

Walkway Non-Compliance Detection Project

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Project Description

This capstone project develops an intelligent, automated system to enhance industrial workplace safety by ensuring adherence to designated walkways. It employs image processing and machine learning to detect walkway non-compliance in real-time using strategically placed cameras. When violations are detected, the system triggers immediate audible alerts and logs incidents with timestamps, visual evidence, and duration. Authorized personnel access these logs via a secure interface and receive real-time notifications through a user-friendly mobile app. The system's reliability and accuracy are validated in both indoor and outdoor scenarios, achieving strong performance metrics. Overall, the project significantly advances safety management through automated monitoring and adaptable technology.

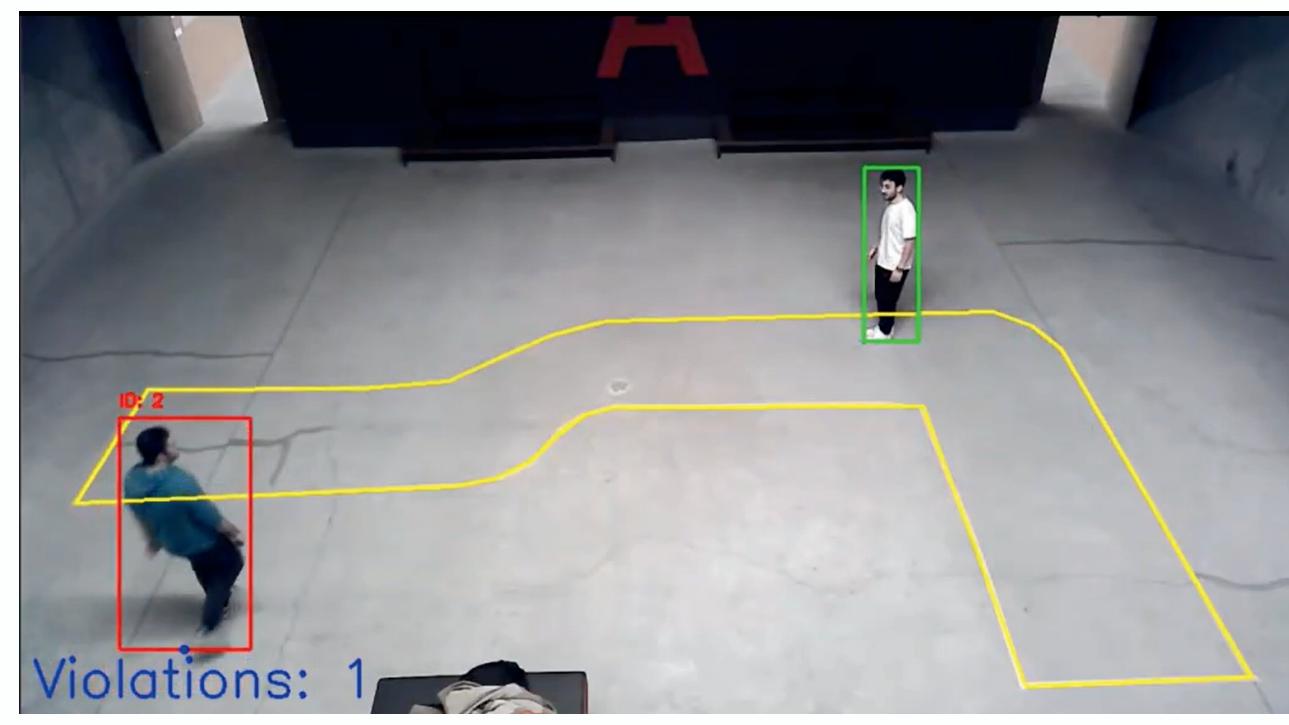


Figure 1. Overall project

Project Requirements

Table 1. Overall Project Requirements

Objectives	Requirements
Real Time Operation	Violation detection delay <= 5 seconds
Accurate Human Detection and Tracking	Precision and Recall should be close to 1
Accurate Walkway Detection	Walkway matching area (%) should be close to 98%
Low cost	Total project cost <= 300 \$
Mobile application support	Notification delay <= 10 seconds
Effective Warning	Alarm should be loud enough to warn humans
Easy to Set up	Set up time of the system <= 5 minutes
Adaptable to Different Environments	The system should cover up to 100 m ² area (both indoor and outdoor)

Method of Solution

- Modular design integrating five subsystems: walkway detection, human detection/tracking, communication, alarm, and mobile application.

