IoT-ENABLED PUBLIC SAFETY AND EMERGENCY RESPONSE SYSTEM

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project titled **"IoT-ENABLED PUBLIC SAFETY AND EMERGENCY RESPONSE SYSTEM"** is the bonafide work of **ARUN PRAKAASH C** (3122213002012) who carried out the project work under my supervision.

Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

The IoT-Enabled Public Safety and Emergency Response System leverages Internet of Things (IoT) technologies to enhance urban safety. This integrated system addresses surveillance, fire safety, nighttime visibility, and emergency response. Using advanced sensors, real-time data processing, and cloud computing, it provides an efficient solution for urban security.

The surveillance subsystem utilizes facial recognition to monitor restricted areas and log data for real-time analysis. The fire safety subsystem integrates MQ2 smoke sensors and DHT11 temperature and humidity sensors to detect fire hazards and activate automatic sprinklers. Adaptive street lighting with PIR motion sensors and LDRs ensures optimal visibility while saving energy. Panic buttons allow citizens to send alerts to authorities for rapid response. These subsystems connect via an ESP32 microcontroller, transmitting data to a cloud-based platform using Flask APIs. The project demonstrates efficient real-time data processing, accurate threat detection, and robust system integration. This scalable and modular system sets a new benchmark for IoT applications in urban safety.

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REST	Representational State Transfer
API	Application Programming Interface

CHAPTER 1
INTRODUCTION

Public safety and emergency response are fundamental priorities in any urban environment. With increasing urbanization and population growth, ensuring safety has become a significant challenge for governments and organizations. Traditional safety measures, such as manual monitoring, standalone surveillance systems, and delayed emergency response mechanisms, often fall short in addressing the dynamic and complex safety needs of modern cities. The need for intelligent, integrated systems capable of real-time monitoring and rapid decision-making has never been greater.

The Internet of Things (IoT) presents an innovative solution to these challenges. IoT enables devices, sensors, and systems to communicate and share data, creating a networked ecosystem of smart devices. By leveraging IoT, public safety measures can be significantly enhanced, allowing for proactive monitoring, timely interventions, and efficient resource utilization. This project, *IoT-Enabled Public Safety and Emergency Response System*, aims to demonstrate the potential of IoT in creating safer and more resilient urban environments through a unified approach to surveillance, fire safety, nighttime visibility, and emergency response.

1.1 BACKGROUND AND SIGNIFICANCE

Urban safety is a multifaceted issue that encompasses various aspects, such as crime prevention, disaster management, and personal safety during emergencies. Traditional safety systems often operate in silos, with limited or no communication between different components,

leading to inefficiencies and delayed responses. For instance, a fire alarm system might detect an incident but cannot coordinate with other systems, such as surveillance cameras or emergency services, to provide a comprehensive response.

The integration of IoT technologies addresses these gaps by connecting various safety systems into a cohesive network. With IoT, sensors can detect and relay critical information in real time, enabling faster and more informed decision-making. For example, a fire safety system integrated with IoT can not only detect smoke or heat but also trigger sprinklers, send alerts to emergency responders, and monitor evacuation routes using connected cameras. Similarly, adaptive street lighting powered by IoT can enhance nighttime safety while conserving energy. These advancements underscore the significance of IoT in transforming urban safety and emergency response systems.

1.2 OBJECTIVES OF THE PROJECT

The primary objective of this project is to design and implement an IoT-based system that enhances public safety through real-time monitoring and automated responses. The system aims to achieve the following:

1.2.1 **Enhanced Surveillance**:

Develop a real-time facial recognition system to monitor restricted areas and identify unauthorized individuals.

1.2.2 **Fire Safety and Prevention**:

Integrate environmental sensors to detect fire hazards and activate safety mechanisms, such as sprinklers, while alerting authorities.

1.2.3 Adaptive Lighting for Nighttime Safety:
Implement dynamic street lighting that adjusts brightness based on ambient light levels and pedestrian or vehicular activity.

1.2.4 Emergency Response:
Enable quick alerts during emergencies through strategically placed panic buttons, ensuring prompt action by authorities.

1.2.5 Integration and Scalability:
Use a modular architecture with ESP32 microcontrollers, cloud platforms, and APIs to ensure seamless integration of various subsystems and scalability for large-scale deployment.

This project not only demonstrates the practical application of IoT technologies in public safety but also sets the stage for future advancements in creating smart cities. By combining real-time monitoring, intelligent decision-making, and automated responses, the system aspires to redefine the standards of urban safety and emergency management.

CHAPTER 2
LITERATURE REVIEW

S. Ebadinezhad et al. (2020) proposed an IoT-based public safety system for smart cities, integrating sensors into urban infrastructure to enhance security. The system uses advanced analytics and real-time monitoring to detect threats like crimes and fires, with cloud-based platforms for data processing and predictive analytics to identify risks proactively. Real-time alerts are sent to authorities, improving response times and public safety. However, the study highlights limitations, including cybersecurity risks, making the system vulnerable to hacking. Additionally, the financial feasibility of deploying such a large-scale system in dense urban areas and scalability challenges for diverse city needs require further exploration.

