA-based filament allowed for easier manufacturing, faster iteration, and greater flexibility in design modifications, making it well-suited for rapid prototyping and refinement within the project constraints.

III. Engineering Specifications

The Dizzy-n-Copter system is designed to meet a set of engineering specifications that ensure stable operation, efficient performance, and reliable telemetry. These specifications define the functional and performance requirements of the system and guide the overall design process.

Table 1. Specifications

Specifications	
Communication rate:	3600 Samples per minute (1 sample per 10 degrees)
Drone	
Performance:	Maintain ~60 RPM rotation about the Z-axis
Weight:	Less than 250 g total system weight
Production:	Modular frame for ease of maintenance and component replacement
Battery:	11.4V 3S 850mAh LiHV rechargeable battery
Minimum Lifespan:	Minimum 5 minutes of continuous operation
Flight Requirements:	Maintain stable hover with minimal drift
Safety:	Enclosed propellers for safe indoor operation
Base Station/BLE	
Display:	Display rotation speed and sensor data via BLE interface
Sensor Integration	Continuous communication with onboard ToF sensor

A. Weight and Power Considerations

Maintaining a total system weight under 250 grams is a critical design constraint for the Dizzy-n-Copter. A lower weight reduces the required thrust for hover, improving overall efficiency and extending flight time. This requirement influenced the selection of lightweight components, including motors, battery, and structural materials. Additionally, power consumption must be carefully managed to ensure that the system can meet both performance and flight time requirements.

B. Rotational Performance

A key objective of the Dizzy-n-Copter is to maintain a controlled rotational speed of approximately 60 RPM about the vertical axis. Unlike conventional drones that minimize yaw rotation, this system is designed to sustain continuous rotation while maintaining stability. Achieving this requires careful tuning of motor outputs and control parameters to balance rotational motion with stable hover behavior.

C. Flight Stability

Stable hover performance is essential for indoor operation. The system must minimize drift while maintaining a consistent altitude. Factors such as weight distribution, control tuning, and sensor feedback all contribute to achieving reliable flight stability. The integration of a time-of-flight sensor provides additional data that can be used to assist with maintaining a fixed height.

D. Communication and Telemetry

The system relies on Bluetooth Low Energy (BLE) communication to transmit real-time telemetry data and receive control inputs. Telemetry includes battery voltage, rotational speed, and sensor measurements. Reliable communication is necessary to ensure that the user can monitor system performance and interact with the drone during operation.

E. Safety and Operation Constraints

Safety is a key consideration due to the system's intended indoor operation. The use of enclosed propellers reduces the risk of injury or damage during flight. Additionally, the system must respond appropriately to conditions such as low battery or signal loss to prevent unsafe operation. These constraints influence both hardware design and system behavior.

IV. System Overview & CAD

The Dizzy-n-Copter system is composed of multiple interconnected subsystems that work together to achieve stable flight while maintaining controlled rotational motion. These subsystems include the flight controller, electronic speed controller, propulsion system, sensors, microcontroller, and communication interface. The overall system is designed to operate as an integrated platform that enables controlled flight, real-time telemetry, and wireless user interaction.

A. System Overview

At power-up, the system initializes all onboard components, including the flight controller, ESP32 microcontroller, sensors, and communication interfaces. Once initialized, a Bluetooth Low Energy (BLE) connection is established between the ESP32 and the ground interface, allowing the user to send commands and monitor system status.

Upon receiving an arm command, the flight controller activates the motors through the electronic speed controller. A controlled throttle ramp is applied to gradually increase thrust until the drone achieves takeoff. Once airborne, the system maintains a hover state while sustaining a rotational speed of approximately 60 RPM about the vertical axis.

During flight, the flight controller continuously processes sensor data to adjust motor outputs and maintain stability. At the same time, the ESP32 collects telemetry data, including battery voltage, rotation speed, and distance measurements, and transmits this information to the ground interface via BLE.

