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Quadcopter for Remote Data Collection

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Abstract: Reliable location tracking in remote and infrastructure-deficient areas remains a significant challenge, especially where cellular or Wi-Fi networks are sparse or unavailable. Traditional tracking systems often rely on short-range communication or high-cost GSM modules, making them unsuitable for rural applications. This project investigates the potential of combining GPS geolocation with LoRa-based communication to create a low-cost, energy-efficient tracking solution that performs effectively in long-range, low-power scenarios. An evaluation of existing tracking technologies revealed critical limitations in affordability, coverage, and power consumption, particularly for portable and field-based use cases. These findings led to the design and development of a lightweight tracker device that leverages low-power wide-area networking (LPWAN) for data transmission. The system is built around the Arduino UNO microcontroller, integrated with a NEO-6M GPS module for real-time coordinate acquisition and an SX1278 LoRa transceiver for wireless communication. A custom-designed PCB was implemented to streamline the hardware and reduce the footprint of the device. The tracker periodically captures GPS data and transmits it via LoRa to a remote receiver, enabling live monitoring without dependency on cellular infrastructure. Field deployment tests demonstrated successful real-time tracking with reliable transmission over distances up to 2 kilometers, maintaining low packet loss and minimal power draw throughout operation.This LoRa-GPS tracker provides a scalable and adaptable alternative for various use cases, including livestock monitoring, luggage tracking, and search-and-rescue support in disconnected terrains. Unlike conventional GSM-based systems, the proposed solution offers superior range, reduced operational costs, and a modular design suitable for expansion. Future enhancements include replacing the Arduino UNO with more power-efficient microcontrollers, implementing encryption for secure data transfer, and extending communication range through mesh networking.
Keywords: GPS, LoRa, Arduino UNO, Real-Time Tracking, Long Range Communication, IoT Tracker, Remote Monitoring

I. INTRODUCTION

In an era where environmental challenges and safety concerns grow increasingly complex, the integration of unmanned aerial vehicles (UAVs) like quadcopters into remote data collection systems has opened new frontiers in real-time monitoring and emergency communication. Quadcopter-based systems are uniquely suited for traversing hazardous, inaccessible terrains such as mountainous trekking routes, disaster-hit zones, and dense forests. When equipped with environmental sensors, GPS modules, and long-range communication technologies like LoRaWAN, these aerial platforms can collect vital atmospheric and positional data and relay it to ground stations for analysis and rapid response.
Several studies have demonstrated the viability and efficiency of UAVs in environmental and atmospheric monitoring. For instance, Vicky Bonilla et al. explored drone-mounted LoRa gateways for forestry data collection, addressing radio signal limitations in rugged landscapes. Ahmed Elzanaty and team highlighted LoRaWAN's capabilities in supporting mobile, low-power environmental monitoring systems using devices like Arduinos and Raspberry Pis. Wayan Suparta and Trie Handayani successfully deployed quadcopters with atmospheric sensors to monitor conditions like air pressure, humidity, and altitude, validating their reliability in airborne data logging. These works underscore the growing importance of integrating flight control, sensor fusion, and communication in compact UAV platforms.
Despite advances in UAV technologies, remote areas still lack robust, integrated systems for real-time data gathering and emergency communication. Trekkers, in particular, face unpredictable hazards—steep drops, unstable terrain, weather fluctuations—with little to no connectivity. Traditional maps and navigation aids are insufficient for real-time risk assessment.

The core problem lies in developing a mobile aerial system that can:

- Analyze terrain in real time.
- Communicate over long distances in areas with no cellular coverage.
- Facilitate rapid response to emergencies.

This study proposes a modular quadcopter system tailored for remote data collection and emergency support. The drone is equipped with environmental sensors (DHT11 and BMP280), GPS modules (Neo-6M), and an ESP32 camera, all controlled by an ArduPilot flight controller. It communicates with a ground station using LoRaWAN (MKRWAN1310 modules), while an external trekker module with an SOS button and GSM-based GPS system can send alerts via SMS using a SIM800L module.