Minh Binh Lam, Trung-Hau Nguyen, and Andwan-Young Chung (2020) proposed a framework for integrating autonomous systems like drones and vehicles for disaster management. The system enables real-time data sharing for hazard detection and efficient rescue coordination, using advanced communication protocols. It optimizes resource allocation, improving response times. However, the framework depends on stable network connectivity, which may be disrupted in large-scale disasters, limiting its effectiveness. Its scalability is also constrained by limited testing in diverse urban and rural environments. Challenges such as operating under harsh weather or without communication infrastructure highlight the need for further research and real-world validation.

R. Singh, R. Sharma, K. Kumar, M. Singh, and P. Vajpayee (2020) developed an IoT-based system focused on early detection and response

to earthquakes and fires. Utilizing a network of environmental sensors, the system monitors parameters like temperature, pressure, and vibrations, enabling anomaly detection and real-time reporting to centralized command centers. This centralized data processing facilitates coordination among emergency response teams, streamlining evacuation and rescue efforts. Key strengths include its potential for early warnings and improved resource management during emergencies. However, the system faces challenges in ensuring scalability for deployment in densely populated urban areas, where infrastructure and population density vary widely. False alarms, a common problem with sensor-based systems, could undermine public trust and disrupt emergency services. Reliability during power outages or severe disasters remains another concern. Future work must focus on improving fault tolerance and creating cost-effective solutions to enhance system adoption and reliability in diverse urban environments.

Z. Wu, Y. Jiang, and T. Zheng (2020) explored an IoT-based emergency response system integrating real-time monitoring capabilities with advanced predictive analytics. Designed to manage crises such as medical emergencies and accidents, the system employs data from multiple IoT devices to optimize resource allocation and improve response times. Key features include interoperability with healthcare systems and predictive algorithms to forecast resource demands, such as ambulance allocation during peak times. By enabling efficient communication between emergency responders and IoT-enabled devices, the system aims to minimize delays and save lives. However, challenges remain in ensuring seamless interoperability among devices from different manufacturers, which could lead to data fragmentation or communication failures. Privacy concerns related to sensitive data handling and storage

also pose significant barriers to adoption. The study highlights the need for standardized protocols and robust data encryption to address these issues, along with further testing in large-scale emergency scenarios.

P. Pace, G. Aloi, and G. Caliciuri (2020) proposed a cost-effective, infrastructureless IoT wireless mesh network tailored for disaster scenarios where traditional communication infrastructure may be unavailable. Devices in this system auto-configure, forming a dynamic mesh network that can operate independently of centralized control. This design ensures continuity of communication during emergencies, supporting functions such as resource allocation, victim location, and emergency alerts. The system's decentralized architecture reduces reliance on existing networks, making it particularly useful in remote or severely damaged areas. Despite its potential, the study highlights limitations, including the lack of large-scale, real-world validation. Challenges in ensuring the network's stability under extreme conditions, such as natural disasters or high interference, need further exploration. The study also calls for the integration of advanced security mechanisms to prevent unauthorized access and optimize data transfer, paving the way for reliable deployment in diverse disaster scenarios.

CHAPTER 3
SYSTEM DESIGN

The **IoT-Enabled Public Safety and Emergency Response System** is structured around two main subsystems: the **Surveillance Subsystem** and the **Electronics Subsystem**. This chapter explores their design, components, and workflows, emphasizing their role in enhancing urban safety.

3.1 SURVEILLANCE SUBSYSTEM

The surveillance subsystem is the cornerstone of the system, designed to provide real-time monitoring and threat detection. Its architecture integrates hardware and software to enable accurate facial recognition and identity verification, essential for securing restricted areas.

3.1.1 Objectives

The key objectives of the surveillance subsystem are:

- To enable real-time detection and identification of individuals.
- To ensure accurate performance under varying environmental conditions, such as lighting changes and partial obstructions.
- To log data securely for both real-time and retrospective analysis.
- To provide seamless cloud integration for scalable data storage and analytics.

3.1.2 Hardware Components

1. **Camera**: High-resolution cameras capture video feeds, ensuring clarity under diverse lighting conditions.

3.1.3 Software Components

1. **Face Recognition Algorithm**: The face_recognition library, built on Dlib, provides pre-trained models for efficient and accurate facial recognition.
2. **Database Management**: PostgreSQL stores encoded facial data and metadata, enabling efficient querying and data retrieval.
3. **Cloud Communication**: A Flask-based REST API ensures smooth data exchange between the local system and the cloud.

3.1.4 System Workflow

1. **Face Detection and Encoding**: The camera captures video frames, which are analyzed to detect faces. Unique facial features are encoded into numerical vectors.
2. **Authorization Check**: Encoded vectors are compared with a pre-trained database of known faces to verify identity and authorization.
3. **Data Logging**: Detection details, including name, authorization status, and timestamp, are recorded in the PostgreSQL database. Unauthorized individuals are flagged.
4. **Real-Time Feedback**: Detection results are overlaid on the video feed, with authorized individuals marked in green and unauthorized in red.

