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AERO CUBE SURVEILLANCE SYSTEM USING CUBESAT

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Abstract: In The Aero Cube Surveillance System (ACSS) is a Cube Sat-inspired aerial surveillance module for advanced monitoring and data collection. Designed to operate in hard-to-reach or hazardous areas, ACSS captures high-resolution images, and environmental data, transmitting critical information in real time to a ground station. The ACSS optimizes bandwidth and power, ensuring efficient, responsive surveillance. Its modular design allows for easy customization with various sensors and cameras, enhancing its versatility across applications. The ACSS delivers a reliable, adaptable solution for rapid-response and continuous monitoring needs.

Keywords: Aerial surveillance module, modular design, rapid-response monitoring.

I.INTRODUCTION

The Aero Cube Surveillance System (ACSS) represents a cutting-edge innovation in aerial surveillance, drawing inspiration from Cube Sat technology. This compact and modular system is engineered for advanced monitoring and data collection in environments that are difficult to access or pose safety challenges. The ACSS integrates high-resolution imaging capabilities and environmental sensors, enabling it to gather critical information with precision and efficiency. Equipped with real-time data transmission to a ground station, the ACSS ensures timely decision-making while optimizing bandwidth and power through selective data handling. Its customizable modular design supports a wide range of sensor configurations, making it adaptable for diverse applications, from disaster response and environmental monitoring to industrial inspections and defence. By delivering reliable, efficient, and flexible surveillance, the ACSS addresses modern challenges in data-driven monitoring and situational awareness.

By delivering reliable, efficient, and flexible surveillance solutions, the ACSS addresses modern challenges in data-driven monitoring and situational awareness. This versatile system sets a new standard for aerial surveillance, paving the way for advancements in technology-driven monitoring across a broad spectrum of industries.

1.1 MOTIVATION

The motivation behind the Aero Cube Surveillance System (ACSS) stems from the need for a reliable and efficient solution to modern surveillance challenges. Traditional methods often fail in hazardous or remote areas, making the compact and deployable ACSS essential for accessing such environments. Its real-time data transmission enhances decision-making in emergencies, while selective data handling optimizes power and bandwidth usage. The system's modular design ensures versatility, enabling customization for diverse applications like environmental monitoring and defense. By drawing inspiration from CubeSat technology, ACSS bridges the gap between satellite-level and ground-based systems, offering an innovative, sustainable approach to advanced monitoring.

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1.2 OBJECTIVE

The primary objective of the Aero Cube Surveillance System (ACSS) is to develop a compact, efficient, and modular aerial surveillance module capable of real-time data collection and transmission. This system is designed to provide high-resolution imaging and environmental monitoring in hard-to-reach or hazardous areas. By leveraging advanced technology and optimizing power and bandwidth, the ACSS aims to:

- Enable rapid-response surveillance in critical scenarios such as disaster management and defense.
- Enhance situational awareness through continuous, real-time data transmission.
- Support diverse applications by integrating customizable sensors and cameras.
- Deliver a cost-effective and adaptable solution for modern monitoring challenges.
- Facilitate security and intrusion detection by capturing intruder photographs and implementing automated alerts via a Telegram bot integration.

II.METHODOLOGY

The primary task for this CubeSat uses a camera module to capture data and a Raspberry Pi 4 Model B to process it.The Raspberry Pi sends the processed data to the transmission station using a LoRa receiver.The transmission station receives data from the CubeSat using a LoRa transmitter and processes it through an Arduino Uno and Node Sensors.The processed data is then sent to the User Interface