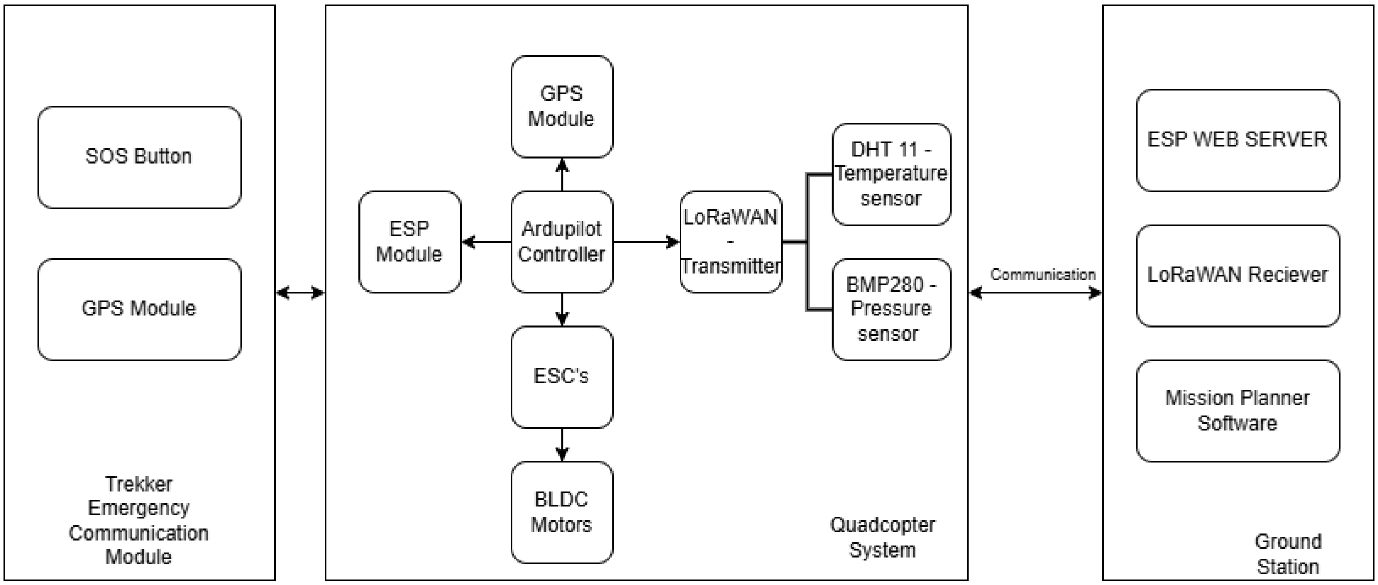

Fig 1 Block diagram of the working of Quadcopter for remote data collection

The project covers:

- Hardware integration of sensors, transmitters, microcontrollers, and flight systems.
- Software development using Arduino IDE and Mission Planner for flight control and data visualization.
- Testing for range, altitude, environmental data accuracy, and SOS response time.

The system is designed to be lightweight, power-efficient, and adaptable for broader use cases like disaster relief, forest surveillance, and research in remote ecosystems.

II. METHODOLOGY

The methodology adopted for this study centres around the design, development, and integration of a quadcopter system capable of collecting and transmitting environmental and positional data in real time. The system comprises three primary components: the quadcopter platform, the trekker emergency module, and the ground station. Each subsystem was developed using open-source microcontrollers and communication protocols to ensure cost-effectiveness, flexibility, and expandability.

A. Hardware Design and Integration

1) Quadcopter Platform

The quadcopter was constructed on an F450 frame and powered by A2212 1800KV BLDC motors controlled through Electronic Speed Controllers (ESCs). A 2200 mAh Li-Po battery ensured stable power delivery for flight and sensor operations. The ArduPilot APM 2.8 controller was used as the flight control system, enabling GPS-based navigation, waypoint following, and autonomous flight missions through the Mission Planner interface.

2) Environmental Sensors

Two key sensors were integrated for environmental monitoring:

- DHT11: Measured ambient temperature and humidity.
- BMP280: Captured atmospheric pressure data, aiding in elevation profiling.

