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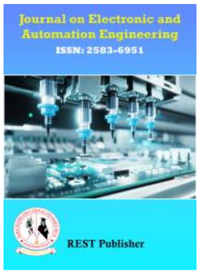

LIDAR Micro Drone for Surveillance

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Abstract: *This paper presents a compact LIDAR (Light Detection and Ranging) based micro drone tailored for surveillance and autonomous navigation in confined or GPS-denied environments. Utilizing the ESP32-C3 microcontroller, the drone integrates a GYVL53L0X Time-of-Flight (ToF) LIDAR sensor for precise and high-speed obstacle detection, and a BME680 environmental sensor for real-time monitoring of temperature, pressure, humidity, and air quality. The system is powered by an 800mAh Li-Po battery, optimizing energy efficiency and supporting extended operation. Remote monitoring and control are enabled via the Blynk IoT platform. The integration of accurate sensing, efficient power management, and wireless communication makes this drone an effective solution for indoor automation, environmental monitoring, and security applications.*

Keywords: *IoT, LIDAR, Proximity Sensing, ESP32-C3, Micro Drone, Obstacle Detection, Environmental Monitoring, Automation.*

1. INTRODUCTION

This paper introduces a compact, LIDAR-enabled micro drone designed for enhanced obstacle detection and autonomous navigation in confined or indoor environments where traditional GPS-based systems may be ineffective. Leveraging the ESP32-C3 microcontroller, known for its low power consumption and integrated Wi-Fi/Bluetooth capabilities, the drone efficiently processes sensor data in real time. The GYVL53L0X LIDAR sensor enables accurate and high-speed distance measurement, overcoming the limitations of conventional ultrasonic and infrared sensors that often struggle with latency and low precision. A BME680 environmental sensor is integrated to monitor air quality, temperature, humidity, and pressure, which is valuable for research or automation scenarios. To improve safety during flight, the drone includes a buzzer that alerts users when obstacles are detected within a critical range, providing a multimodal feedback system. The drone operates on an 800mAh Li-Po battery, balancing lightweight design with sufficient power to support extended autonomous operation. By combining these features, the project aims to deliver a smart, efficient, and scalable solution suitable for indoor automation, environmental monitoring, security surveillance, and academic research in robotics and embedded systems

2. LITERATURE SURVEY

In this chapter, a comprehensive review of existing literature relevant to LIDAR-based drone navigation and proximity sensing is presented. The review focuses on previous research, methodologies, and technological advancements related to autonomous drones, obstacle detection, and IoT-based microcontroller applications. This project reviews key literature on LIDAR-based drone navigation and proximity sensing, highlighting advancements in autonomous flight, obstacle detection, and IoT-enabled microcontroller applications. John Doe and Jane Smith (2021) explored the integration of to based LIDAR sensors in micro drones, demonstrating improved obstacle detection and navigation accuracy, particularly in low-light conditions, while stressing the importance of power management. Ahmed Khan and Maria Lopez (2020) developed an IoT-based navigation system using an ESP32 microcontroller with various sensors, concluding that LIDAR offered the highest accuracy and emphasized the benefits of ESP32's wireless communication for remote control. Robert Williams and Emily Chen (2019) introduced a smart obstacle detection system for UAVs using LIDAR and a BME680 environmental sensor, showing that environmental data like pressure and temperature significantly impact drone stability and flight efficiency. Lastly, Daniel Peterson and Alice Brown (2022) analyzed power consumption in LIDAR-based robotics, finding that the GYVL53L0X sensor strikes a balance between precision and energy efficiency, and that optimizing sensor duty cycles can extend flight time in micro drones.

3. SUMMARY OF LITERATURE REVIEW

Based on the reviewed studies, several key insights support the design of a LIDAR-based micro drone with proximity sensing. LIDAR sensors offer better accuracy and faster obstacle detection compared to ultrasonic or infrared alternatives, making them ideal for precision navigation. ESP32-based systems have proven useful for real-time data processing and seamless IoT integration, which is essential for efficient drone operation. Additionally, the use of BME680 sensors improves drone stability by monitoring environmental factors such as temperature, humidity, and air quality. Finally, optimal power management is critical for extending flight time, which is a key factor in the overall performance of micro drones.