If a fault condition is detected, such as low battery or loss of communication, the system transitions into a safe state, reducing motor output and disarming to prevent damage.

B. System Block Diagram

The system architecture can be represented as a block diagram illustrating the interaction between major components. The battery supplies power to both the flight controller and the electronic speed controller (ESC), which in turn drives the brushless motors to generate thrust. The flight controller receives input from onboard sensors, including the gyroscope and time-of-flight sensor, and processes this data to generate control signals for stable flight.

The ESP32 microcontroller interfaces with the flight controller through a UART communication link, allowing it to receive telemetry data and transmit control commands. The ESP32 also communicates with the ground interface via Bluetooth Low Energy (BLE), serving as the primary link between the user and the drone. Through this architecture, the system enables real-time monitoring and control while maintaining stable flight behavior.

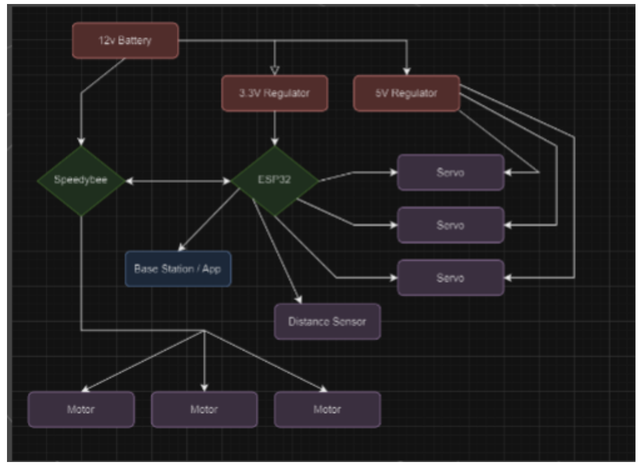


Figure 2. Hardware Block Diagram

C. System Operation Flow

The system operation of the Dizzy-n-Copter is illustrated using an activity diagram, which represents the sequence of actions performed during flight. The process begins when the base station sends a start signal to the drone. Upon receiving this command, the system initializes communication between the flight controller, ESP32 microcontroller, and onboard sensors.

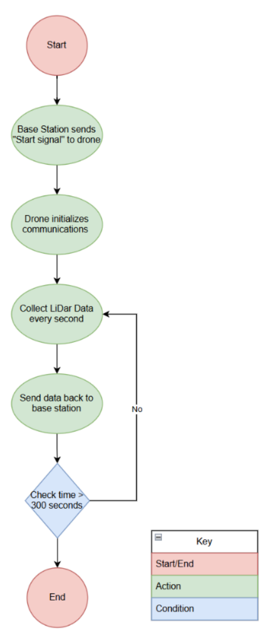


Figure 3: Activity Diagram

Once initialization is complete, the drone begins collecting distance data from the Time-of-Flight (ToF) sensor at regular intervals. This data is processed and transmitted back to the base station via a Bluetooth Low Energy (BLE) connection. During this period, the drone maintains stable hover while sustaining a controlled rotational speed.

The system operates in a continuous loop, repeatedly collecting and transmitting telemetry data. This loop continues until a termination condition is met, such as reaching the predefined operation time or detecting a fault condition. At that point, the system exits the loop and safely ends operation.

D. CAD Design and Mechanical Layout

The mechanical and CAD design of the system adopts a tridrone configuration rather than the more conventional quadcopter layout, allowing for reduced weight and improved efficiency within the project constraints. A primary design requirement was to maintain a total mass below 250 grams in accordance with FAA guidelines, which significantly influenced component selection and structural design. The frame was designed to accommodate essential components, including three motors with 3.5-inch propellers, a SpeedyBee flight controller, a custom PCB, and a servo for yaw control. To meet weight and manufacturability goals, a lightweight, 3D-printable material was selected, enabling rapid prototyping and straightforward design modifications. Multiple design iterations were developed and evaluated, resulting in two distinct models before achieving a configuration that satisfied the sub-250 gram requirement specified by the project sponsor.