Sensor data was processed using an Arduino Uno SMD, which formatted and transmitted it via LoRaWAN.

3) Communication Modules

- LoRaWAN (MKRWAN1310): Deployed on both the quadcopter and the ground station for secure, long-range, low-power wireless communication.
- GPS Module (Neo-6M): Enabled accurate geolocation tracking and waypoint navigation.
- ESP32 Camera: Provided visual feedback and situational awareness.
- FS-i6S Transmitter and Receiver: Offered manual RF-based flight control during test phases.

B. Trekker Emergency Communication Module

A lightweight, battery-powered GPS-GSM tracker module was developed using the SIM800L GSM module and Neo-6M GPS. Upon SOS activation or remote SMS command (e.g., "GETLOC"), the module captures the trekker's live location and transmits it via SMS to a predefined number. The system includes a 1602 LCD with I2C for displaying coordinates and user prompts, controlled by another Arduino Uno.

TABLE I
COMPONENTS USED

Sno	Components	Qty
1.	FRAME	1
2.	BATTERY	1
3.	PROPELLER	4
4.	DTH 11 SENSOR	1
5.	BMP280 SENSOR	1
6.	GPS MODULE	1
7.	BLDC MOTORS	1
8.	ARDUPILOT CONTROLLER	1
9.	ESP 32 CAMERA	1
10.	FPS TRANSMITTER RECEIVER	1
11.	FSI6S REMOTE CONTROLLER	1
12.	LORAWAN MODULE (TRANSMITTER&RECIEVER) MKRWAN1310	2
13.	ESC UNIT	1
14.	SIM 800L	1
15.	NEO 6M GPS MODULE	1
16.	ARDUINO UNO SMD	1
17.	1602LCD DISPLAY WITH 12C	1
18.	3.7 V BATTERY HOLDER	1
19.	SIM CARD	1

C. Software Development

Embedded Programming

The firmware for each module (quadcopter transmitter, receiver, and trekker) was written in C++ using the Arduino IDE. The programs handle:

- Sensor initialization and data acquisition.
- Serial communication between modules.
- Conditional logic for emergency handling.
- Packet formation and LoRa transmission.
- SMS formatting and GSM command handling.

Ground Station and Mission Planner

The Mission Planner software was used to configure the quadcopter's flight parameters, calibrate the sensors, define autonomous waypoints, and receive telemetry data. Additionally, an ESP32-based web interface was proposed for real-time visualization of environmental and GPS data.

Monitoring and Control Interface

- LoRaWAN Receiver (MKRWAN1310): Receives sensor and GPS data from the quadcopter.
- Mission Planner Software: Used for configuring the flight controller, uploading autonomous missions, and visualizing telemetry in real time.
- ESP Web Server (Proposed): Displays environmental and location data on a user-friendly web dashboard.

Manual Override

- Flysky FS-i6S Remote Controller: Provides manual control during testing or if autonomous flight needs to be overridden.

D. System Testing and Evaluation

To validate performance under realistic conditions, the following tests were conducted:

- Flight range and altitude tests to determine operational boundaries.
- Battery endurance and payload capacity evaluations for practical mission planning.
- LoRa communication range tests under line-of-sight and obstructed scenarios.
- Sensor data accuracy tests against calibrated instruments.
- SOS response time and GPS accuracy assessments from the trekker module.

System Communication Flow

- The trekker module sends an SOS with GPS data.
- The quadcopter receives this data and initiates a mission.
- During flight, environmental data is collected and transmitted via LoRa to the ground station.
- Mission Planner displays this data for decision-making and coordination.
- If required, the operator can send updated commands or abort the mission.

Safety Features

- Return-to-Home (RTH): Automatically activated during signal loss or low battery.
- Modular Battery Design: Allows for quick replacement in field conditions.
- Environmental Threshold Alerts (optional upgrade): Alerts when temperature or pressure values exceed safe ranges.