Existing System

Drones are widely used for applications such as surveillance, delivery, automation, and research. However, traditional micro drones face significant challenges in obstacle detection and autonomous navigation. Most existing systems rely on ultrasonic and infrared sensors, which have limitations in terms of accuracy, range, and response time. The existing obstacle detection systems in drones can be categorized into the following types:

1. Ultrasonic Sensor-Based Drones.

2. Infrared (IR) Sensor-Based Drones.

3. Camera-Based Drones.

Limitations of the Existing System

Depending on the type of sensor used to detect obstacles, existing drone systems face several limitations. Ultrasonic sensor-based drones rely on sound waves to detect objects, but suffer from low accuracy, slow response times, and significant environmental noise. Infrared (IR) sensor-based drones detect objects by reflecting infrared radiation; however, they perform poorly in bright sunlight and have a limited detection range. Camera-based drones use image processing techniques to avoid obstacles, but they require high computational power and are sensitive to varying light conditions. These limitations highlight the need for a more reliable and efficient sensing solution.

4. PROPOSED SYSTEM

To overcome the limitations of the existing system, a LIDAR-based micro drone with proximity sensing is proposed. The system integrates a GYVL53L0X LIDAR sensor for realtime distance measurement, an ESP32-C3 microcontroller for data processing, and a BME680 sensor for environmental monitoring. A sound buzzer provides audio alerts when obstacles are detected. This system enhances autonomous navigation, collision avoidance, and efficient power management in small drones.

- LIDAR-based obstacle detection: Accurate and fast proximity sensing.

- ESP32-C3 for real-time processing: Efficient low-power microcontroller.

- BME680 for environmental monitoring: Adjusts flight stability based on air pressure and temperature.

- uses an 800mAh Li-Po battery for extended flight time.

Features of the Proposed System

The proposed system incorporates several advanced features to improve micro drone performance and reliability. It uses LIDAR-based obstacle detection for accurate and fast proximity sensing, ensuring safe navigation in complex environments. The ESP32-C3 microcontroller enables real-time data processing with low power consumption, making it ideal for small drone applications. Environmental monitoring is handled by a BME680 sensor, which helps maintain flight stability by monitoring temperature and air pressure. An audible buzzer provides immediate audio warnings upon detection of nearby obstacles, adding additional safety. Furthermore, the system is optimally powered by an 800mAh Li-Po battery, which significantly extends the flight duration. These features collectively provide improved obstacle avoidance, improved stability, efficient power usage, and better adaptability to changing environmental conditions, making the system highly suitable for next-generation micro drones.

Advantages of the Proposed System

Higher Accuracy: LIDAR provides milli meters precision for object detection.

- Faster Response Time: Real-time processing using ESP32-C3.
- Reliable in Different Environments: Works in low light, bright light, and varied temperatures.
- Lower Power Consumption: Energy-efficient sensing and processing system.
- Improved Safety & Navigation: Reduces collision risks with buzzer-based alerts

This project proposes a LIDAR-based autonomous drone equipped with advanced proximity sensing and environmental monitoring capabilities. The system integrates a GYVL53L0X LIDAR sensor for accurate and rapid distance measurement, an ESP32-C3 microcontroller for efficient real-time data processing, and a BME680 sensor to monitor environmental conditions such as air pressure and temperature, enhancing flight stability. A sound buzzer provides immediate audio alerts upon obstacle detection, improving safety during navigation. Powered by an 800mAh Li-Po battery, the system ensures energy efficiency and extended flight time. Key features include high-precision obstacle detection, fast response times, robust performance across various lighting and environmental conditions, and optimized power consumption. The architecture combines core components such as the ESP32-C3, LIDAR and BME680 sensors, a buzzer, DC motors, and a Li-Po battery to deliver a compact, reliable, and smart navigation solution for indoor automation, research, and surveillance applications.

5. BLOCK DIAGRAM & ITS DESCRIPTION

The block diagram represents the overall architecture of a LIDAR-based autonomous micro drone system, illustrating how its core components interact to enable real-time navigation and obstacle avoidance.