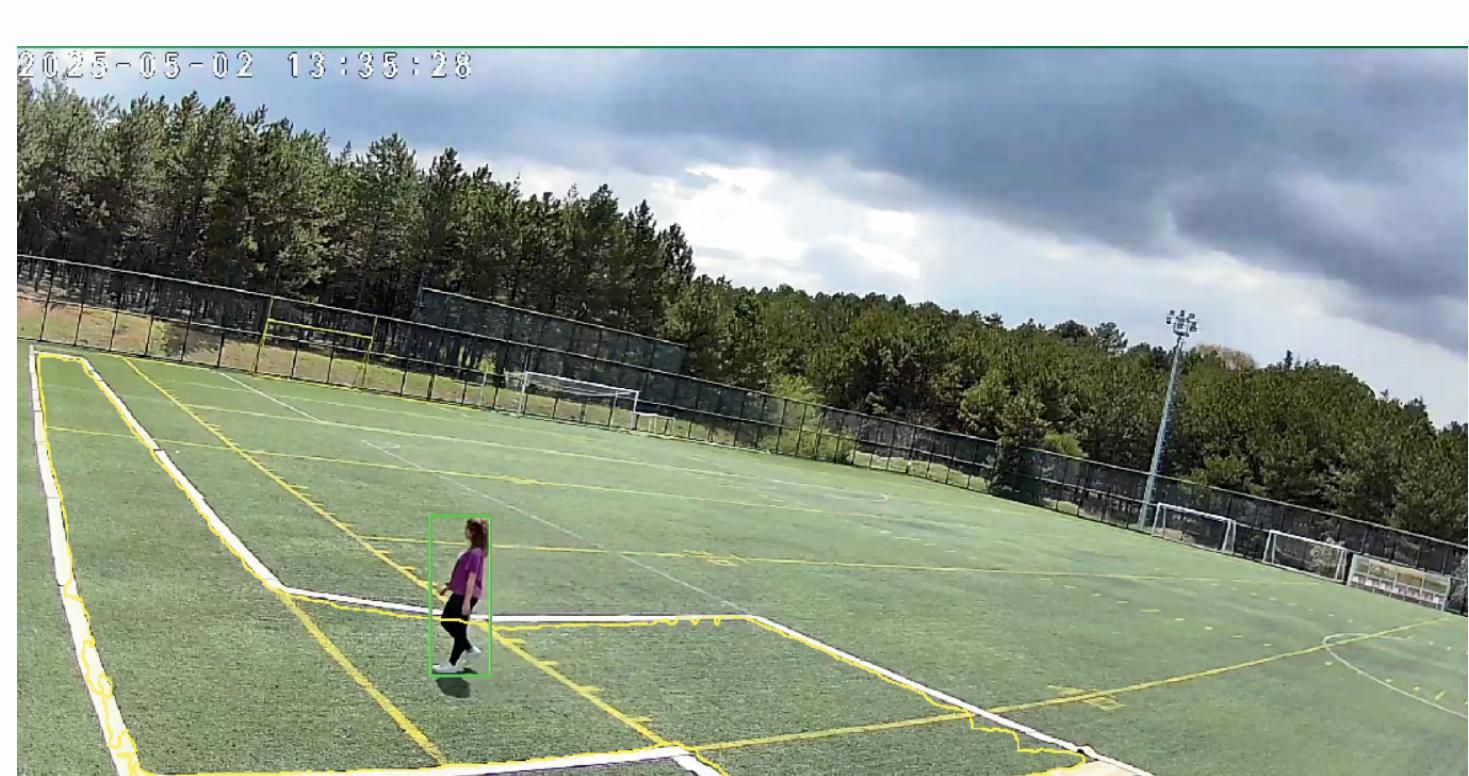


Figure 2. Overall system in the outdoor test

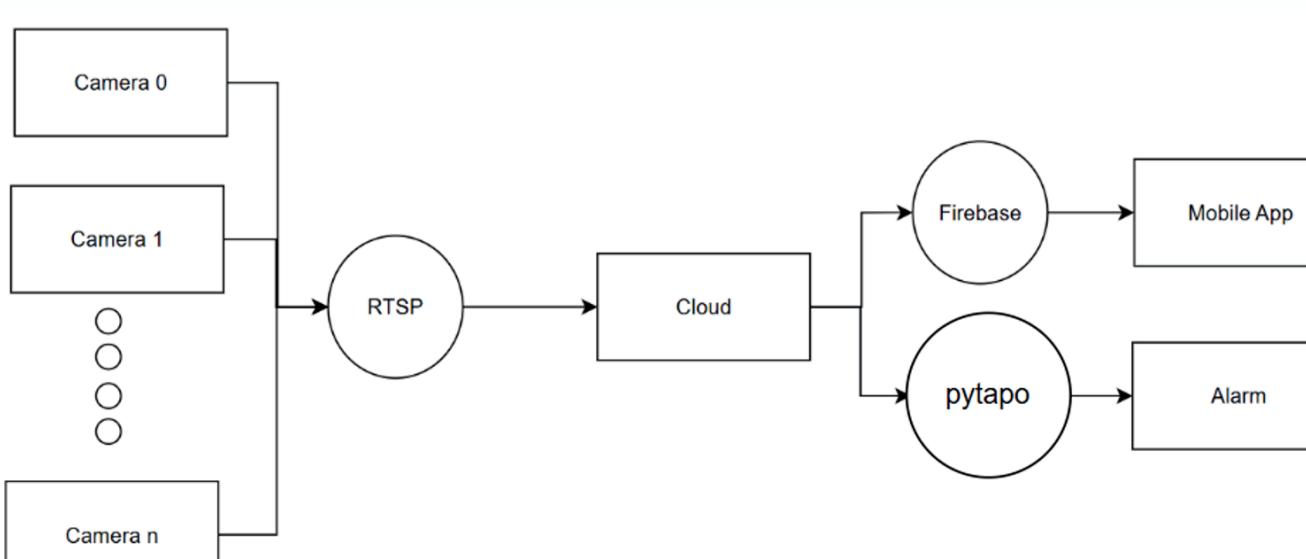


Figure 3. Overall system diagram

Walkway Detection Subsystem

- Walkway detection subsystem uses Segment Anything Model (SAM) for AI-based semantic segmentation.
- Region of Interest (ROI) selected via GUI; users refine segmentation with interactive prompts.
- Outputs a binary mask defining the walkway, saved as a polygon (JSON) for tracking module.