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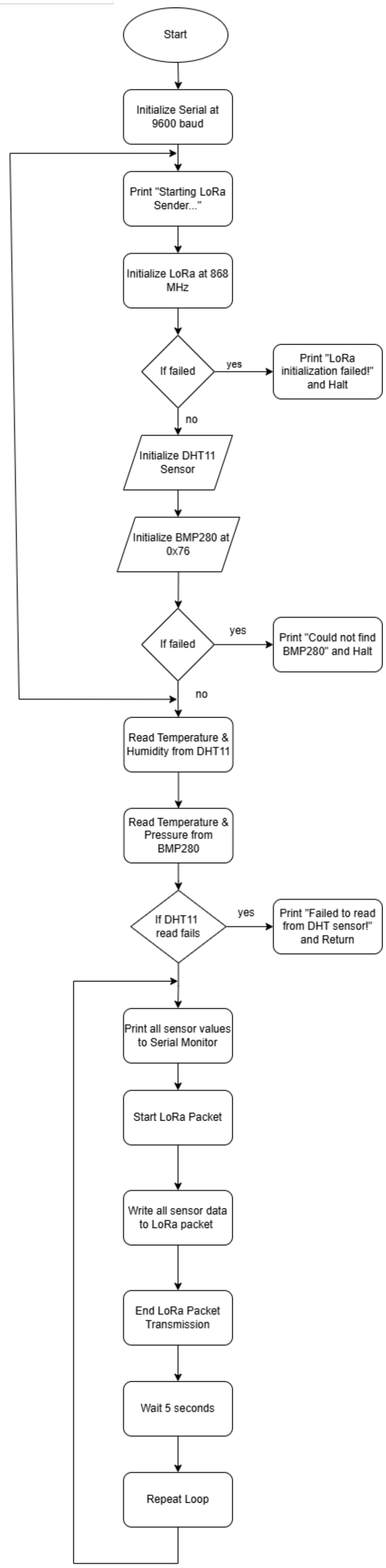