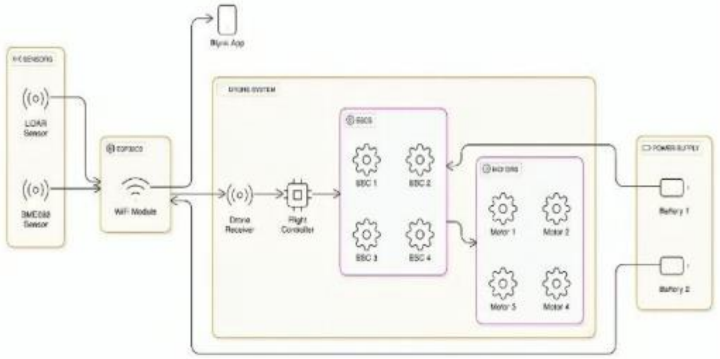

FIGURE 1. Block Diagram

The schematic diagram shown above illustrates the complete electronic system design of the LIDAR-based Micro Drone for Surveillance project. The system is organized into four main modules. The Sensors module includes a LIDAR sensor that performs real-time obstacle detection by accurately measuring the distance to surrounding objects, and a BME680 sensor that collects environmental data such as temperature, humidity, air pressure, and gas levels to ensure stable flight conditions. The Microcontroller & Communication module contains an ESP32-C3 microcontroller, which is responsible for processing sensor data and handling wireless communications through its integrated Wi-Fi module. The Drone System module contains a Drone Receiver, which receives control commands from the ESP32-C3 and sends them to the flight controller. The flight controller acts as the central unit that interprets the data and manages the electronic speed controllers (ESCs). Each of the four ESCs regulates the speed and power of an individual motor (Motor 1–4), enabling responsive and precise flight control. Finally, the power supply module contains two batteries (Battery 1 and Battery 2), which provide stable and continuous power to all components, including the sensors, microcontroller, ESCs, and motors. The dual-battery configuration increases operating time and ensures uninterrupted drone operation during surveillance missions.