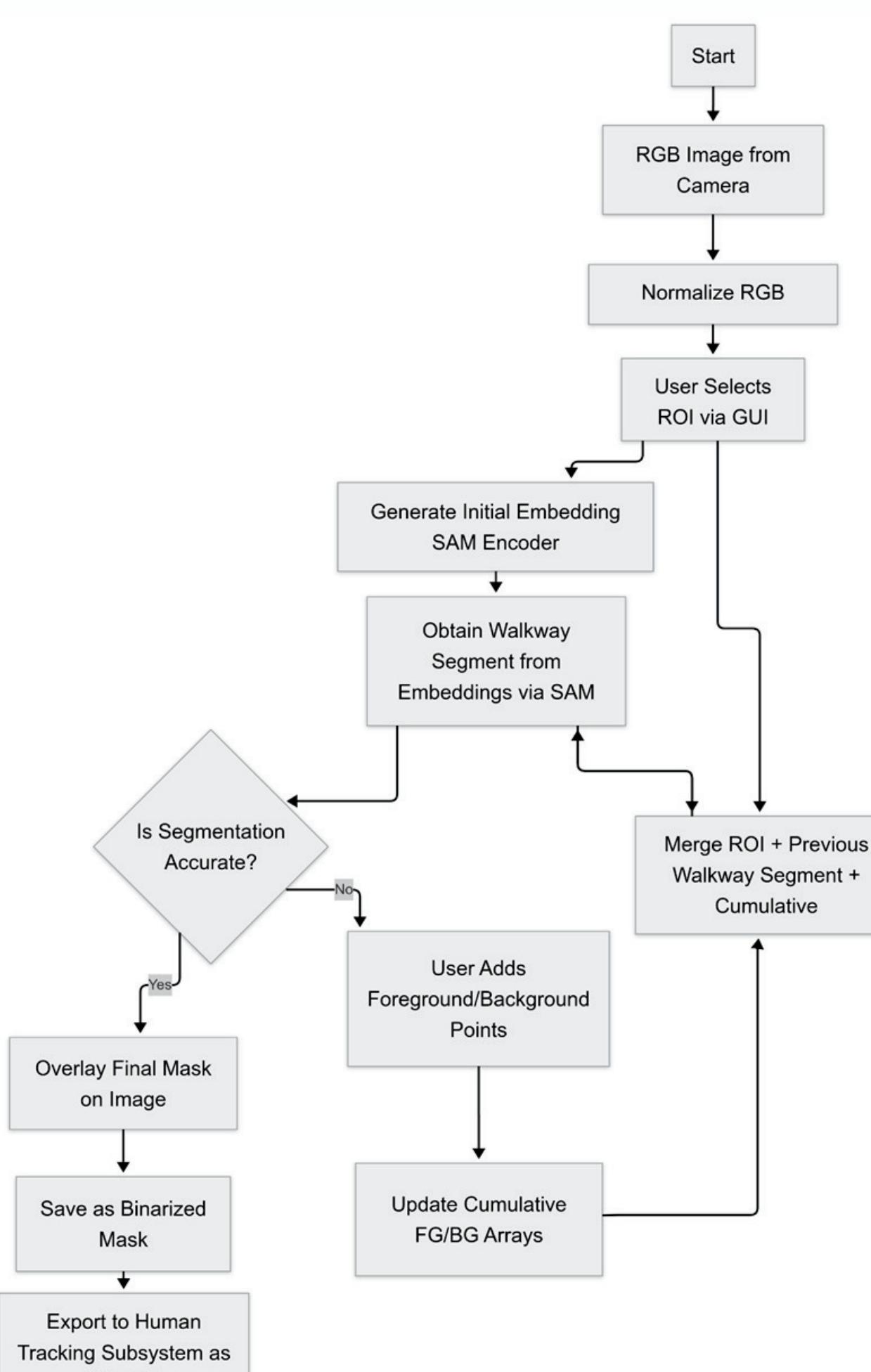


Figure 4. Walkway detection algorithm

Human Detection and Tracking Subsystem

- Employs YOLOv11 for detecting "person" objects in real-time.
- Uses SORT algorithm for tracking people outside walkway areas.
- Bounding boxes are checked against the walkway polygon to identify violations.
- Parameters like IoU threshold and tracker age are tuned for robust performance under various conditions.