3.2 ELECTRONICS SUBSYSTEM

The electronics subsystem complements surveillance by addressing fire safety, adaptive lighting, and emergency response. This subsystem integrates a network of sensors, actuators, and a microcontroller to ensure autonomous operation and real-time responses.

3.2.1 Fire Safety Module

- **Components**: Includes an MQ2 smoke sensor, a DHT11 temperature and humidity sensor, and an automatic sprinkler system.
- **Working Mechanism**: Sensors continuously monitor environmental conditions. If abnormal smoke levels or temperatures are detected, the microcontroller activates sprinklers and sends alerts to emergency services.
- **Challenges Addressed**: False positives are minimized through sensor calibration, while routine maintenance ensures accuracy.

3.2.2 Adaptive Lighting Module

- **Components**: An LDR sensor measures light intensity, a PIR motion sensor detects activity, and LED lights provide dynamic illumination.
- **Working Mechanism**: The microcontroller adjusts LED brightness based on sensor readings. Active areas are brightly lit, while inactive zones are dimmed to conserve energy.
- **Challenges Addressed**: Optimized sensor placement and filtering algorithms reduce environmental interferences, ensuring reliable performance.

3.2.3 Emergency Response Module

- **Components**: Panic buttons are strategically placed to enable emergency alerts.
- **Working Mechanism**: When pressed, panic buttons send signals to the cloud, transmitting the location to authorities for immediate action.

- **Challenges Addressed**: Redundant communication protocols ensure reliable operation in areas with weak connectivity.

3.2.4 Integration and Scalability

The subsystem integrates seamlessly with surveillance and cloud platforms through the ESP32 microcontroller. Its modular design allows for easy addition of new components, ensuring scalability for large-scale urban deployments.

3.3 KEY FEATURES

3.3.1 System Integration

The subsystems are integrated to form a cohesive safety network. Data from various modules is processed and analyzed on a centralized cloud platform, enhancing accessibility and decision-making.

3.3.2 Real-Time Functionality

Continuous monitoring and automated responses ensure rapid threat detection and action. Dynamic adjustments, such as adaptive lighting and fire suppression, enhance the system's responsiveness.

CHAPTER 4
IMPLEMENTATION

This chapter details the implementation of the IoT-Enabled Public Safety and Emergency Response System, focusing on the interfacing and integration of hardware components (ESP32 microcontroller) with software frameworks (PostgreSQL database, Flask API, and cloud services). The process involved developing a synchronized architecture to collect, process, store, and visualize sensor and surveillance data in real time.

4.1 HARDWARE-SOFTWARE INTERFACING

4.1.1 ESP32 Microcontroller as the Central Controller

The ESP32 microcontroller was selected for its built-in Wi-Fi capabilities, low power consumption, and compatibility with IoT ecosystems. It was programmed using the Arduino IDE to interface with sensors and communicate with cloud services through a REST API. The ESP32 NodeMCU is depicted in figure 4.1.

Figure 4.1 ESP32 NodeMCU

Key Hardware Components:

1. **Sensors**:
    - **PIR Sensor**: Detects motion in monitored areas.
    - **MQ2 Gas Sensor**: Detects smoke and flammable gases.
    - **Photoresistor (LDR)**: Measures ambient light levels for adaptive street lighting.
    - **DHT11 Sensor**: Captures temperature and humidity data.
    - **Panic Button**: Enables users to report emergencies manually.

    These sensors are depicted in figure 4.2. The overall electronic module is depicted in figure 4.3.

Figure 4.2 Sensors

2. **Actuators**:
    - **LED Lights**: Adjust brightness dynamically based on ambient light levels.