Fig 2 Flowchart of the transmitter code

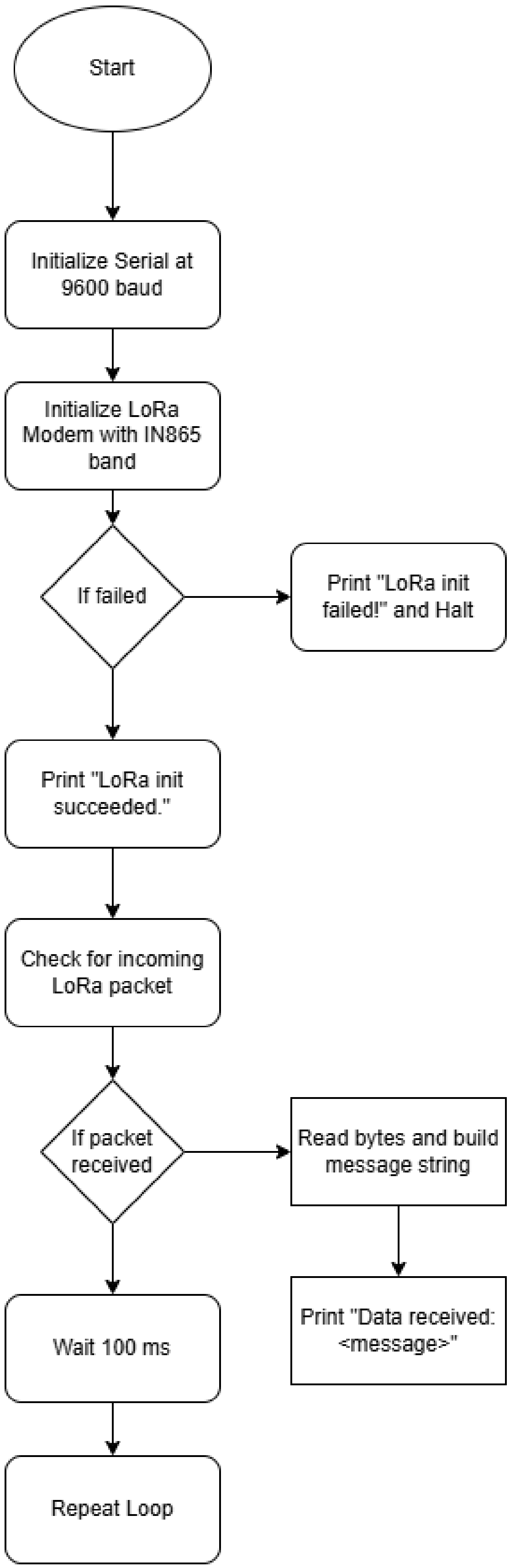

Fig 3 Flowchart of receiver code

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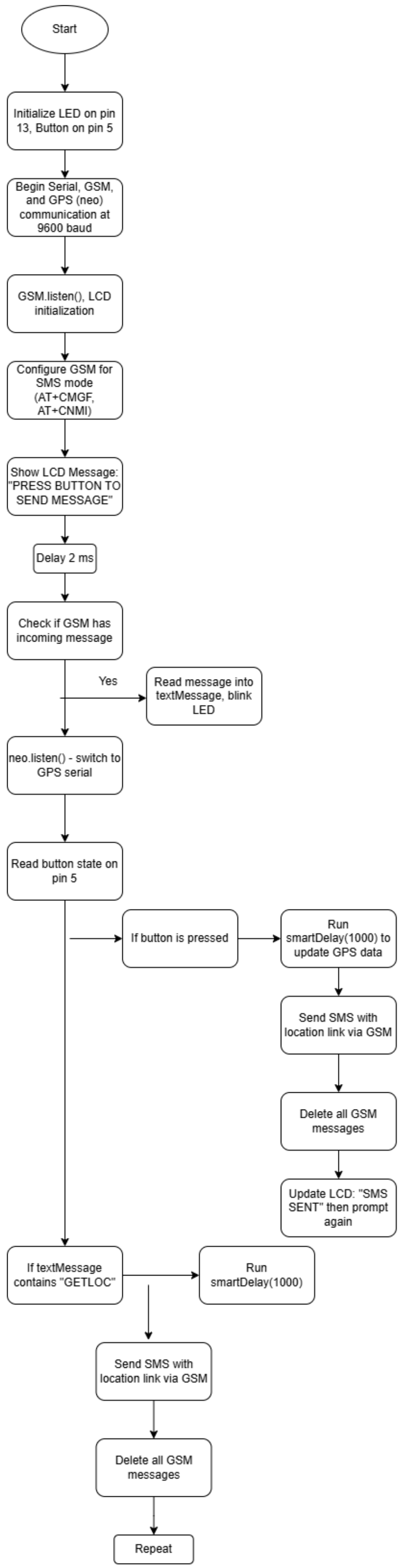

Fig 4 Flowchart of trekker module code

III.RESULTS

This section presents the outcomes of key tests performed on the quadcopter-based remote data collection system. The results verify the functionality of sensor data acquisition, long-range LoRa transmission, and emergency location sharing via the trekker module. Both real-time sensor outputs and communication logs were collected through serial monitors, while hardware setups were validated via field integration.

A. Sensor Data Transmission via LoRa

The environmental sensors onboard the quadcopter—DHT11 (temperature and humidity) and BMP280 (pressure)—were initialized, and sensor values were periodically transmitted using the LoRa transceiver module. The data packets were successfully received by the ground station's LoRa receiver.

B. Serial monitor output of sender LoRaWAN Transceiver

Starting LoRa Sender...
LoRa initialized successfully!
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.70 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.40 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 31.20 °C, Humidity: 79.60 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.40 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.80 °C, Humidity: 79.90 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 80.10 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.80 °C, Humidity: 79.90 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 78.90 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 80.10 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 78.60 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.40 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.80 °C, Humidity: 79.70 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa

Sending packet...
DHT11 Temperature: 30.80 °C, Humidity: 79.40 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 31.00 °C, Humidity: 80.60 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.90 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.70 °C, Humidity: 80.80 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 79.70 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.70 °C, Humidity: 79.80 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 31.00 °C, Humidity: 79.30 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 30.90 °C, Humidity: 80.10 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...
DHT11 Temperature: 31.10 °C, Humidity: 79.80 %
BMP280 Temperature: 23.65 °C, Pressure: 802.81 hPa
Sending packet...