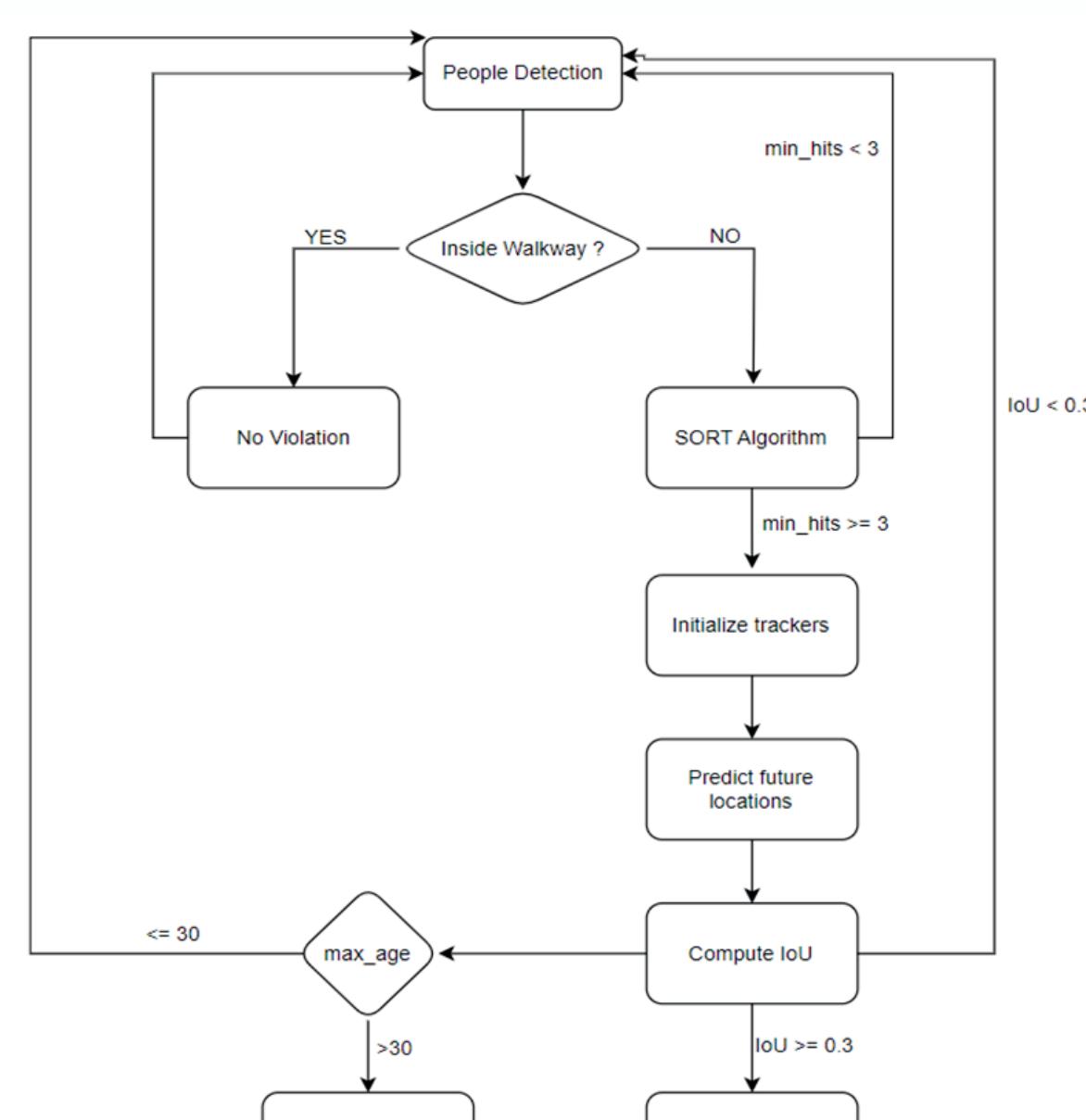


Figure 5. Human tracking algorithm

Communication and Alarm Subsystem

- Video is streamed via RTSP protocol from TAPO C310 cameras to the cloud.
- A custom 2.4 GHz network bridge enables compatibility with campus Wi-Fi infrastructure.
- Uses camera's internal speaker as an alarm, controlled via the Python library pytapo.

Mobile Application Subsystem

- Web-based Progressive Web App (PWA) hosted on Firebase.
- Receives real-time alerts via Firebase Cloud Messaging (FCM).
- UI includes realtime tab for live alerts and history tab for logs.

