Smart Incident Detection System Using Seeed XIAO ESP32S3 and Multimodal LLM

Team Name: Reboot Rebels

Team Members:

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GradinnoHack Table Choices:

- **Tech & Skills:** AI for Social Good, Cybersecurity/Digital Ethics, Machine Learning/Big Data, IoT/Embedded Systems, Mobile/Web Development
- **Impact Area:** Smart Cities/Urban Mobility, Public Safety/Crisis Response
- **User Group / Audience:** First Responders.

OBJECTIVE:

To create an intelligent surveillance system that detects emergencies in real-time using a combination of IoT devices and multimodal AI models—enhancing public safety, reducing manual monitoring, and ensuring rapid response.

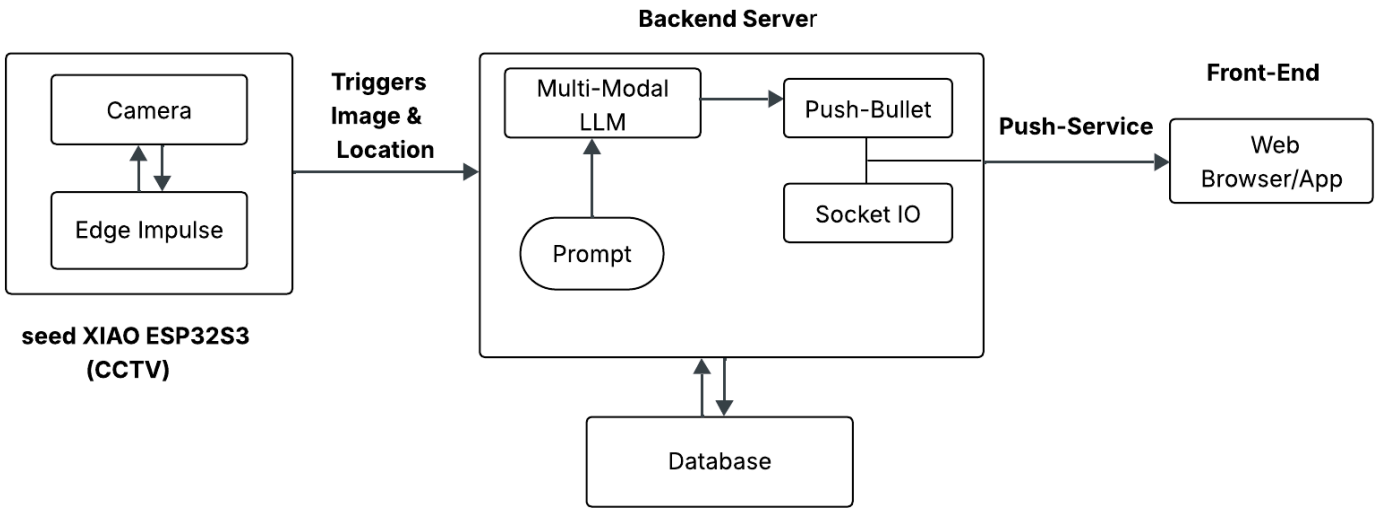
PROBLEM STATEMENT:

Traditional CCTV surveillance requires manual monitoring, which is inefficient and slow. As a result, emergencies like fires, accidents, or crimes may go unnoticed until it's too late. There is an urgent need for an automated, intelligent incident detection system to enhance real-time public safety in smart city environments.

PROPOSED SOLUTION:

We built a smart surveillance system that uses a Seeed XIAO ESP32S3 camera module for capturing visual inputs and a Multimodal Large Language Model (LLM) to analyze these feeds. The model extracts incident-related keywords based on the context of the incident and classifies the event as an emergency or not. Alerts are then dispatched to appropriate first responders.

SYSTEM ARCHITECTURE:



IMPLEMENTATION:

Hardware:

- **Seeed XIAO ESP32S3 (compact, low-power microcontroller with camera module)**

Software Stack:

- **Multimodal LLM: GPT-4o Vision Model**
- **Backend: Python, Flask, Socket.IO, PushBullet**
- **Database: MongoDB**
- **Frontend: ReactJS and Nodejs for live notifications and push notification services, PushBullet App**
- **Dispatch: REST APIs and WebSocket**