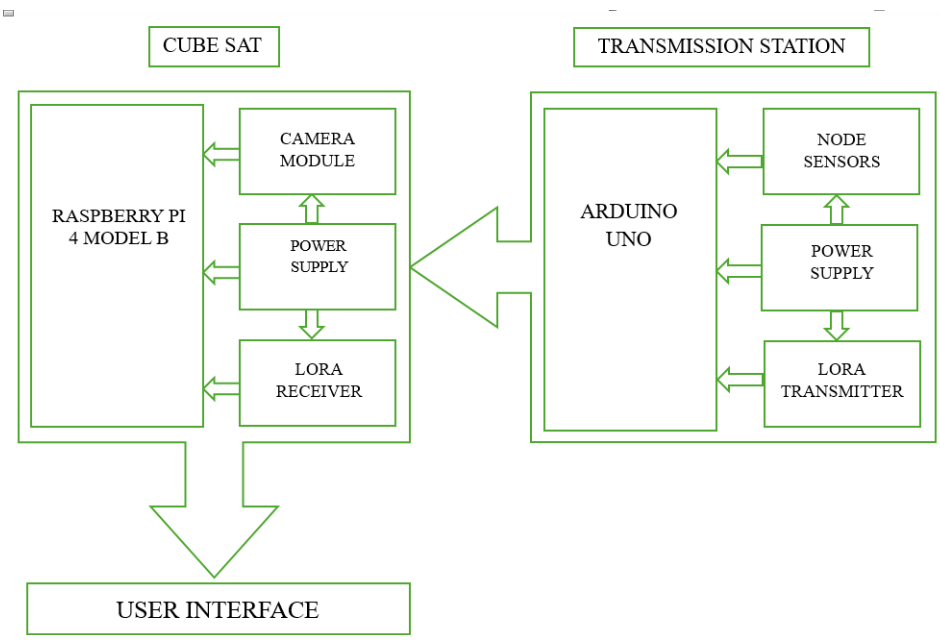

Fig: 1 BLOCK DIAGRAM OF AERO CUBE SURVEILLANCE SYSTEM USING CUBE SAT

2.1 CUBE SAT:

- **Raspberry Pi 4 Model B:** The central processing unit of the system. It receives data from the sensor module and processes it to send to the transmission station through Lora communication. It also manages the camera module to capture images in case of intrusion.
- **Camera Module**: This module captures live feed videos of the environment.
- **Lora Receiver**: Receives data from the transmission station.

2.2 TRANSMISSION STATION:

- **Arduino Uno:** The microcontroller that receives data from the sensor module.
- **Node Sensors:** This module contains multiple sensors including DHT11, motion sensor, smoke sensor, and ultrasonic sensor.

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- **Power Supply:** Provides power to the Raspberry Pi 4 Model B,Arduino Uno, camera module and the sensor module through power banks.

- **Lora Transmitter:** Sends data to the Raspberry Pi through Lora communication.

2.3 USER INTERFACE:

- This interface displays live feeds and data from the sensor module and the camera. It can be a web interface or a mobile app.

III. IMPLEMENTATION

3.1 HARDWARE SETUP

3.1.1 Setting Up the CubeSat Module: The hardware setup begins with the integration of the Raspberry Pi 4 Model B as the primary processing unit. The Raspberry Pi Camera Module 3 is connected to capture high-resolution live video feeds. A LoRa Receiver is attached to facilitate communication with the Transmission Station, while a dedicated power supply module ensures consistent power delivery to the CubeSat components. The captured video feed and data will later be transmitted to the user interface for monitoring.

3.1.2 Integrating the Camera for Real-Time Video: The Raspberry Pi Camera Module 3 is configured to stream live video. It captures footage from the surveillance area and sends it to a Flask-based user interface, where the video feed can be viewed in real time. Additionally, the camera is programmed to take a snapshot of an intruder if triggered by an event, such as distance threshold detection by the ultrasonic sensor.

3.1.3 Configuring the Transmission Station Sensors: The **Arduino UNO** serves as the core of the Transmission Station, where various **node sensors** are connected. These include the **DHT11 sensor** for temperature and humidity, a **motion sensor (PIR)** for movement detection, a **smoke sensor** for hazardous smoke levels, and an **ultrasonic sensor** for distance measurement. The sensors continuously collect data, which the Arduino processes and prepares for transmission.

