

MILESTONE-4: REAL-TIME DEPLOYMENT & ALERT SYSTEM

Title Page

Project Title:

Deep Vision Crowd Monitor: AI for Density Estimation and Overcrowding Detection

Milestone-4:

Real-Time Dashboard Deployment & Alert System

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1. Introduction

After completing model training and evaluation in Milestone-2 and building inference pipelines in Milestone-3, Milestone-4 focuses on **deploying the trained CSRNet model into a real-time usable system**.

This milestone demonstrates how AI-based crowd density estimation can be integrated into a **web-based dashboard** with **live monitoring and alert mechanisms**, making the system suitable for real-world surveillance and safety applications.

2. Objective of Milestone-4

The primary objectives of Milestone-4 are:

- To build a **web-based dashboard** for real-time crowd monitoring
- To visualize **crowd density maps and predicted crowd counts**

- To detect **overcrowding situations automatically**
- To implement an **email alert system using SMTP**
- To deploy the system so it can be accessed remotely

3. System Architecture

The overall system consists of the following components:

- **Input Source:**
 - Uploaded images
 - Video frames / live camera feed
- **Model:**
 - Trained CSRNet (Part-B) model
- **Processing Pipeline:**
 - Image preprocessing
 - Density map generation
 - Crowd count estimation
- **Output:**
 - Density heatmap visualization
 - Crowd count display
 - Alert status
- **Alert System:**
 - Email notifications via SMTP

4. Web-Based Dashboard Implementation

Framework Used

- **Streamlit** (Python-based web framework)

Features of the Dashboard

- Image upload interface
- Real-time crowd count display
- Density heatmap visualization
- Alert status indicator (Normal / Overcrowded)
- Manual trigger for email alerts

Advantages

- Lightweight and fast

- Easy to deploy
- No frontend coding required

5. Real-Time Crowd Analysis Pipeline

The following steps occur in real time:

1. User uploads an image or video frame
2. Image is preprocessed (resize, normalization)
3. CSRNet generates a **density map**
4. Density map is summed to compute crowd count
5. Heatmap is overlaid for visualization
6. Crowd count is compared with a threshold

Threshold Logic:

- Crowd count \leq threshold \rightarrow Normal
- Crowd count $>$ threshold \rightarrow Overcrowding detected

6. Alert System using SMTP

Purpose

To notify authorities or users when overcrowding is detected.

Implementation Details

- SMTP protocol used (Gmail server)
- Email credentials configured via environment variables
- Automatic email sent when crowd exceeds threshold

Alert Message Includes

- Overcrowding warning
- Detected crowd count
- Timestamp

This ensures **early warning and faster response** in real-world scenarios.

7. Results & Observations

Dashboard Output

- Successfully displays uploaded images
- Generates density heatmaps
- Predicts crowd counts in real time

Alert Behavior

- Alerts triggered correctly when threshold exceeded
- Email notifications logged successfully

Model Performance

- Optimized for **Part-B (low to medium density)** scenes
- Provides stable density maps suitable for deployment

8. Deployment Details

Deployment Platform

- **Streamlit Cloud / Local Server**

Accessibility

- Dashboard accessible via browser
- Can be shared with mentor for evaluation

Deployment Outcome

- Fully functional real-time crowd monitoring system
- Meets all Milestone-4 requirements

9. Conclusion

Milestone-4 successfully demonstrates the **end-to-end deployment** of an AI-based crowd monitoring system.

This milestone achieved:

- Real-time crowd density estimation
- Web-based visualization dashboard
- Automated overcrowding detection
- Email alert notification system
- Deployment-ready architecture

The project now transitions from **model training** to a **practical, real-world AI application** suitable for surveillance and safety monitoring.