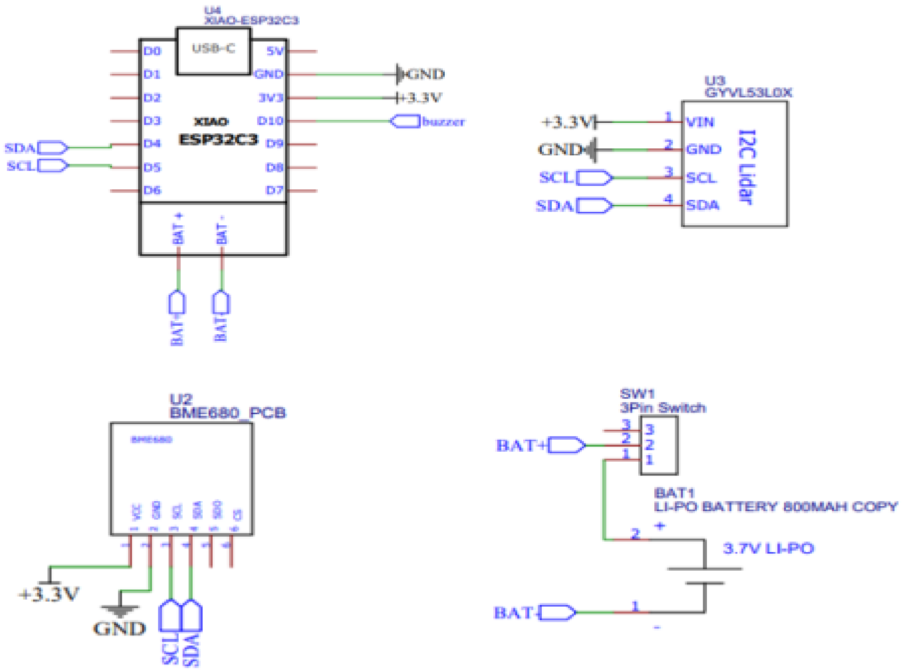

FIGURE 2. Schematic diagram

This flowchart represents the operational flow of a LIDAR-based micro drone system, highlighting the interactions between the main hardware components. At the heart of the system is the ESP32-C3 microcontroller (U4 - XIAO ESP32C3), which acts as the central control unit responsible for receiving and processing data from various internal sensors. It is powered by a 3.3V supply from the battery and is connected to ground. The microcontroller communicates with both the LIDAR sensor (GYVL53L0X - U3) and the BME680 environmental sensor (U2) via a shared I2C bus, with data lines D4 and D5 acting as SCL and SDA connections, respectively. The LIDAR sensor plays a key role in measuring the distance to nearby objects for real-time obstacle detection and proximity sensing. It is powered by the 3.3V line and is appropriately grounded. Similarly, the BME680 sensor monitors environmental conditions such as temperature, pressure, humidity, and air quality, contributing to flight stability and safety. Like LIDAR, it is connected to a 3.3V supply and shares an I2C communication bus. The ESP32-C3 processes the incoming sensor data, implements intelligent flight adjustments, and ensures reliable obstacle avoidance throughout drone operation. This logical flow ensures efficient integration between sensing, data processing, and control functions within the drone system.