3.1.4 Establishing LoRa Communication: The communication between the CubeSat and the Transmission Station is enabled using LoRa modules. A LoRa Transmitter is connected to the Arduino at the Transmission Station to send sensor data, while a LoRa Receiver on the CubeSat receives this information. LoRa ensures long-range, low-power communication, allowing the two modules to function efficiently even over extended distances.

3.1.5 Threshold Detection and Intruder Alert: The ultrasonic sensor continuously monitors distance, and when an intruder crosses the set threshold, it triggers the system. The Raspberry Pi Camera Module 3 captures an image of the intruder, which is immediately sent to a Telegram bot for alert notifications. This ensures the user receives real-time intruder alerts for prompt action.

3.1.6 Powering the System: Both the CubeSat and Transmission Station rely on dedicated power supply modules. The Raspberry Pi, camera module, and LoRa Receiver draw power from the CubeSat's supply, while the Arduino and connected sensors are powered separately at the Transmission Station. Proper power management ensures uninterrupted operation of all components.

3.1.7 Updating the User Interface: The collected sensor data (temperature, humidity, motion, smoke levels, and distance) is transmitted to the user interface using Flask. The live video feed from the Raspberry Pi Camera Module 3 is also updated in real time. Users can monitor the surveillance area and receive critical alerts, ensuring an efficient and user-friendly experience.

4.1 SOFTWARE DEVELOPMENT:

4.1.1 Configuring the Raspberry Pi Operating System: The software development begins with setting up the Raspberry Pi 4 Model B by installing an operating system such as Raspberry Pi OS. The necessary libraries and dependencies, including Python, Flask, and OpenCV, are installed to enable video streaming, sensor data processing, and communication. This forms the base for running all required software components.

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4.1.2 Developing the Flask-Based User Interface: A Flask application is developed to serve as the user interface for real-time monitoring. The interface displays the live video feed captured by the Raspberry Pi Camera Module 3 and updates sensor data such as temperature, humidity, motion detection, smoke levels, and distance. Flask facilitates smooth interaction between the user and the surveillance system through a web-based interface.

4.1.3 Programming in Arduino IDE for Sensor Data Collection and LoRa Communication: The Arduino UNO is programmed using the Arduino IDE to collect data from node sensors, including DHT11, motion sensor (PIR), smoke sensor, and ultrasonic sensor. The sensor data is processed using Arduino Python code to ensure reliable readings. Additionally, the Arduino code integrates LoRa communication to transmit the sensor data to the CubeSat. By sending real-time environmental and motion data, the Arduino enables smooth and efficient communication with the Raspberry Pi.

4.1.4 Live Video Streaming Integration: Python scripts utilizing the OpenCV library are used to control the Raspberry Pi Camera Module 3. The live video feed is streamed to the user interface via Flask, providing continuous surveillance. The software is configured to capture an image when triggered by a threshold breach from the ultrasonic sensor.

4.1.5 Automating Intruder Detection and Telegram Alerts: A Python script is developed to monitor the ultrasonic sensor data for threshold breaches. When an intruder is detected, the system captures an image using the Raspberry Pi Camera Module 3. The image is sent to a Telegram bot using the Telegram API, alerting the user with real-time notifications. This ensures prompt situational awareness.

4.1.6 Data Display and User Interface Updates: The Flask application is programmed to display live updates of the sensor data and video feed. Sensor readings, including temperature, motion detection, smoke levels, and ultrasonic measurements, are processed in real time and shown on the user interface. The Flask framework ensures a responsive and user-friendly platform for monitoring the system. rduino Firmware Development.