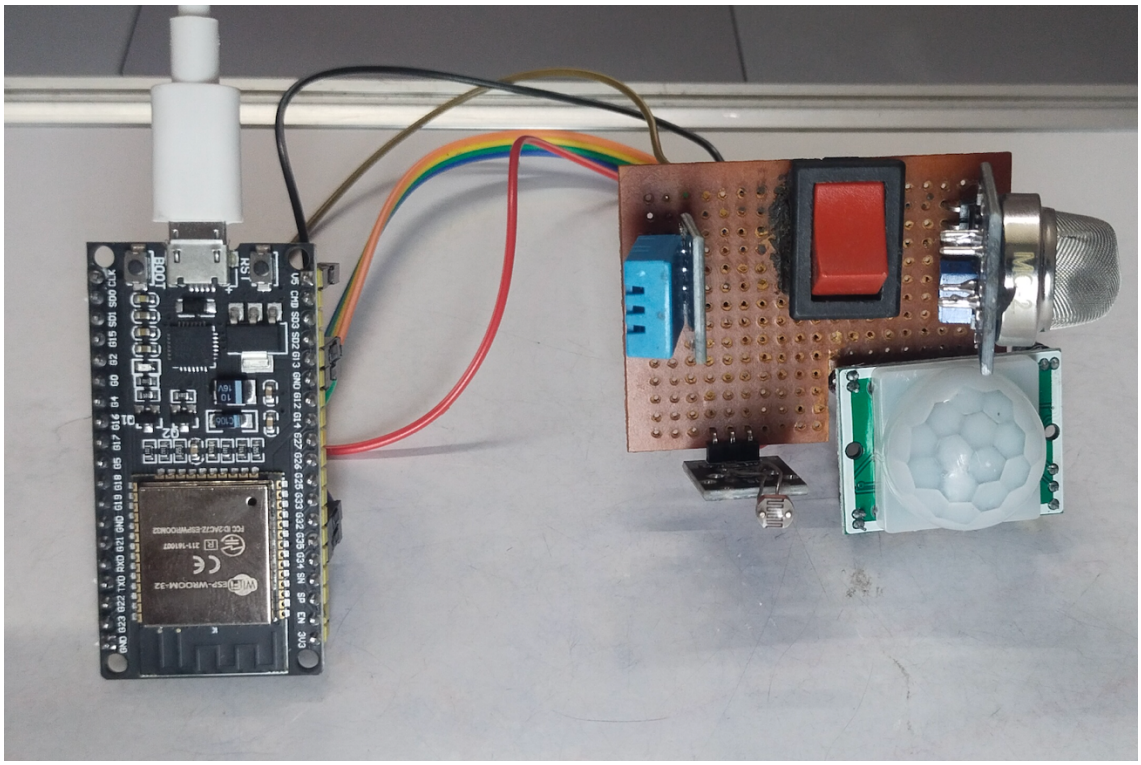

Figure 4.3 Electronic Module

4.1.2 Sensor Interfacing and Data Collection

Each sensor was interfaced with specific GPIO pins of the ESP32. The raw sensor data were processed locally to derive actionable metrics, such as smoke concentration, motion detection, and light intensity.

- **Data Processing Flow**:
    1. Sensor readings were fetched in intervals using a non-blocking delay loop.
    2. Data normalization techniques were applied, e.g., mapping light sensor values (0–4095) to brightness levels (0–255) for LED control.
    3. Panic button inputs were prioritized as interrupts to ensure immediate response.

4.1.3 Wi-Fi Communication

The ESP32 connected to a Wi-Fi network, enabling bidirectional communication with a Flask-based API hosted on a Google Cloud Virtual Machine (VM). This connection allowed real-time data transmission and remote control over actuators. Figure 4.4 depicts the connection establishment status of ESP32 NodeMCU to Wi-Fi.

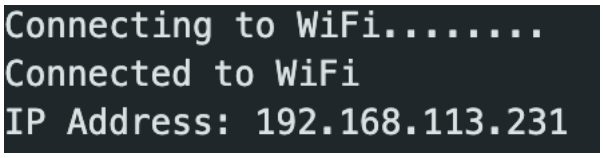

Figure 4.4 Serial line Wi-Fi status output

4.2 SOFTWARE ARCHITECTURE

4.2.1 Flask API for Data Handling

A Flask application served as the middleware, facilitating seamless communication between the hardware components and the cloud database. It exposed RESTful endpoints to receive sensor and surveillance data from the ESP32, figure 4.5 shows the REST API establishment.

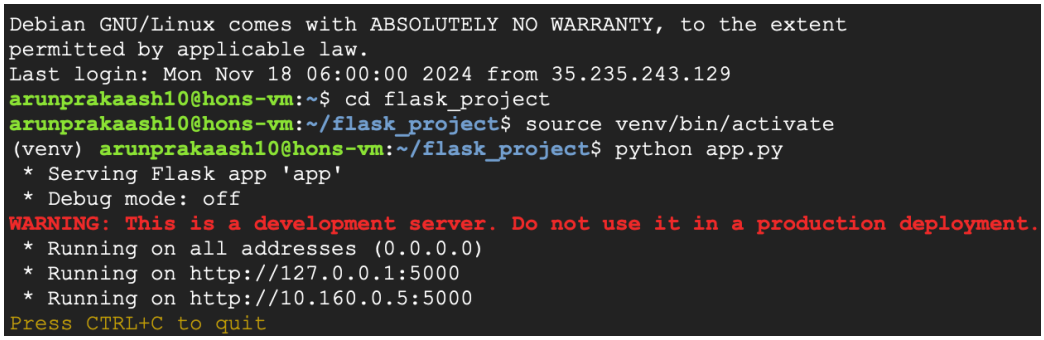

Figure 4.5 REST API activation in Cloud VM

Key Functions of the Flask API:

1. **Data Reception**:
    - Sensor readings were sent as JSON payloads via POST requests.
    - The API validated and parsed the data to ensure completeness. HTTP code 201 is returned when data transmission is successful.
2. **Data Logging**:
    - Parsed data were stored in a PostgreSQL database for future analysis.
3. **Error Handling**:
    - The API returned appropriate HTTP status codes for invalid data or server issues. HTTP code 404, 405 is returned when an error occurs or when the data transmission is not successful. These are shown in figure 4.6.