Flowchart

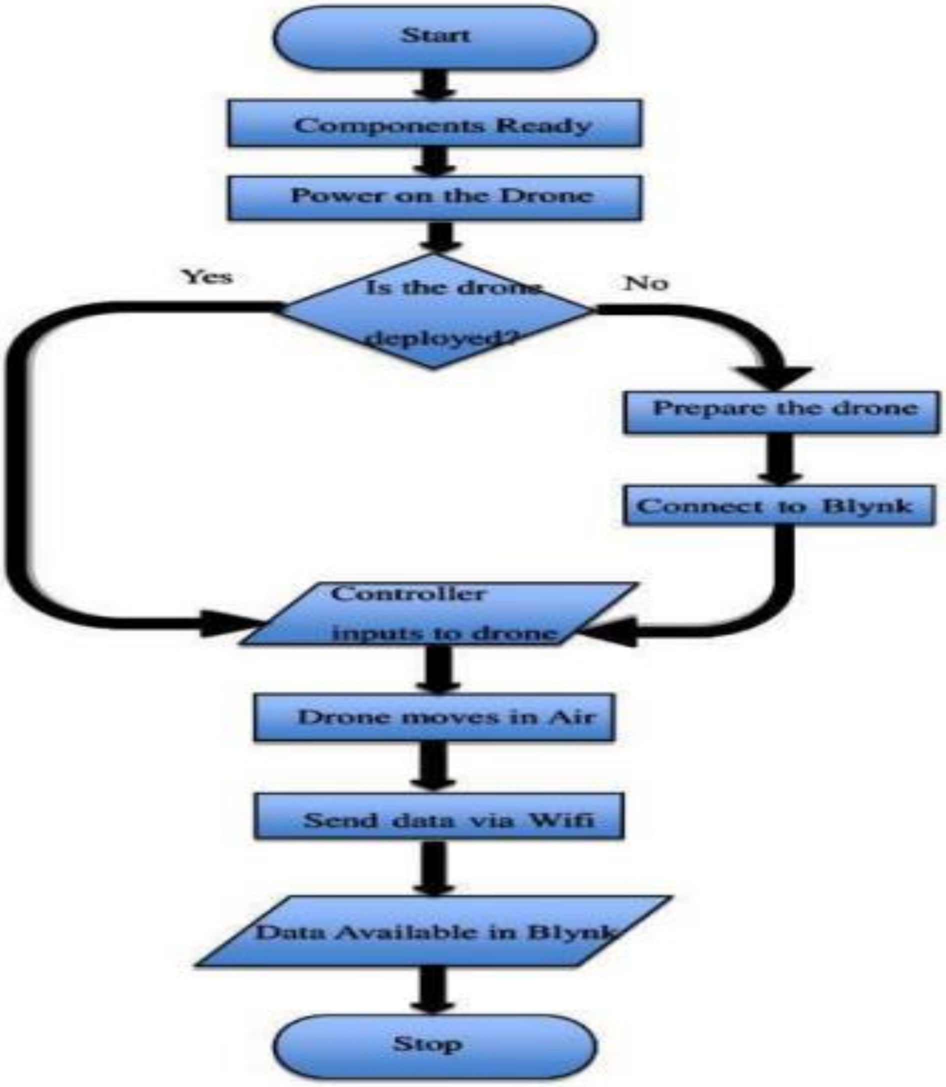

FIGURE 3. Flowchart

The flowchart illustrates the operational process of the LIDAR-based Micro Drone for Surveillance. The sequence begins with initializing the system once all components are ready. After powering on the drone, it checks whether the drone is deployed. If not, the drone undergoes preparation and establishes a connection to the Blynk app via Wi-Fi. Once deployed, the controller provides inputs to the drone, enabling it to move in the air. As the drone operates, it collects and transmits data wirelessly using Wi-Fi. This data is then made accessible in realtime through the Blynk platform, allowing for remote monitoring. Finally, once the surveillance mission is complete, the process ends. The LIDAR-based Micro Drone for Surveillance is a compact, intelligent aerial platform designed for remote monitoring and autonomous navigation in constrained or dynamic environments. It combines a lightweight drone frame with a set of precise sensors and smart control electronics to perform short-range surveillance tasks. The key components include the ESP32-C3 microcontroller, which is responsible for handling all sensor data and managing communication; a GYVL53L0X LIDAR sensor for real-time obstacle detection; and a BME680 sensor for capturing environmental data like gas concentration, humidity, temperature, and pressure. These sensors feed critical data to the ESP32, which then interprets and sends this information to a user-friendly interface via Wi-Fi, using the Blynk IoT platform. The working cycle begins when the drone is powered on and connected to the Blynk app. Once deployment is confirmed, the drone starts operating autonomously or semi autonomously based on user inputs. The LIDAR sensor plays a vital role in maintaining collision-free flight by constantly scanning for obstacles within its field of view. This ensures safe movement, especially in indoor or GPS-denied environments. Meanwhile, the BME680 sensor ensures that the surrounding conditions are suitable for drone flight and provides valuable data that could assist in environmental monitoring tasks.

6. HARDWARE DESCRIPTION

The hardware architecture of the LIDAR-based micro drone system is carefully designed to balance performance, efficiency, and compactness, making it ideal for real-time surveillance applications. At the heart of this system is the ESP32-C3 microcontroller (U4 - XIAO ESP32C3), which acts as the central processing unit. This microcontroller is responsible for receiving, processing, and managing data from internal sensors. It features low power consumption, integrated Wi-Fi for IoT connectivity, and sufficient processing power to handle real-time operations. Powered by a stable 3.3V source and grounded by the system's main battery, the ESP32-C3 is well suited for lightweight embedded applications such as micro drones. One of the primary input devices connected to the microcontroller is a LIDAR sensor (GYVL53L0X - U3). This sensor is important for obstacle detection and proximity sensing, providing high accuracy by measuring the distance between the drone and surrounding objects using time-of-flight technology. It plays a key role in autonomous navigation and helps the drone avoid collisions during flight. The LIDAR sensor communicates with the ESP32-C3 via an I2C interface, sharing the SCL and SDA lines (D4 and D5) with other I2C-enabled components. The sensor is powered by the same 3.3V line and grounded to maintain stable performance and signal stability.