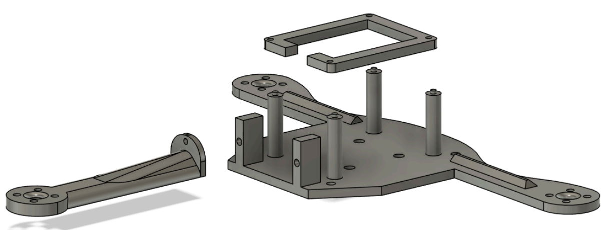


Figure 4. Final Drone Model

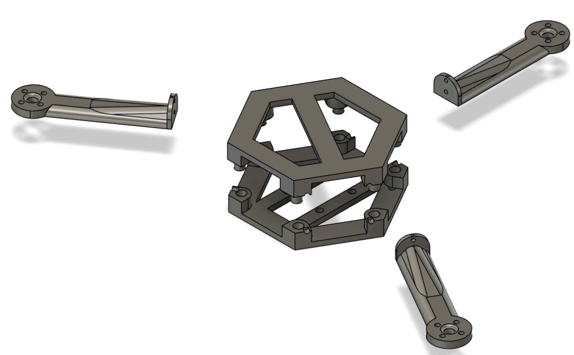


Figure 5. First Drone Model

V. PCB Designs

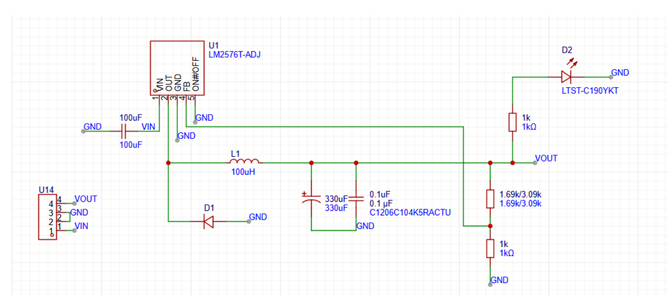
The Dizzy-n-Copter system incorporates a custom-designed printed circuit board (PCB) to support power distribution, sensor integration, and communication between system components. The PCB serves as a central platform for organizing electronic connections while minimizing wiring complexity and overall system weight

A. PCB Design Overview

The system is composed of three primary hardware modules: the main PCB board, the regulator board, and the distance sensor board, each designed to perform a specific function while operating as part of an integrated platform. The main PCB acts as the central hub, managing communication between the flight controller, microcontroller, and peripheral components. Supporting this, the regulator board ensures that all devices receive stable and appropriate voltage levels by stepping down the battery input into regulated outputs. The distance sensor board provides environmental awareness through precise time-of-flight measurements, enabling the system to interact intelligently with its surroundings. Together, these three boards form a cohesive architecture that balances power management, signal integrity, and sensing capability, resulting in a reliable and scalable embedded system design.

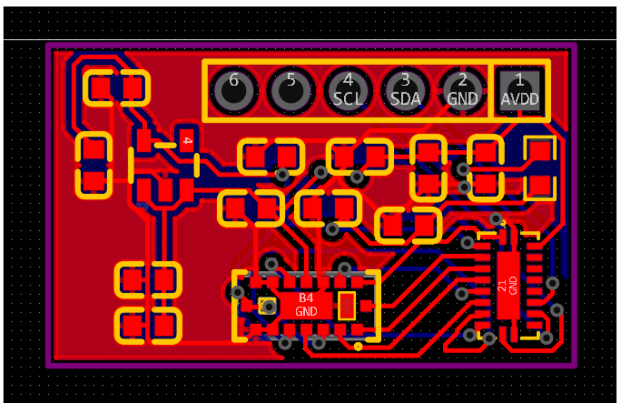
The PCB designs for all three modules were developed using EasyEDA, which provided an integrated environment for schematic capture, component selection, and layout design. The platform enabled efficient iteration by allowing seamless transitions between schematic and PCB views, helping to quickly identify and correct design issues. Its built-in component libraries, along with direct access to manufacturer parts, simplified the selection of compatible components and footprints, ensuring consistency between the electrical design and physical implementation. Additionally, EasyEDA's design rule checking and visualization tools were used to verify trace routing, spacing, and connectivity, contributing to a reliable and manufacturable layout. This streamlined workflow supported rapid development while maintaining accuracy across all stages of the PCB design process.