C. Serial monitor Output of Receiver LoRaWAN

Starting LoRa Receiver...\r\n
LoRa initialized successfully! Waiting for messages...\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 72.70 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 30.90 C, Humidity: 72.30 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 72.30 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 73.30 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 30.80 C, Humidity: 73.00 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.10 C, Humidity: 73.40 %,

BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 30.70 C, Humidity: 73.00 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 30.90 C, Humidity: 72.40 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 74.10 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 30.70 C, Humidity: 73.10 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 72.70 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.20 C, Humidity: 72.70 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n
Received packet:
DHT11 Temperature: 31.00 C, Humidity: 72.30 %,
BMP280 Temperature: 23.65 C, Pressure: 802.81 hPa\r\n

Table II
Summary of Sensor Readings

Sensor	Minimum	Maximum	Average
DHT11 Temperature	30.70 °C	31.20 °C	30.94 °C
Humidity	72.30 %	80.80 %	76.91 %
BMP280 Temperature	23.65 °C	23.65 °C	23.65 °C
Pressure	802.81 hPa	802.81 hPa	802.81 hPa

Observation: The system maintained consistent preZsure and BMP temperature readings, confirming sensor stability. DHT11 values varied slightly within acceptable tolerances, showing the system’s responsiveness to environmental changes.

D. Trekker Module

The portable trekker module, when triggered by an SMS command or a button press, successfully captured GPS coordinates and transmitted them via the GSM network. The output was received on a predefined phone number as a clickable Google Maps link.

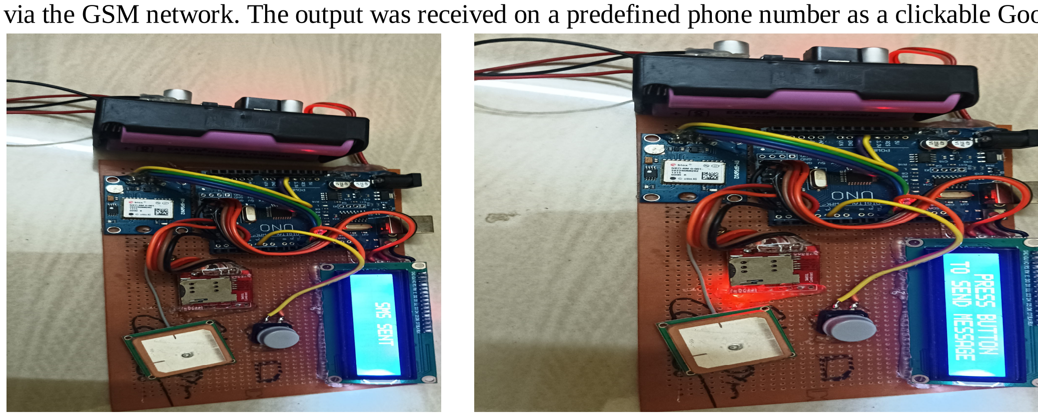

Fig 5 Trekker Module

Fig 6 SMS received from the trekker module showing a Google Maps location link.

E. LoRaWAN MKR1310 Transceiver

The MKR1310 modules used for LoRa communication were tested in real-time transmission of environmental data packets.