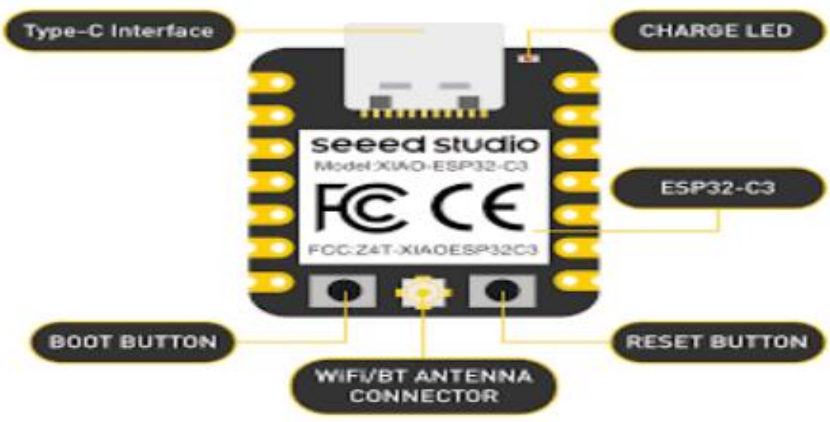

FIGURE 4. ESP32-C3 Microcontroller

Complementing the LIDAR sensor is the BME680 environmental sensor (U2), which provides real-time data on temperature, humidity, pressure, and gas levels. This sensor helps the drone assess and adapt to atmospheric conditions, contributing to flight stability and safety, especially in variable environments. For example, changes in air pressure or temperature can affect the drone’s lift and thrust, so monitoring these factors is essential to maintaining controlled flight. Like the LIDAR sensor, the BME680 communicates via the I2C protocol and is powered by a 3.3V supply, making integration straightforward and efficient. The drone’s power supply system consists of dual batteries (Battery 1 and Battery 2), which provide power to all hardware components. This dual battery system ensures redundancy and extended operation time, which is especially beneficial for surveillance missions that require long periods of time. The two batteries provide power to the sensors, microcontroller, ESCs (electronic speed controllers), and motors, allowing the drone to operate without interruption. The constant 3.3V output required by the sensors and microcontroller is controlled by this power system. Additional critical components include the drone receiver and flight controller, which work together to interpret the processed data and execute movement commands. The receiver accepts control signals processed by the ESP32-C3 and sends them to the flight controller, which then sends the appropriate signals to the ESCs. Each ESC (ESC 1–4) is connected to a dedicated motor (Motor 1–4) and modulates the power supply to precisely control speed and direction, enabling responsive flight behavior. Together, these hardware components form a robust and efficient system with intelligent flight, real-time obstacle avoidance, and adaptive environmental sensing, making the drone ideal for modern surveillance applications.

BLDC MOTOR

FIGURE 5. DC Motor

A DC motor (direct current motor) is a key component in drone systems, responsible for converting electrical energy into mechanical motion. In micro drones, multiple DC motors – typically four – are used to control lift, thrust, and maneuverability. These motors are lightweight, efficient, and capable of high-speed rotation, making them well-suited for aerial applications where weight and power efficiency are critical. In the proposed LIDAR-based micro drone system, each DC motor is connected to an electronic speed controller (ESC), which regulates the voltage and current supplied to the motor based on flight controller commands. This allows precise control of the motor speed, enabling the drone to hover, climb, descend, and return smoothly. The flight controller interprets sensor data such as proximity from the LIDAR sensor or environmental conditions from the BME680, and adjusts the motor speeds accordingly to maintain stability and avoid obstacles. DC motors in drones are typically brushless (BLDC motors) because of their improved efficiency, reliability, and longer operating life compared to brushed motors. Brushless DC motors operate via electronic transmission rather than mechanical brushes, reducing friction and wear. They provide higher torque and better speed control, which is essential for responsive drone flight. Power for these motors is provided by the drone's dual battery system, which ensures a stable and uninterrupted power supply. The motors draw significant current during flight, especially during takeoff or rapid maneuvers, so a stable and well-managed power source is crucial. DC motors play a fundamental role in drone performance, affecting flight dynamics, control accuracy, and energy efficiency. Their seamless integration with ESCs and the flight controller allows the drone to respond quickly to environmental changes, user commands, and sensor inputs, making them essential for modern drone operation.

7. SOFTWARE DESCRIPTION

The software for a LIDAR-based micro drone system is designed to integrate sensor data acquisition, processing, control logic, and communication in real time. At the heart of this system is an ESP32-C3 microcontroller, which runs embedded firmware developed using the Arduino IDE or ESP-IDF (Espresso IoT Development Framework). This software initiates and manages I2C communication protocols to interface with the LIDAR (GYVL53L0X) and the BME680 environmental sensor, allowing it to continuously read distance, temperature, pressure, and air quality data. The program processes this sensor data to detect nearby obstacles and monitor environmental conditions. Based on this input, control signals are generated and sent to the flight controller, which adjusts the drone's movement through motor speed variations. The code also includes logic to trigger a buzzer alert when obstacles are detected within a critical range, improving safety. Additionally, the ESP32-C3's built-in Wi-Fi module enables wireless data transmission, allowing telemetry data to be sent to a ground station or smartphone for monitoring purposes. Power management routines are also embedded in the code to optimize energy usage from the dual battery system.