B. Power Regulation and Distribution



The regulator board is responsible for converting the primary battery input into stable voltage levels required by the system components. We are using the LM2576 which is designed to step down a nominal 12 V input, the board provides regulated 5 V and 3.3 V outputs to support servos, sensors, and the microcontroller. Switching regulators were selected to maximize efficiency and minimize thermal losses, particularly under varying load conditions. Component selection, including inductors, diodes, and capacitors, was based on manufacturer recommendations to ensure stable operation and low output ripple. The design also incorporates decoupling and filtering techniques to maintain voltage stability and protect sensitive electronics from transient disturbances.

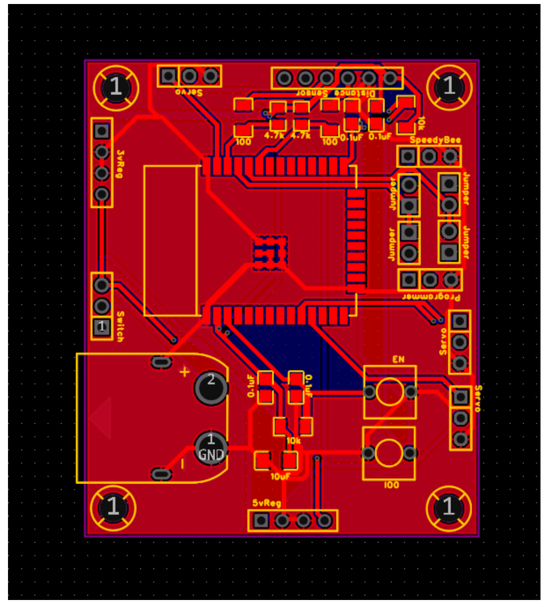
C. Sensor Integration



The distance sensor board integrates a VL53L8CX time-of-flight sensing module to enable accurate environmental perception for the system. The sensor communicates with the microcontroller using an I²C interface, allowing for efficient data transfer and simple integration with existing firmware. Proper power supply design was critical, with separate consideration given to analog and digital voltage domains to ensure reliable operation and measurement accuracy. Pull-up resistors were included on the communication lines to maintain signal integrity, and careful PCB layout practices were followed to minimize noise coupling near the sensor. The compact design of the board allows it to be easily positioned for optimal field-of-view while maintaining consistent and repeatable distance measurements.

D. Communication Interface

The PCB facilitates communication between the ESP32 microcontroller and the flight controller. This is achieved through serial communication interfaces, allowing telemetry data to be transmitted and control information to be exchanged. From here the ESP32 communicates with the servo, distance sensor, and flight controller on the main PCB. The PCB ensures stable signal routing and minimizes noise that could interfere with communication.



E. Design Considerations

A key design consideration for the system was ensuring that all three PCBs could be effectively integrated within the overall CAD model of the platform without interfering with mechanical components or assembly constraints. Board dimensions, mounting hole placement, and connector orientations were carefully selected to align with the enclosure geometry and surrounding hardware, allowing for straightforward installation and secure mounting. Clearance was maintained around critical components such as connectors, sensors, and wiring interfaces to prevent mechanical conflicts and to support ease of assembly and maintenance. Additionally, the placement of the distance sensor board was coordinated with the CAD layout to preserve an unobstructed field of view, while the regulator and main boards were positioned to optimize cable routing and minimize strain on connections. This coordinated electrical and mechanical design approach ensured that the PCBs function cohesively within the physical system while maintaining reliability and accessibility.