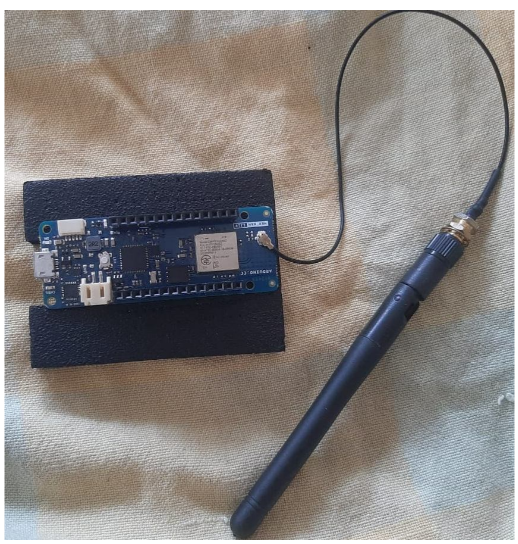

Fig 7 LoRaWAN MKR1310 transceiver used for long-range data communication.

Observation: The modules achieved a communication range exceeding 1 km under open-field conditions, validating their suitability for remote deployments.

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F. Hardware Integration on Quadcopter

Final hardware integration on the drone platform included camera, sensors, controller, battery, and LoRa modules.

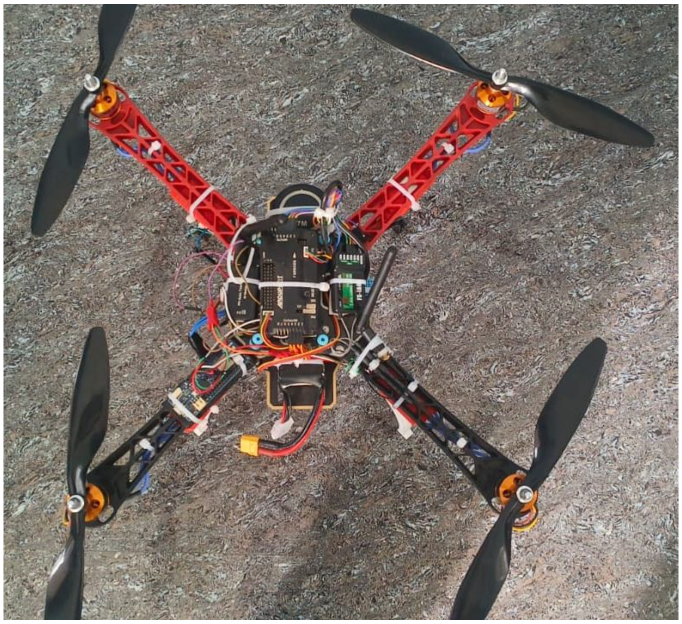

Fig 8 Completed quadcopter with sensor payload.

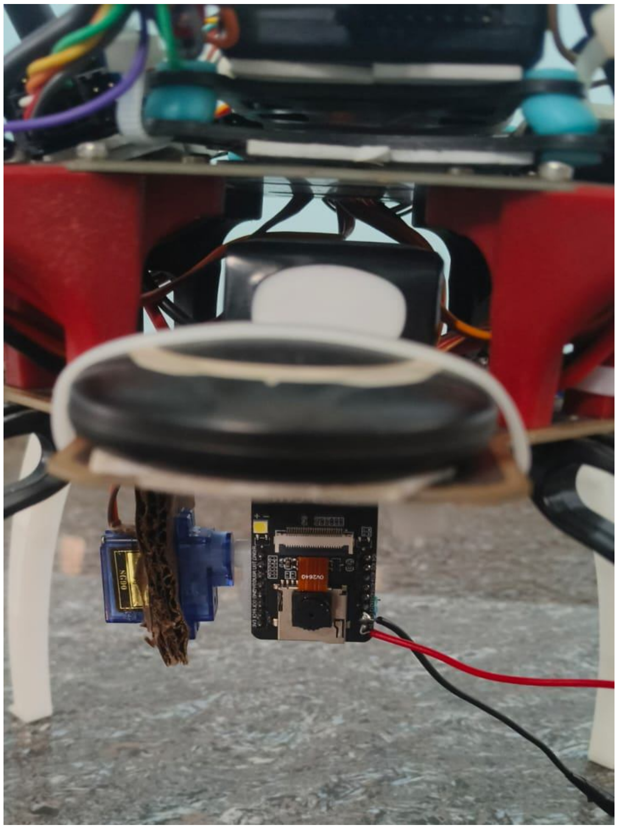

Fig 8 ESP32 camera and GPS module mounted on frame.