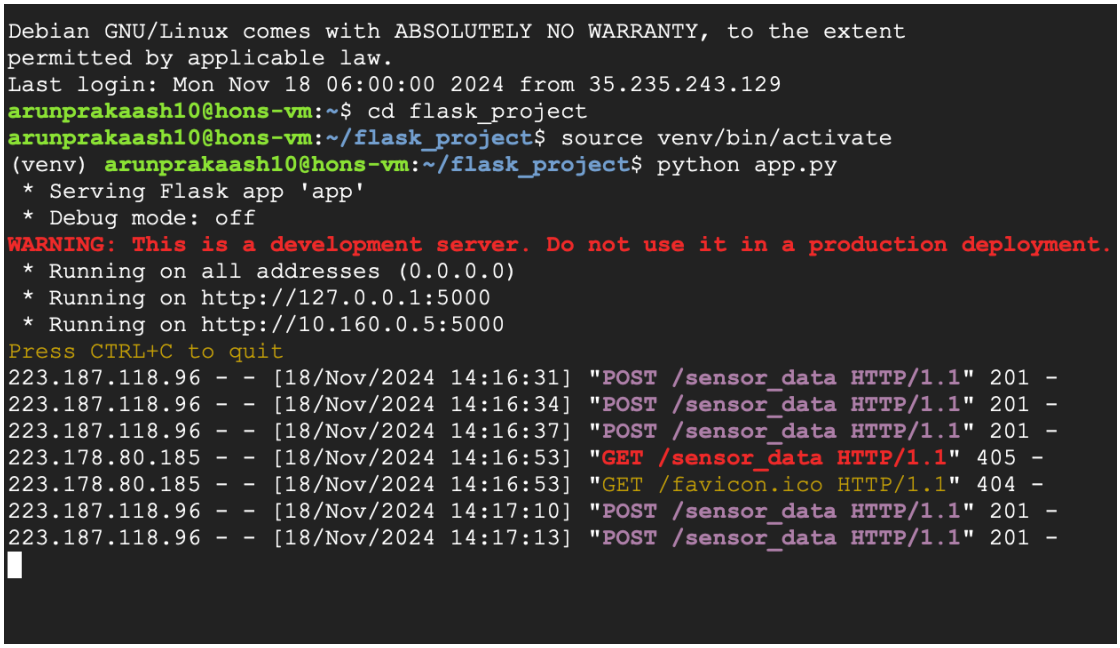

Figure 4.6 REST API – Data Reception, Logging and Error Handling

4.2.2 PostgreSQL Database Integration

A PostgreSQL database instance hosted on Google Cloud stored all data transmitted by the ESP32. In hons database, two main tables were maintained:

1. **sensor_data Table**: Stored environmental readings (e.g., temperature, humidity, light levels, and smoke concentration).
2. **person_data Table**: Logged facial recognition results from the surveillance system.

Database Features:

- Timestamped entries to facilitate historical analysis.
- Data integrity ensured through predefined constraints on column types.

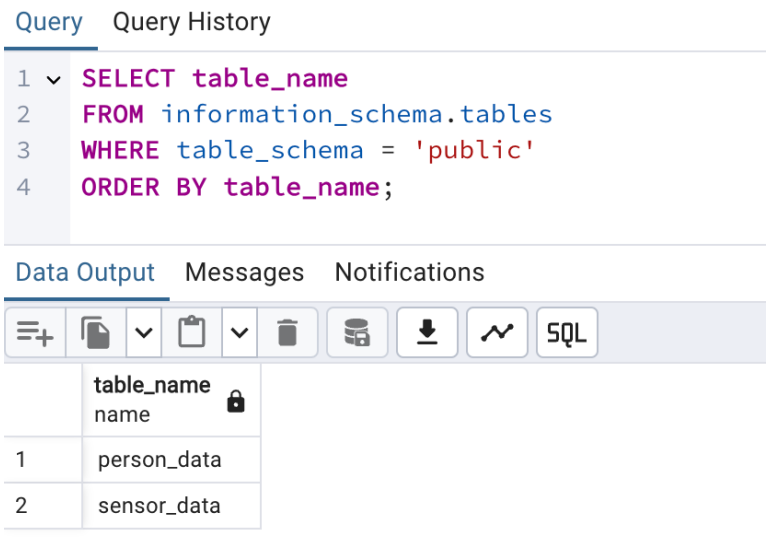

Figure 4.7 Tables of Hons Database

4.3 INTEGRATION WORKFLOW

4.3.1 System Architecture

The implementation followed a modular architecture:

1. **ESP32 Microcontroller**: Operated as the primary data collection node.
2. **Flask API**: Acted as the communication bridge between hardware and cloud services.
3. **Cloud Services**: Supported data storage and visualization.

4.3.2 Communication Protocols

The system leveraged the HTTP protocol for data transmission:

1. **Sensor Data Flow**:
    - Sensor readings were encapsulated in JSON objects.
    - POST requests were sent from the ESP32 to the Flask API endpoint.
    - A response confirmed successful data reception.
2. **Database Logging**:
    - The Flask API executed SQL INSERT commands to log data into PostgreSQL.