V.RESULT

Fig 2: Prototype of Cube SAT and tansmission stationmodel

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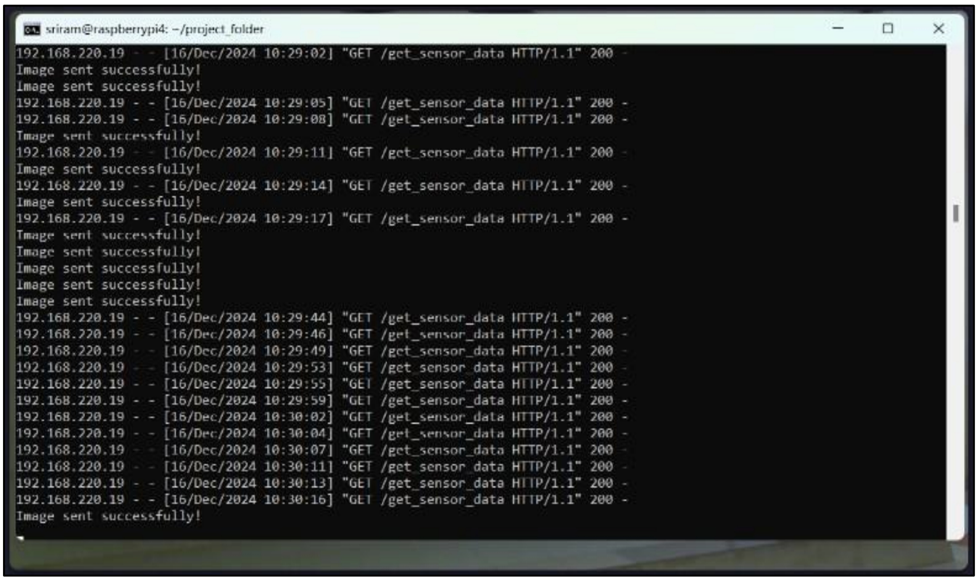

Fig 5.2 Raspberry pi OS Terminal SSH Interface

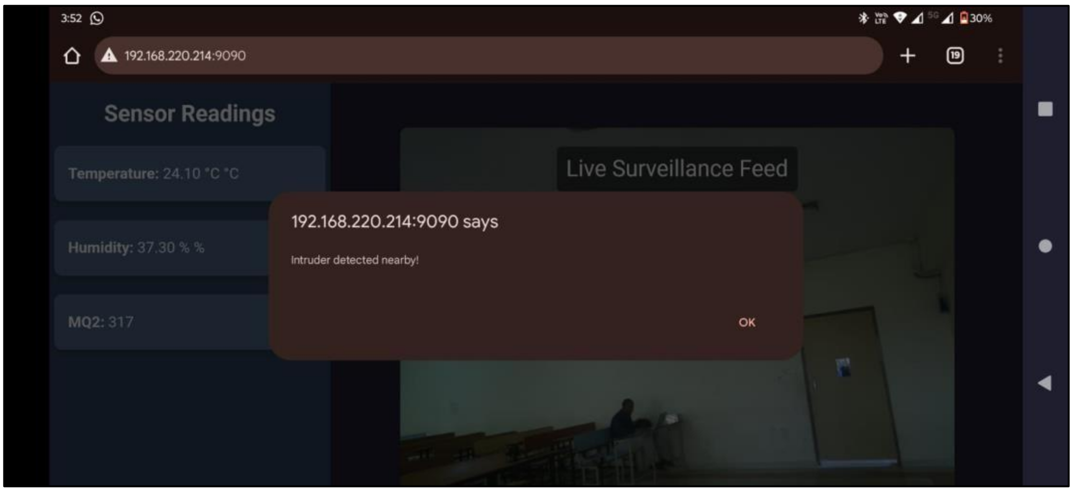

Fig 3: Live feed of Transmitted readings with real time video showing on User Interface