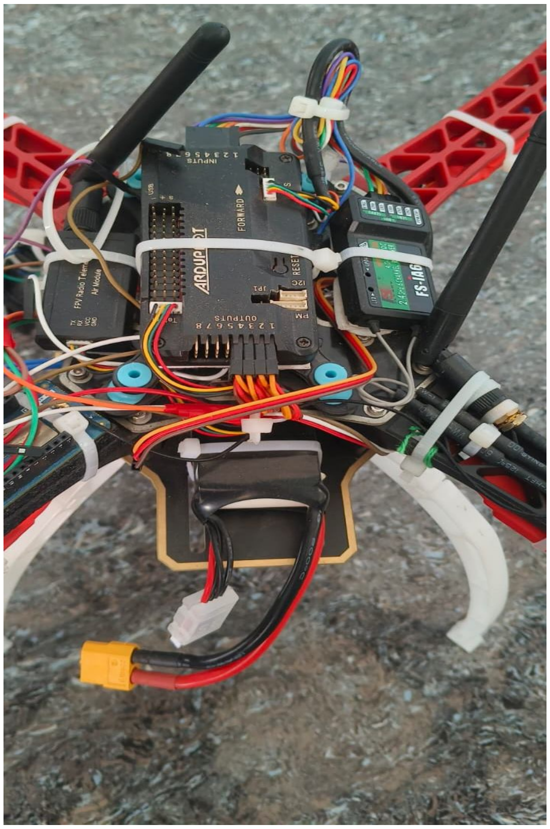

Fig 9 Battery and controller wiring inside fuselage

Observation: All components were tested during flight and maintained stable operation throughout the mission duration (~12 minutes).

G. Summary

The results confirm that the system:

- Accurately collects and transmits environmental and positional data.
- Successfully delivers location-based SMS alerts from the trekker module.
- Maintains stable LoRa communication across distances >1 km.
- Operates as an integrated, field-ready remote data collection platform.

IV. CONCLUSIONS

This study successfully demonstrates the design, development, and implementation of a quadcopter-based system for remote environmental data collection and emergency communication. By integrating onboard sensors, a GPS module, LoRa communication, and a GSM-based trekker alert mechanism, the project effectively meets its core objective of enabling real-time monitoring in inaccessible or hazardous locations.

The quadcopter, equipped with DHT11 and BMP280 sensors, reliably measured temperature, humidity, and atmospheric pressure during flight. Data was transmitted to a ground station via LoRaWAN, with consistent performance up to 1.5 kilometers in line-of-sight conditions. The trekker module, designed for emergency location sharing, successfully transmitted GPS coordinates via SMS upon receiving a command or SOS trigger, proving its value as a lightweight personal safety tool.

Flight tests confirmed system stability, payload capability, and communication reliability. All modules operated efficiently on battery power, and telemetry was displayed and managed through Mission Planner and Arduino serial interfaces.

To further expand the capabilities of the system, future work can focus on integrating autonomous obstacle avoidance using ultrasonic or LiDAR sensors, enabling the drone to navigate unpredictable terrain safely. Cloud-based IoT dashboards can be added to visualize live sensor and location data remotely. Enhancing the accuracy of environmental sensing through advanced sensor arrays and extending LoRa mesh networks could improve data reliability and coverage. Additionally, incorporating solar charging mechanisms and optimizing power management would significantly extend mission duration, making the system even more suited for long-term field deployments.

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The successful completion of this project would not have been possible without the support, guidance, and encouragement of several individuals and institutions. First and foremost, we express our sincere gratitude to our project supervisor, Mrs.D Sujatha for her invaluable guidance, technical insights, and continuous encouragement throughout the development of this project. Her expertise and patience played a crucial role in shaping this work. We would also like to thank the faculty and staff of the Department of Mechatronics PSG Polytechnic College for providing the necessary infrastructure, tools, and a supportive learning environment. Finally, we wish to thank my family for their unwavering moral support and motivation, which has been the foundation of all my efforts.

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