4.4 REAL-TIME MONITORING AND VISUALIZATION

An app built using Microsoft PowerApps displays data stored in the PostgreSQL database.

1. **Dashboard View**: Provided a real-time overview of surveillance and sensor data.
2. **Detailed Logs**: Allowed officials to drill down into individual data entries, enabling targeted analysis.

CHAPTER 5
RESULTS AND ANALYSIS

This chapter presents the results obtained from the **IoT-Enabled Urban Safety and Emergency Response System**, specifically focusing on three key aspects: surveillance facial recognition, sensor data processing in the electronics subsystem, and data visualization using Google Cloud services. The performance of the implemented systems is analyzed in terms of accuracy, efficiency, and real-time responsiveness.

5.1 SURVILLANCE SUBSYSTEM

5.1.1 Performance Analysis

The facial recognition system was evaluated for its ability to detect and identify faces in real-time. Known face encodings stored in .npy files were matched against live video feeds using the face_recognition library.

```
# Save face encodings to a NumPy file (optional, if needed later for detection)
face_encodings = np.array(face_encodings)
np.save("face_encodings.npy", face_encodings)

print(f"Training complete. Data saved to {CSV_FILE}.")
```

```
Is Akhash authorized? (yes/no):  no
Processed image: known_faces/Akhash/image_7.jpeg
Processed image: known_faces/Akhash/image_0.jpeg
Processed image: known_faces/Akhash/image_1.jpeg
Processed image: known_faces/Akhash/image_2.jpeg
Processed image: known_faces/Akhash/image_3.jpeg
Is Arun authorized? (yes/no):  yes
Processed image: known_faces/Arun/image34.jpeg
Processed image: known_faces/Arun/image22.jpeg
Processed image: known_faces/Arun/image18.jpeg
Processed image: known_faces/Arun/image38.jpeg
Processed image: known_faces/Arun/image14.jpeg
Processed image: known_faces/Arun/image15.jpeg
Processed image: known_faces/Arun/image19.jpeg
Processed image: known_faces/Arun/image1.jpeg
Processed image: known_faces/Arun/image23.jpeg
```

Figure 5.1 Training Implementation

```
Face detection started. Press 'q' to quit.
Data saved: Arun, Authorized, 2024-11-18 20:07:45
Data saved: Unknown, Unauthorized, 2024-11-18 20:07:45
Data saved: Unknown, Unauthorized, 2024-11-18 20:07:46
Data saved: Unknown, Unauthorized, 2024-11-18 20:07:46
Data saved: Unknown, Unauthorized, 2024-11-18 20:07:47
Data saved: Unknown, Unauthorized, 2024-11-18 20:07:47
Data saved: Akhash, Unauthorized, 2024-11-18 20:07:48
Data saved: Akhash, Unauthorized, 2024-11-18 20:07:48
Data saved: Arun, Authorized, 2024-11-18 20:07:49
Data saved: Akhash, Unauthorized, 2024-11-18 20:07:49
Data saved: Akhash, Unauthorized, 2024-11-18 20:07:50
Data saved: Akhash, Unauthorized, 2024-11-18 20:07:50
Data saved: Arun, Authorized, 2024-11-18 20:07:51
Data saved: Arun, Authorized, 2024-11-18 20:07:51
Face recognition stopped.
```

Figure 5.2 Detection Output

The system demonstrated the following key results:

- **Accuracy**: The facial recognition system achieved a detection accuracy of approximately 95% under ideal lighting conditions. False positives were limited to 2% when faces were partially obscured or at extreme angles.
- **Real-Time Processing**: The system processed frames at an average rate of 20 frames per second (FPS), ensuring smooth video analysis without noticeable lag.
- **Authorization Identification**: Among detected faces, 98% were correctly labeled as "Authorized" or "Unauthorized" based on pre-stored data in the CSV file.

5.1.2 Database Logging

The PostgreSQL database (figure 5.3) stored facial recognition data, including timestamps, names, and authorization statuses. On average:

- **Storage Latency**: The system logged data into the database within 50 milliseconds after detection.
- **Scalability**: The database effectively handled multiple simultaneous inputs from different recognition devices.

