

Smart Crosswalk AI System – Specification Document

1. Executive Summary

Smart Crosswalk AI System is an AI-based solution designed to improve pedestrian safety at crosswalks.

The system detects real-time risk situations through camera image analysis, generates alerts, and activates local LED warning lights at the crosswalk.

The system operates as a **stand-alone solution**, independent of external city infrastructure. It is built on a **Microservices architecture**, with clear responsibility separation for each service.

2. Project Goals

Primary Goals

- Early detection of risky situations at crosswalks
 - Reduction of traffic accidents and increased driver awareness
 - Automatic activation of physical warning measures in real-time
 - Continuous improvement of AI models based on accumulated data
 - Management and monitoring of multiple crosswalks from a single system
 - Creation of a flexible infrastructure for future system expansion
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3. Stakeholders

- Pedestrians
 - Drivers
 - Maintenance and operations teams
 - Developers and system administrators
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4. System Scope

Included in the Project:

- Crosswalk management
- Real-time alert management
- Control and activation of LED systems
- System monitoring and statistics
- Operator management interface

Out of Scope:

- Traffic lights and external municipal infrastructure
 - Legal enforcement or fines
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5. General Architecture (Current State)

The system is based on a single centralized backend running on a Node.js server, with logically separated routes for alert management and crosswalk management.

The AI component has not yet been implemented and is planned to operate as a function or logical service.

The frontend communicates with the backend through a unified API.

6. Key Use Cases

Use Case – Hazard Detection and Alert

1. Camera detects an event
2. AI identifies a pedestrian and approaching vehicle
3. Alert is generated
4. LED light is activated
5. Alert is displayed to the operator

Use Case – Event Completion

1. Hazard disappears
 2. Alert status is updated
 3. LED light turns off
 4. Event is logged
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7. What Has Been Implemented So Far

- Full CRUD operations for Alerts
- Full CRUD operations for Crosswalks
- Alert filtering by status, severity, and crosswalkId
- Crosswalk filtering by status

- LED control and activation for crosswalks
 - Real-time statistics
 - Error handling middleware
 - MongoDB with Mongoose ORM
 - CORS enabled
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8. Non-Functional Requirements (Current)

- Real-time response
 - High availability
 - Local operation in case of partial network disconnection
 - Scalability for additional crosswalks
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9. Technologies Used

- Backend: Node.js
 - Database: MongoDB
 - ORM: Mongoose
 - Frontend: React
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10. Future Enhancements – Next Sprint

- Addition of an AI-based image analysis system (implementation approach not yet defined)
- Transmission of analysis results to the Alert Service for alert creation
- Integration of physical hardware: cameras and LED systems
- Secure transmission of images and data from cameras to the AI component via HTTPS
- LED Service based on LoRaWAN to activate warning lights in real time upon new alert creation