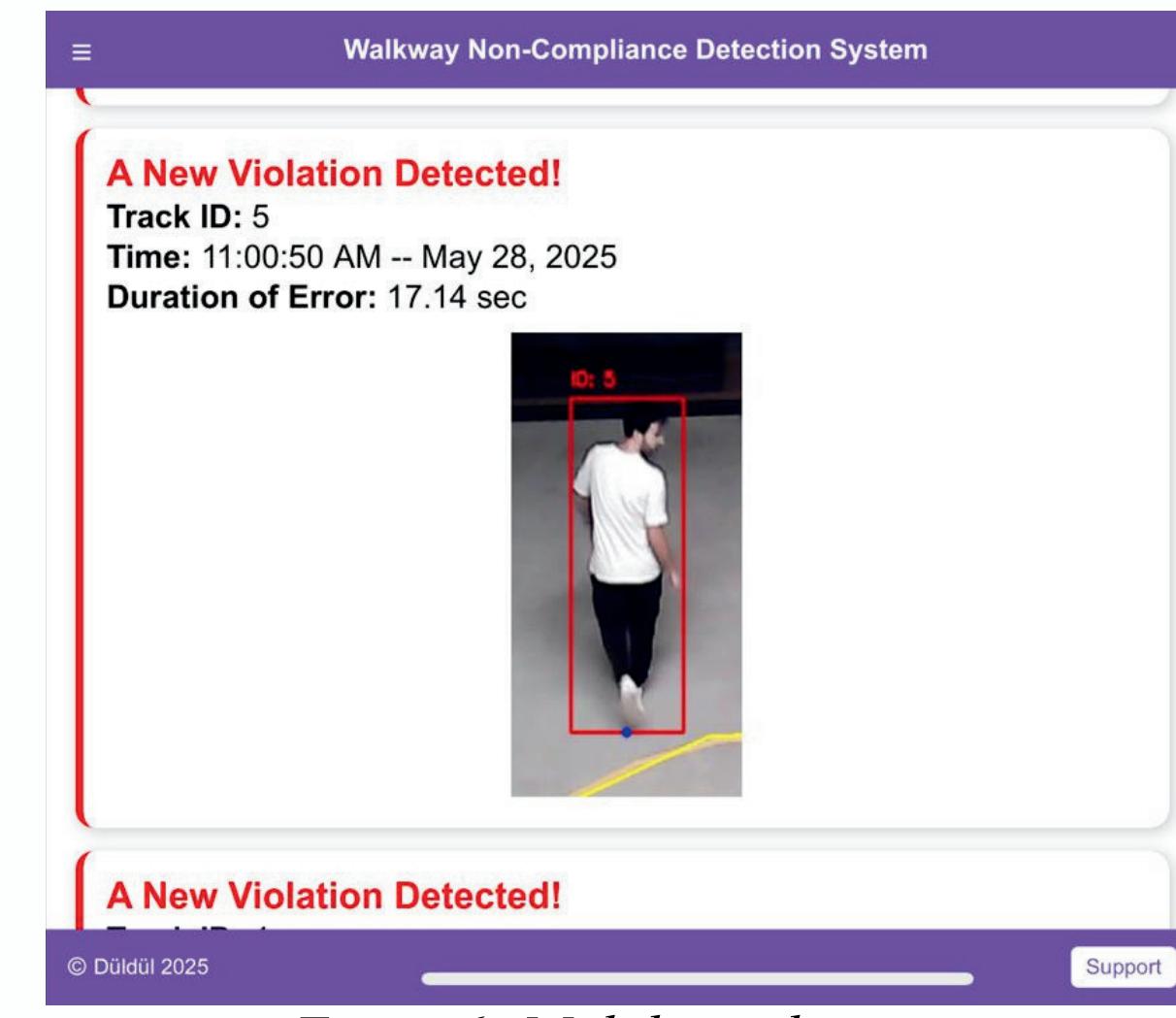


Figure 6. Mobile application

Cost Analysis

Table 2. Overall cost analysis

Walkway materials including paint	4000TL
3 TAPO C310 cameras	4500TL
Total Cost	8500TL