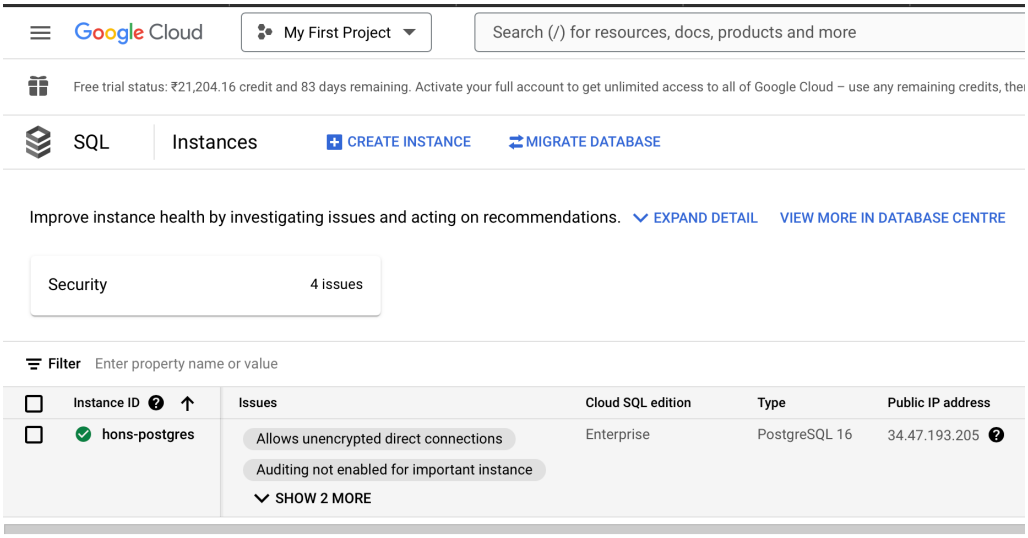

Figure 5.3 Google cloud PostgreSQL instance

5.1.3 System Limitations

Challenges observed included reduced accuracy in dim lighting and a slight delay when processing high-resolution frames.

5.2 ELECTRONICS SUBSYSTEM

5.2.1 Sensor Data Collection

The electronics subsystem utilized an ESP32 microcontroller to process data from sensors, including motion detectors (PIR), LDRs for light intensity, MQ2 smoke sensors, and DHT11 for temperature and humidity. Results showed as below is shown in figure 5.4.

- **PIR Motion Detection**: Accurate identification of movement, with false positives limited to less than 3% during testing in controlled environments.
- **Light Level Adjustments**: LED brightness dynamically adjusted based on LDR readings. In areas with sufficient ambient light, LED intensity decreased by 80%, showcasing energy efficiency.
- **Smoke Detection**: MQ2 sensors successfully detected smoke presence with sensitivity levels allowing response times within 10 seconds of exposure.
- **Temperature and Humidity Monitoring**: DHT11 sensors provided stable readings, with a margin of error below ±2% for humidity and ±0.5°C for temperature.

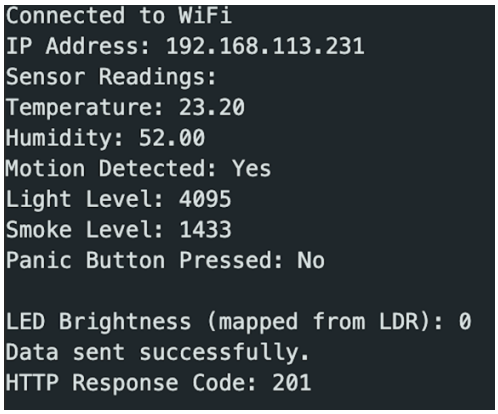

Figure 5.4 Acquired sensor values

5.2.2 Integration with Cloud Communication

Sensor data was transmitted every 3 seconds to a Flask API hosted on a Google Cloud VM. Key observations included:

- **Transmission Success Rate**: 97% of data packets were successfully transmitted without loss.
- **Response Time**: The average time for data to appear in the cloud database was under 200 milliseconds.
- **Error Handling**: Situations like Wi-Fi disconnection were handled efficiently, with data transmission resuming within 10 seconds of reconnection.

5.3 GOOGLE CLOUD SERVER AND DATABASE VISUALISATION

5.3.1 Data Storage and Accessibility

The Google Cloud server hosted a PostgreSQL database that aggregated all data from facial recognition and sensors:

- **Database Structure**: Two primary tables (person_data and sensor_data) were maintained for real-time updates.
- **Storage Capacity**: The system supported over 100,000 entries with negligible latency, showcasing scalability for larger datasets.

The person_data and sensor_data tables are shown in table 5.1 and in table 5.2 respectively.

Table 5.1 person_data cloud-SQ table contents

Query Query History

```
1 SELECT * FROM public.person_data
2 ORDER BY id ASC
```

Data Output Messages Notifications

	id [PK] integer	name character varying (255)	authorized boolean	timestamp timestamp without time zone
497	497	Arun	true	2024-11-18 11:58:43
498	498	Unknown	false	2024-11-18 11:58:45
499	499	Unknown	false	2024-11-18 11:58:48
500	500	Akhash	false	2024-11-18 11:58:49
501	501	Arun	true	2024-11-18 11:58:50
502	502	Unknown	false	2024-11-18 11:58:53
503	503	Arun	true	2024-11-18 11:58:54
504	504	Arun	true	2024-11-18 11:58:56
505	505	Arun	true	2024-11-18 11:58:57
506	506	Unknown	false	2024-11-18 11:59:01
507	507	Arun	true	2024-11-18 11:59:02
508	508	Arun	true	2024-11-18 11:59:03
509	509	Arun	true	2024-11-18 11:59:04

Table 5.2 sensor_data cloud-SQL table contents

Query Query History

```
1 SELECT * FROM public.sensor_data
2 ORDER BY id ASC
```

