INF2009: Edge Computing & Analytics
Project Proposal Report

This report requires you to respond to a total of six questions, which are categorized under Section I of the final report. Ensure that you change the title of report to "Team _No_xx_Proposal" while uploading on Dropbox.

The purpose of this report is to submit the **Introduction, Problem Statement and Objectives** for your project. The report must answer the below questions:

1. What specific issue or problem has been identified that requires a solution?
2. Why is your topic important or relevant to industry, academia, or society?
3. What is the potential impact of addressing this challenge?
4. What specific gap or challenge in the field does this work address?
5. What are the main goals of this project or research?
6. What specific outcomes are expected by the end of this study?
7. Do include images/diagrams to illustrate your ideas.

Introduction

To prevent accidents, unauthorized access, and potential damage to lab equipment. It is essential to put these restricted areas under watch. But it is time consuming to have the place under 24/7 constant surveillance by lab safety officers to ensure safety compliance is met.

A possible solution to this problem could be in an automated monitoring system, which has the capability to improve reliability, reduce human error, and speed up response times to safety events. By providing real-time edge-based systems combined with vision and motion detection and alerting, this system can enhance operational efficiency and enable a safer and more compliant laboratory environment in educational and research contexts.

Problem Statement

In laboratory lab safety enforcement, both manual supervision and passive surveillance systems continue to play a critical role. Although these methods are intrinsically slow, erratic, and often susceptible to overlooked events, especially when the human attention span cannot be sustained indefinitely. As such, it raises the likelihood of safety incidents, the damage of equipment, and the non-compliance with laboratory rules. Since unauthorized access to prohibited areas is not detected quickly.

The automated monitoring systems in the market frequently use cloud-based processing, which comes with its disadvantages such as increase latency, network dependency, and possibly data privacy issues. Moreover, single-sensor designs lack the appropriate validation mechanisms to guarantee the accuracy of the detection of non-compliance, and vision-only systems are usually prone to false detections due to

environmental factors such as the lighting and occlusion. All these numerous restrictions make it challenging to implement an intelligent monitoring system in small-scale laboratory settings.

Objectives

The aim of this project is to design and implement an edge-based laboratory monitoring system capable of detecting unauthorized human entry into restricted areas in real time and providing automated alerts to improve safety enforcement.

Specific Objectives

1. Design and develop a Raspberry Pi-based embedded edge platform for continuous laboratory monitoring of humans entering restricted areas.
2. Integrate a pre-trained YOLO object detection model (YOLO11-nano) with a webcam for real-time human detection.
3. Incorporate an mmWave motion sensor to enable multi-source validation and improve detection reliability.
4. Implement an MQTT-based communication mechanism to transmit alerts and system status information in real time.
5. Evaluate system performance in terms of detection accuracy, inference latency, and operational stability.
6. Demonstrate the feasibility of a low-cost, scalable solution suitable for deployment in educational and small research laboratory environments.

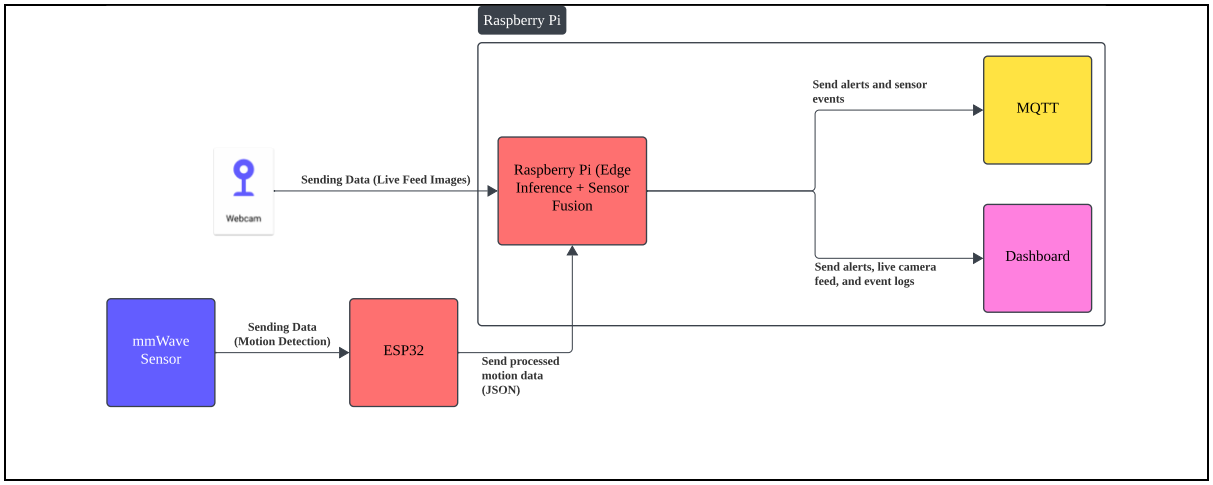
Expected Outcomes.

1. A functional Raspberry Pi prototype capable of detecting human presence in restricted laboratory areas using combined visual and motion sensing, including automatic capture of event evidence from the webcam and mmWave sensors.
2. A real-time alerting system delivering notifications through MQTT messaging.
3. Quantitative performance results documenting latency, accuracy, and system responsiveness.
4. A monitoring dashboard presenting live detection data, live feed, sensor readings, and historical event logs.
5. Documentation covering system architecture, hardware selection, software implementation, and implementation steps.

Equipment:

- 3 x Raspberry Pi
- 1 x ESP32
- 3 x Webcams (Visual capture of entry and exit events)
- 1 x mmWave Sensor (Motion Sensor)

Diagram:


Raspberry Pi
Webcam
Sending Data (Live Feed Images)
Raspberry Pi (Edge Inference + Sensor Fusion
Send alerts and sensor events
MQTT
Dashboard
Send alerts, live camera feed, and event logs
mmWave Sensor
Sending Data (Motion Detection)
ESP32
Send processed motion data (JSON)