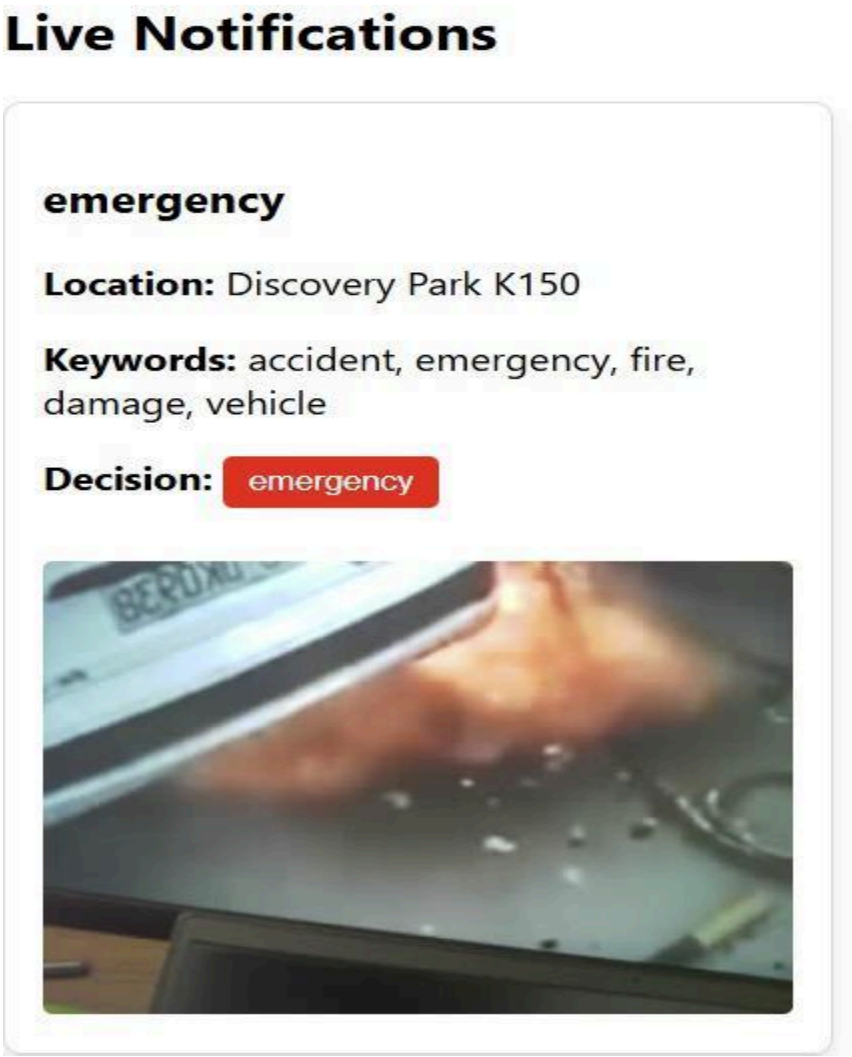
Communication:

- SSL/TLS secured communication between ESP32 and the server
- WebSocket for real-time bidirectional communication

Authentication & Security:

- Secure authentication system with authorization tokens and rate limiting
- Hashed password storage with verification method.
- Content security policy with the application
- Security headers implementation for mitigation of CSRF and XSS

RESULTS



SAMPLE INCIDENT DETECTION:

- **Fire, Robbery, Accident, Flooding**

Prototype Success Metrics:

- Emergency Classification Accuracy in SeedXiao ESP32S3: ~85%.
- Average Incident Detection Time: < 5 seconds.
- Authentication token-based control tested under simulated concurrent access

IMPACT:

Societal Benefits:

- Faster Emergency Response
- Safer Communities
- Reduced Surveillance Load on Humans
- Scalable Across Smart City with current implemented infrastructure
- Secured Data Flow & Device Access using SSL and firewall protection.

Cybersecurity Impact:

- Protects system against brute force and injection attacks
- Rate-limiting ensures denial-of-service resistance
- SSL ensures encrypted data transmission from edge devices.

FUTURE SCOPE:

Web Application Firewall (WAF):

- Restricts unauthorized access
- Blocks malicious traffic
- Mitigate the Vulnerabilities
- Traffic forwarding
- Implements request type restrictions (GET, POST, etc.)
- Security of server, Camera data and API

Network Firewall and IDS:

- For whitelisting the IP address, Ports and devices
- Access control
- Authorization
- Malware Detection

Other Enhancements:

- Add **audio/video input stream analysis**
- Integration with **real-time 911 dispatch** APIs
- Expand **AI Dashboard** for command center control
- Optimize detection models for **ESP32S3 edge deployment**
- Enhance **threat detection logs and access control audit**