Test Results

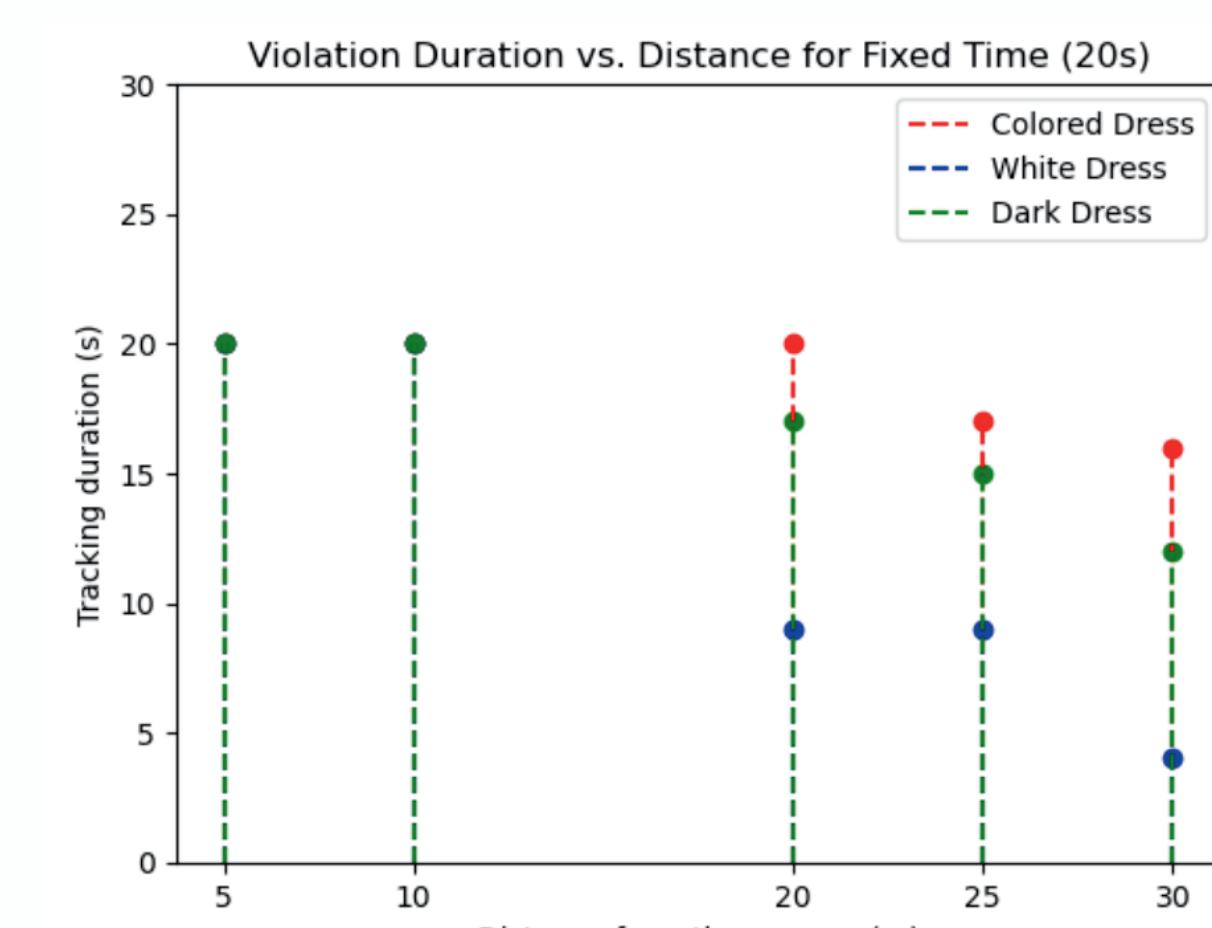


Figure 7. Violation durations at different distances

Table 3. Performance metrics for Football Pitch (100m)

True Positives	False Positives	False Negatives	Precision	Recall	F1 Score
42	4	6	91.3%	87.5%	89.3%

Table 4. Performance metrics for D block corridor

True Positives	False Positives	False Negatives	Precision	Recall	F1 Score
25	3	7	89.3%	78.1%	83.3%

Table 5. Walkway detection algorithm accuracy results

	Brown	Yellow	Mixed
Low Light	99.1%	95.6%	97.3%
High Light	97.3%	98.6%	98.9%

Deliverables

- Camera Setup
- Cloud Server Setup
- Alarm system
- Mobile Application