DEEP VISION CROWD MONITOR
AI-BASED CROWD DENSITY ESTIMATION AND OVERCROWDING DETECTION

Milestone 4 –Documentation

Submitted by:
Avanthikalakshmi Vinod

Table of Contents

1. Introduction

2. Background and Motivation

3. Problem Statement

4. Objectives of Milestone 4

5. Proposed System Overview

6. Detailed System Architecture

7. Data Flow Diagram

8. Flowchart of Image Processing Module

9. Flowchart of Video Processing Module

10. Crowd Density Estimation Technique

11. Crowd Count Estimation Logic

12. Overcrowding Detection Algorithm

13. Email Alert System Design

14. Dashboard Design using Streamlit

15. Implementation Details

16. Pseudo Code Representation

17. Experimental Results and Analysis

18. Performance Discussion

19. Applications of the Proposed System

20. Limitations

21. Future Enhancements

22. Conclusion

1. Introduction

Crowd monitoring has become a critical requirement in modern urban environments due to the increasing frequency of large public gatherings such as festivals, political events, concerts, and transportation hubs. Manual surveillance systems depend heavily on human operators, which limits scalability and reliability.

The Deep Vision Crowd Monitor utilizes artificial intelligence and deep learning techniques to automatically analyze crowd scenes and estimate crowd density. Milestone 4 focuses on transforming the trained model into a deployable, interactive, and user-friendly system.

2. Background and Motivation

Traditional object detection-based crowd counting methods fail in extremely dense crowd scenarios due to severe occlusions and perspective variations. Density-based approaches, such as CSRNet, overcome these limitations by learning a continuous density representation of the crowd.

The motivation behind this milestone is to bridge the gap between model development and real-world deployment by integrating visualization and alert mechanisms.

3. Problem Statement

There is a lack of automated systems capable of accurately estimating crowd density from visual data while providing real-time alerts. Existing systems either require manual intervention or fail under dense crowd conditions.

4. Objectives of Milestone 4

- Deploy the trained crowd density estimation model in a real-time dashboard
- Enable image and video-based crowd analysis
- Visualize crowd density through heatmap overlays
- Automatically detect overcrowding conditions
- Notify authorities using email alerts
- Ensure system usability and portability

5. Proposed System Overview

The proposed system follows a modular approach, combining deep learning inference with visualization and alert generation. Users interact with the system via a web dashboard that processes visual inputs and displays results instantly.

6. Detailed System Architecture

The architecture consists of interconnected modules:

Input Module → Preprocessing Module → Density Estimation Model → Post-processing Module → Visualization Module → Alert Module → User Dashboard

7. Data Flow Diagram

User Input (Image/Video)
↓
Frame Extraction & Normalization
↓
Deep Learning Model (CSRNet)
↓
Density Map Output
↓
Crowd Count Estimation
↓
Dashboard Visualization & Alert Generation

8. Flowchart of Image Processing Module

START → Upload Image → Preprocessing → Density Estimation → Heatmap Generation → Count Estimation → Overcrowding Check → Display Result → END

9. Flowchart of Video Processing Module

START → Upload Video → Frame Extraction → For Each Frame: Density Estimation → Heatmap Overlay → Count Accumulation → Average Count → Overcrowding Check → Display Output → END

10. Crowd Density Estimation Technique

The system uses a CSRNet-based deep convolutional neural network that predicts a density map for each input image. Each pixel value in the density map represents the estimated crowd presence at that location.

11. Crowd Count Estimation Logic

The estimated crowd count is computed by integrating the predicted density map. This provides a robust estimate even in highly congested scenes.

12. Overcrowding Detection Algorithm

A predefined threshold is used to classify crowd conditions. If the estimated count exceeds this threshold, the scene is flagged as overcrowded and alerts are triggered.

13. Email Alert System Design

The email alert system uses SMTP to notify authorities when overcrowding is detected. The alert includes the estimated crowd count and warning status.

14. Dashboard Design using Streamlit

Streamlit provides a simple yet powerful interface for deploying machine learning applications. The dashboard allows users to upload images or videos, view heatmaps, and receive alerts in real time.

15. Implementation Details

The application is implemented in Python using PyTorch for deep learning inference, OpenCV for video processing, and Streamlit for dashboard development.

16. Pseudo Code Representation

```
Input: Image/Video
Load Model
If Image:
  Predict Density → Estimate Count → Display Heatmap
Else If Video:
  For Each Frame:
    Predict Density → Accumulate Count
Check Threshold
```

Trigger Alert if Required
Display Results

17. Experimental Results and Analysis

The system was tested on various crowd images and videos. The generated density maps accurately highlight crowd concentration regions, and alerts are triggered reliably.

18. Performance Discussion

The model performs well under dense crowd conditions. While absolute count accuracy may vary across datasets, the system effectively captures relative crowd density trends.

19. Applications of the Proposed System

- Smart city surveillance
- Public event safety monitoring
- Railway stations and airports
- Shoppingmalls and stadiums
- Emergency response systems

20. Limitations

The current system provides relative crowd estimation and may require dataset-specific calibration. Real-time CCTV integration is limited by hardware constraints.

21. Future Enhancements

Future work includes cloud deployment, real-time CCTV integration, SMS alerts, improved model accuracy, and large-scale system integration.

22. Conclusion

Milestone 4 successfully demonstrates the practical deployment of an AI-based crowd monitoring system. By combining deep learning, visualization, and alert mechanisms, the proposed system offers a scalable and efficient solution for crowd surveillance.