VI. Software and Flight Systems

The drone communication system is composed of three levels: the flight controller (FC) and ESC, which record telemetry data such as battery information; the ESP32, which receives this data through a UART Crossfire Serial Protocol (CRSF) communication port; and an Android device, which receives the data from the ESP32 via a BLE connection.

A. The FC and ESC

The FC and ESC generate telemetry data that describes the state of the drone during operation. This telemetry includes battery voltage and current measurements, as well as orientation data such as pitch, roll, and yaw derived from the flight controller's onboard sensors and attitude estimation algorithms. The FC aggregates this information and transmits it to the ESP32 through a UART interface using the CRSF protocol. CRSF is a lightweight, high-speed serial communication protocol commonly used in radio control systems to transmit control and telemetry data with low latency. Through this connection, the ESP32 continuously receives structured telemetry packets containing the drone's status information, allowing it to process, log, or forward the data to other systems such as a mobile application.

B. The ESP32

The ESP32 functions as the PID Controller and communication bridge between the user's Android device and the drone's FC. It receives telemetry data from the FC through the UART interface using the CRSF protocol, where packets contain information such as battery status, attitude data (pitch, roll, and yaw), and the current flight mode. The ESP32 parses these CRSF packets and organizes the extracted telemetry into a structured format suitable for Bluetooth Low Energy (BLE) transmission. In addition to the data received from the FC, the ESP32 also collects distance measurements from a VL53L8CX time-of-flight sensor connected directly to the microcontroller. Acting as a BLE peripheral, the ESP32 exposes four BLE characteristics that group related telemetry values: distance, battery, attitude, and flight mode. The distance characteristic is populated with measurements from the VL53L8CX sensor, while the battery, attitude, and flight mode characteristics are derived from the CRSF telemetry received from the FC. By structuring the data into these characteristics, the ESP32 enables the Android application to efficiently subscribe to updates and retrieve real-time drone telemetry, making it the primary communication hub between the onboard flight system and the user interface.

C. Android Application

The Android application acts as the user interface for monitoring telemetry and controlling the drone in real time. It connects to the ESP32 via BLE and subscribes to the available telemetry characteristics to continuously receive updates. The application displays key flight information including battery voltage, current draw, total battery used, and estimated battery remaining, allowing the user to monitor the drone's power consumption during operation. It also presents attitude data such as pitch, roll, and yaw to indicate the drone's orientation in space. In addition, the application calculates an approximate rotational speed (RPM) by comparing the change in yaw values over the previous second, providing a measure of the drone's spin rate. Alongside telemetry visualization, the interface includes several control features that allow the user to influence the drone's behavior. A Drone Power button sends a command to arm the drone, enabling the motors and preparing the system for flight. The Drone Hover control activates hover logic that stabilizes the drone and maintains its position. The Spin Mode control increases the yaw command during flight, intentionally inducing a spinning motion for testing or demonstration purposes. Together, these monitoring and control features allow the Android application to serve as both a real-time telemetry dashboard and a command interface for the drone.