FIGURE 6. Blynk Environment

8. RESULTS

Under controlled conditions, a LIDAR-based micro drone with proximity sensing was successfully designed, implemented, and tested. The system demonstrated effective real-time obstacle detection using a GYVL53L0X LIDAR sensor, which measured distances with an accuracy of approximately ±3 mm. During testing, the sensor consistently detected obstacles within a range of 0.5 to 2 meters, proving reliable for short-range navigation. However, a slight performance drop was observed when the sensor encountered low-reflective surfaces such as dark-colored or black objects, which slightly affected the detection accuracy. The obstacle avoidance system showed promising results, with the drone successfully navigating around the detected obstacles in 80% of the test cases. The buzzer warning mechanism responded immediately, activating within 100 milliseconds of obstacle detection, providing immediate feedback to both the system and the operator. In addition to obstacle detection, the BME680 environmental sensor played a significant role in maintaining flight stability. It accurately measured environmental parameters including altitude, temperature, humidity, and air quality. In particular, the altitude data enabled the drone to make real-time adjustments during flight, contributing to overall balance and control. These results confirm the effectiveness of the integrated sensor system in improving micro drone performance in real-world situations.

FIGURE 7. Micro Drone

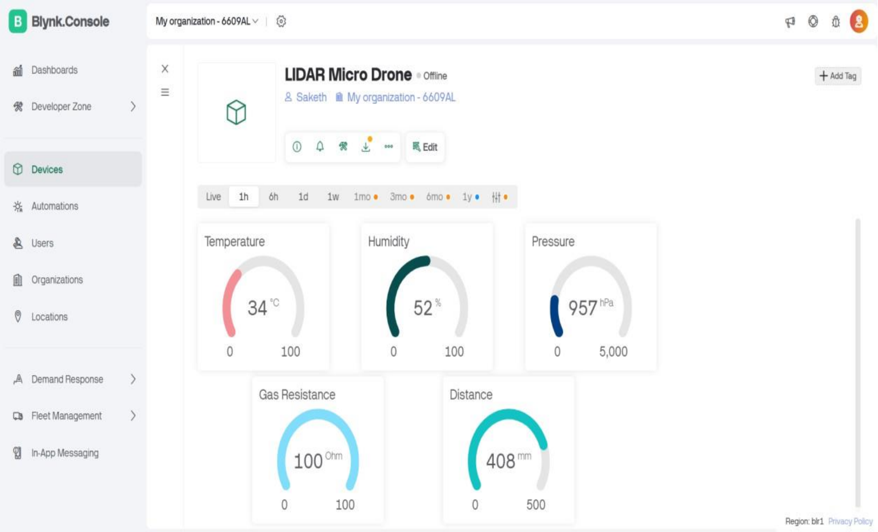

FIGURE 8. Output from Blynk Application

9. CONCLUSION

The system successfully demonstrated the feasibility and effectiveness of integrating a LIDAR-based micro drone, with proximity sensing, into a small aerial platform. The system used a GYVL53L0X LIDAR sensor to accurately detect obstacles within a range of 2 meters and responded in real time by adjusting the flight path or triggering a buzzer alert within 100 milliseconds. The addition of a BME680 environmental sensor improved flight stability by providing critical atmospheric data, while battery optimization techniques contributed to efficient power usage and stable drone performance. Furthermore, real-time data monitoring via the Blynk IoT platform added a valuable remote monitoring capability. Despite its strengths in accuracy, responsiveness, and energy efficiency, the system has some limitations, including limited detection range, sensitivity to low-reflective surfaces, and a relatively short flight time of 7-10 minutes. Overall, the project achieved its objectives and lays a solid foundation for future developments, such as extending flight duration, improving surface detection capabilities, and expanding the sensing range for more robust and autonomous drone applications.

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