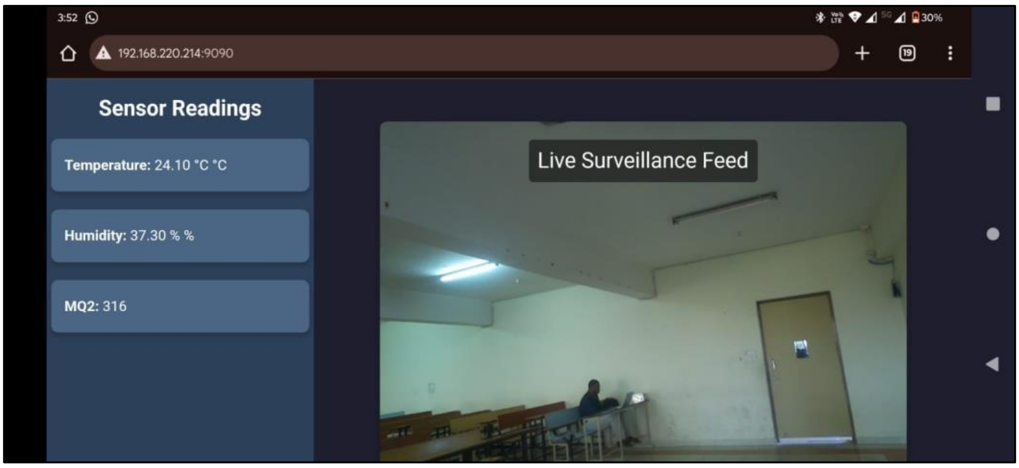

Fig 4: Intruder Alert on Interface

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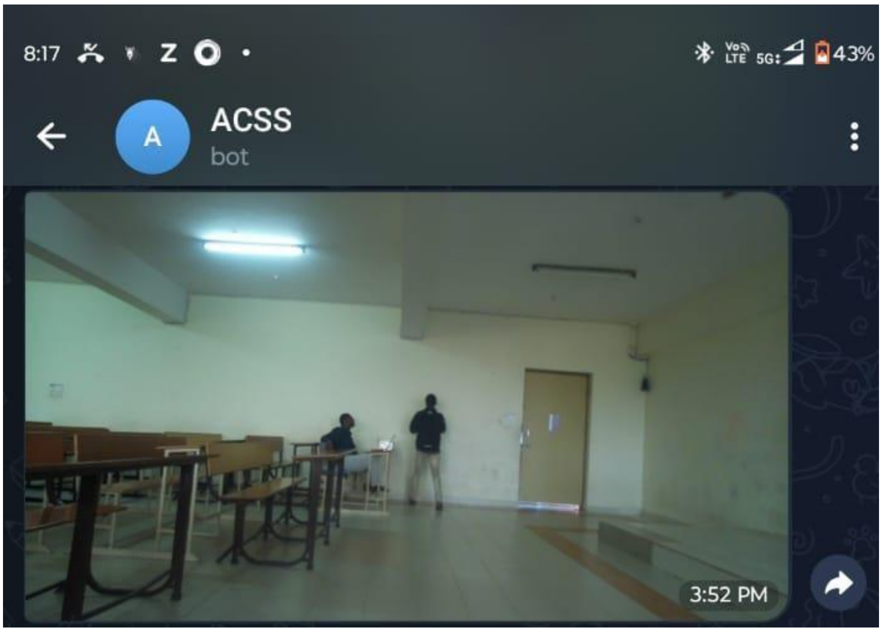

Fig 5: Intruder Alert Photo Sent To Telegram Bot

CONCLUSION

The Aero Cube Surveillance System (ACSS) provides an innovative and adaptable solution for real-time monitoring, intruder detection, and environmental assessment in challenging or hazardous environments. By integrating advanced hardware, including the Raspberry Pi, Arduino UNO, multiple sensors, and LoRa communication, with a Flask-based user interface and automation via Python scripts, the system ensures efficient data processing, seamless communication, and actionable alerts. Its modular design and cost-effectiveness make it a valuable tool for applications in security, disaster management, and environmental monitoring, addressing modern challenges with precision and reliability.

FUTURE SCOPE

- **Integration of AI for Advanced Detection:** Implement machine learning algorithms for improved intruder detection, object classification, and anomaly recognition.
- **Autonomous Operation:** Add AI-driven navigation and deployment capabilities for fully autonomous surveillance and monitoring.
- **Enhanced Communication:** Incorporate 5G or satellite-based communication systems for faster and more reliable data transmission over greater distances.
- **Energy Efficiency with Solar Power:** Equip the system with solar panels to ensure sustainable and long-term operations in remote areas.

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