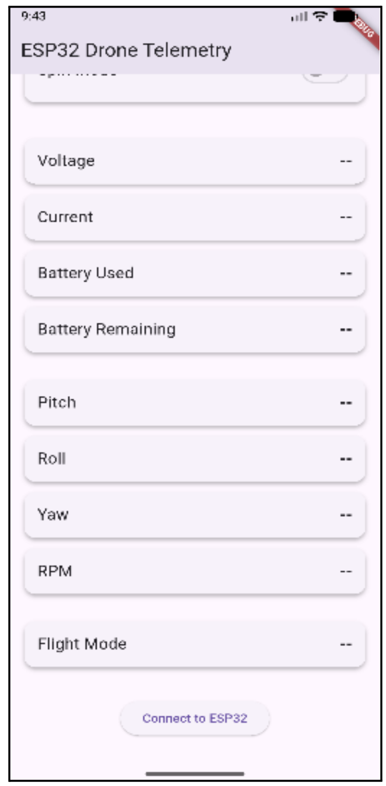


Figure 3. Current Prototype Display

D. Hover Logic

A downward-facing distance sensor is used to assist with altitude stabilization during flight. The sensor measures the distance between the drone and the ground, providing real-time altitude information to the control system. By continuously monitoring this distance, the system evaluates how the altitude is changing over time by observing the acceleration of the distance measurements. When the distance acceleration is negative, indicating that the drone is descending faster toward the ground, the control logic responds by incrementally increasing the throttle to counteract the descent and regain altitude. Conversely, when the distance acceleration is positive, indicating that the drone is rising too quickly away from the ground, the system reduces the throttle to prevent overshooting the desired height. By dynamically adjusting the throttle based on the rate of change of altitude, the drone can maintain a more stable position at a target altitude, compensating for disturbances such as airflow changes or minor control variations during hover.

E. Object Avoidance

Object avoidance can also be implemented using the same distance sensor by mounting it at an upward angle of approximately 20 degrees. In this orientation, the sensor's field of view captures both the floor and nearby vertical surfaces such as walls while the drone rotates. As the drone spins, distance readings are continuously sampled and averaged, with the larger values typically corresponding to the floor and the shorter values indicating the presence of nearby obstacles such as walls. By monitoring these readings over time, the system can detect when a wall begins to approach within a predefined safety threshold. When such a condition is detected, the drone temporarily halts its spinning motion and adjusts its position by moving slightly in the opposite direction of the detected obstacle. After the distance readings return to a safe range, the drone resumes its spinning behavior. This approach allows the drone to maintain dynamic awareness of its surroundings while rotating, enabling it to avoid collisions using a single angled distance sensor and simple distance-based logic.

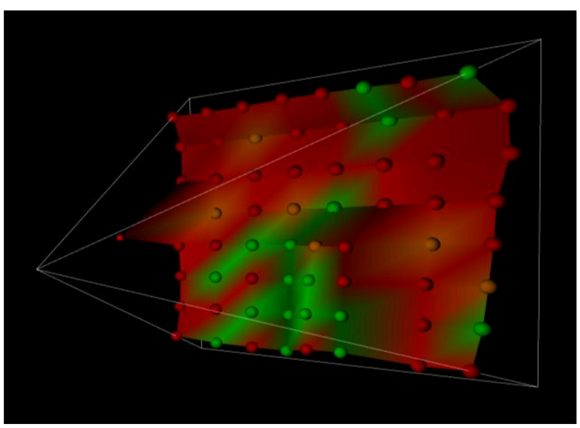


Figure 7. Depiction of the ToF sensor POV

VII. Conclusion

The Dizzy-n-Copter project demonstrates the design and implementation of a lightweight tricopter capable of maintaining stable flight while continuously rotating about its vertical axis. By integrating a flight controller, brushless motors, custom PCB, sensors, and an ESP32-based communication system, the project successfully combines embedded control, wireless telemetry, and mechanical design into a single platform.

A key objective of the system is to sustain controlled rotational motion while maintaining stable hover, which introduces unique challenges compared to traditional drone designs. Through iterative testing and system tuning, the platform is able to achieve controlled flight behavior while transmitting real-time telemetry data, including battery voltage, rotational speed, and distance measurements.

The development process highlighted several challenges, including drift reduction, weight optimization, and system integration. Addressing these challenges required careful component selection, tuning of control parameters, and refinement of the mechanical design. Despite these challenges, the system demonstrates the feasibility of controlled rotational flight in a compact aerial platform.

Future improvements may include enhanced control algorithms for improved stability, tighter integration of the servo-based yaw mechanism, and expanded use of sensor data for autonomous flight control. The Dizzy-n-Copter provides a foundation for further exploration into rotating aerial systems and their potential applications in sensing, mapping, and compact robotics

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