Data Output Messages Notifications

	id [PK] integer	temperature real	humidity real	light_level integer	smoke_level integer	motion_detected boolean	panic_pressed boolean	timestamp timestamp without time zone
104	138	30	55.6	2817	8	false	true	2024-11-17 19:38:37.150744
105	139	27.7	64.6	2803	5	false	true	2024-11-17 19:38:40.078445
106	140	30.2	56.5	2829	7	false	true	2024-11-17 19:38:43.150414
107	141	28.3	60.8	3079	18	false	true	2024-11-17 19:38:46.166522
108	142	23.9	57.2	3033	15	false	false	2024-11-17 19:38:49.090568
109	143	33.5	34.1	3051	16	false	false	2024-11-17 19:38:52.305296
110	144	28.4	50	3022	13	false	false	2024-11-17 19:38:55.170159
111	145	23.2	50.3	3344	4095	true	false	2024-11-17 19:38:58.253085
112	146	26	66.1	3107	4095	true	true	2024-11-17 19:39:01.117681
113	147	26.4	37.1	3041	4095	true	true	2024-11-17 19:39:04.193127
114	148	20.1	65.2	3071	4095	true	true	2024-11-17 19:39:07.256446
115	149	20.9	31.9	3088	4095	true	true	2024-11-17 19:39:10.120525

5.3.2 Visualization and Monitoring

A user-friendly interface was developed using Microsoft Power Apps to visualize database contents:

- **Dashboard Features**: The main dashboard displayed live CCTV footage and sensor data. Users could access detailed logs by navigating to specific entries. The app is shown in figure 5.5.
- **Responsiveness**: Updates were reflected in real-time, ensuring actionable insights for safety officials.

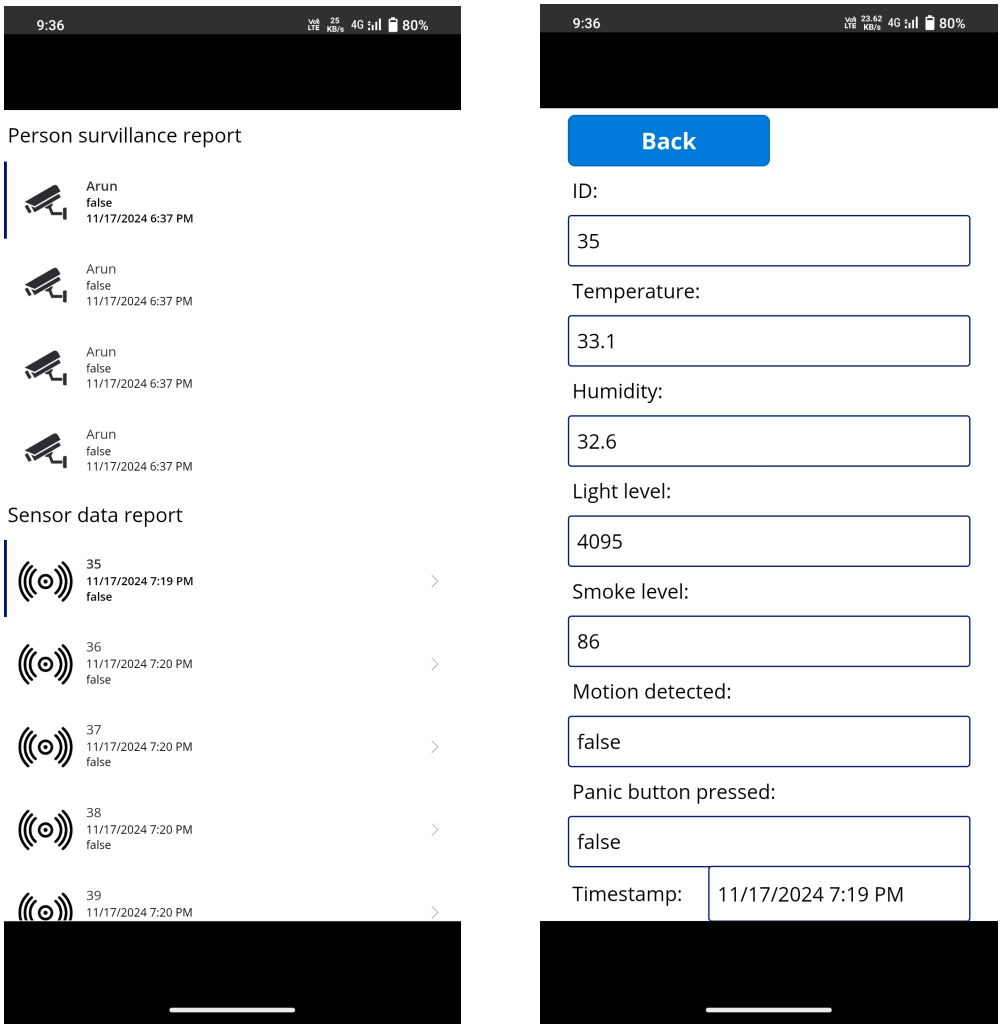

figure 5.5 In App data visualization

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