Harnessing Deep Learning to Optimize Emergency Response

REAL-TIME ACCIDENT DETECTION AND INTELLIGENT EMERGENCY COORDINATION SYSTEM

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Every second matters in emergencies.

Car accidents are among the most critical challenges facing public safety. Currently, emergency response depends heavily on human calls and eyewitness reports, which creates dangerous delays. During these lost minutes, outcomes can shift from survival to tragedy. By the time emergency services receive information, precious time has already been wasted—time that could have saved a life.

Our Motivation: *Saudi Road Accidents* (2023 vs 2024)

More serious accidents and injuries, thousands of lives at risk every year.

17,231 serious traffic accidents in 2024

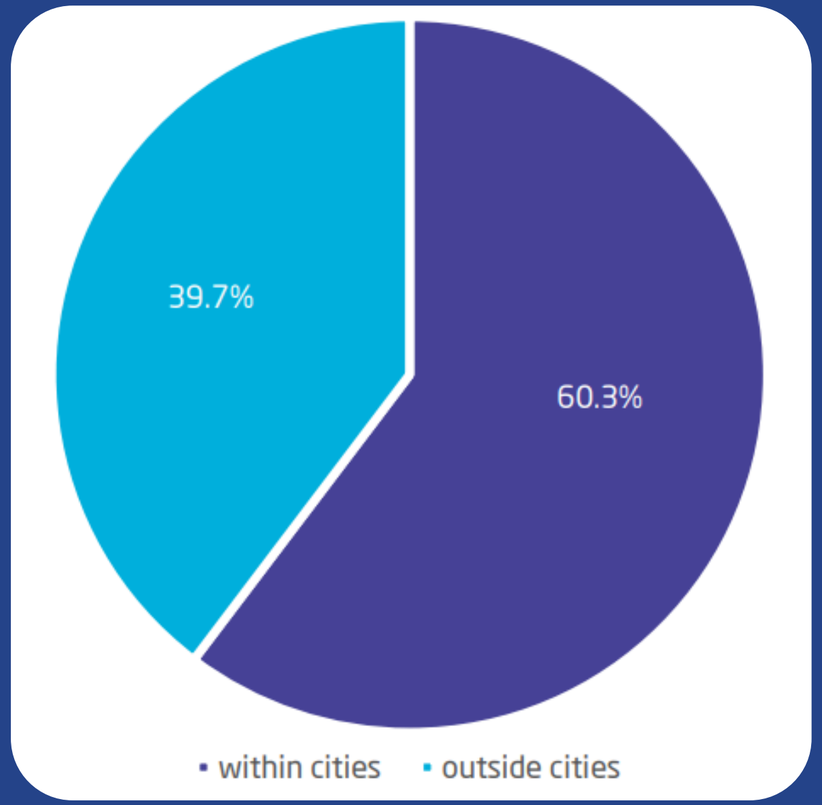
4,282 lives lost in traffic crashes

24,077 people injured on the roads

These numbers will not change unless **detection** and **response** become faster and more intelligent.

Source: GASTAT, Road Transport Statistics 2024

Where Accidents Happen — City vs Outside City



Source: GASTAT, Road Transport Statistics 2024

Most accidents occur within cities, where roads are often congested.

Congestion and unclear location details can delay access and dispatch.

This tells the need for faster incident awareness to support timely response.

Current approaches

Human-Dependent: Relies on witnesses calling emergency services

Slow: Average 3-5 minute delay from accident to emergency dispatch

Unreliable: Inaccurate descriptions lead to poor resource allocation

The Impact

Lives lost due to delayed response

Increased secondary accidents from traffic disruption

Inefficient emergency resource deployment

Our Solution

Eliminate human reporting delays by automatically detecting accidents the moment they happen, giving emergency teams instant, accurate information to respond faster and save lives.

What We're Building

An AI-powered real-time accident detection system that continuously monitors live CCTV feeds and automatically alerts emergency services the moment a collision occurs.

Why This Matters

Current emergency response systems lose critical time waiting for human reporting. Our system removes this delay entirely—delivering instant alerts with precise location and severity data directly to first responders.

Core Objectives

Lightning-Fast Detection

- Detect accidents within <2 seconds
- 85%+ accuracy (precision, recall, F1-score)
- <5% false alarm rate

System Scale & Reliability

- Monitor 100+ cameras simultaneously
- Automatic severity classification (mild/moderate/severe)
- Multi-camera redundancy for safety

Real-World Impact

- Cut emergency response time by 40-60%
- Give responders actionable intelligence before arrival
- Prevent secondary accidents through smart traffic rerouting

HOW IT WORKS – SYSTEM OVERVIEW

Continuous Monitoring

Multiple CCTV cameras stream live video feeds from intersections and highways. The system analyzes 24/7 without human intervention.

AI Detection Engine

YOLOv12 deep learning model processes frames at high speed, identifying vehicles and detecting collisions within milliseconds.

Severity Analysis

CNN classifier determines severity: Mild | Moderate | Severe, estimating vehicle damage instantly.

Event Orchestration

System correlates detection with location, traffic context, and responder zones to understand the full situation.

Instant Alert Generation

Emergency services receive alerts with:

- Exact GPS location + street address
- Severity & damage assessment

Responder Dashboard

First responders see actionable information on devices, enabling faster departure and better resource allocation.

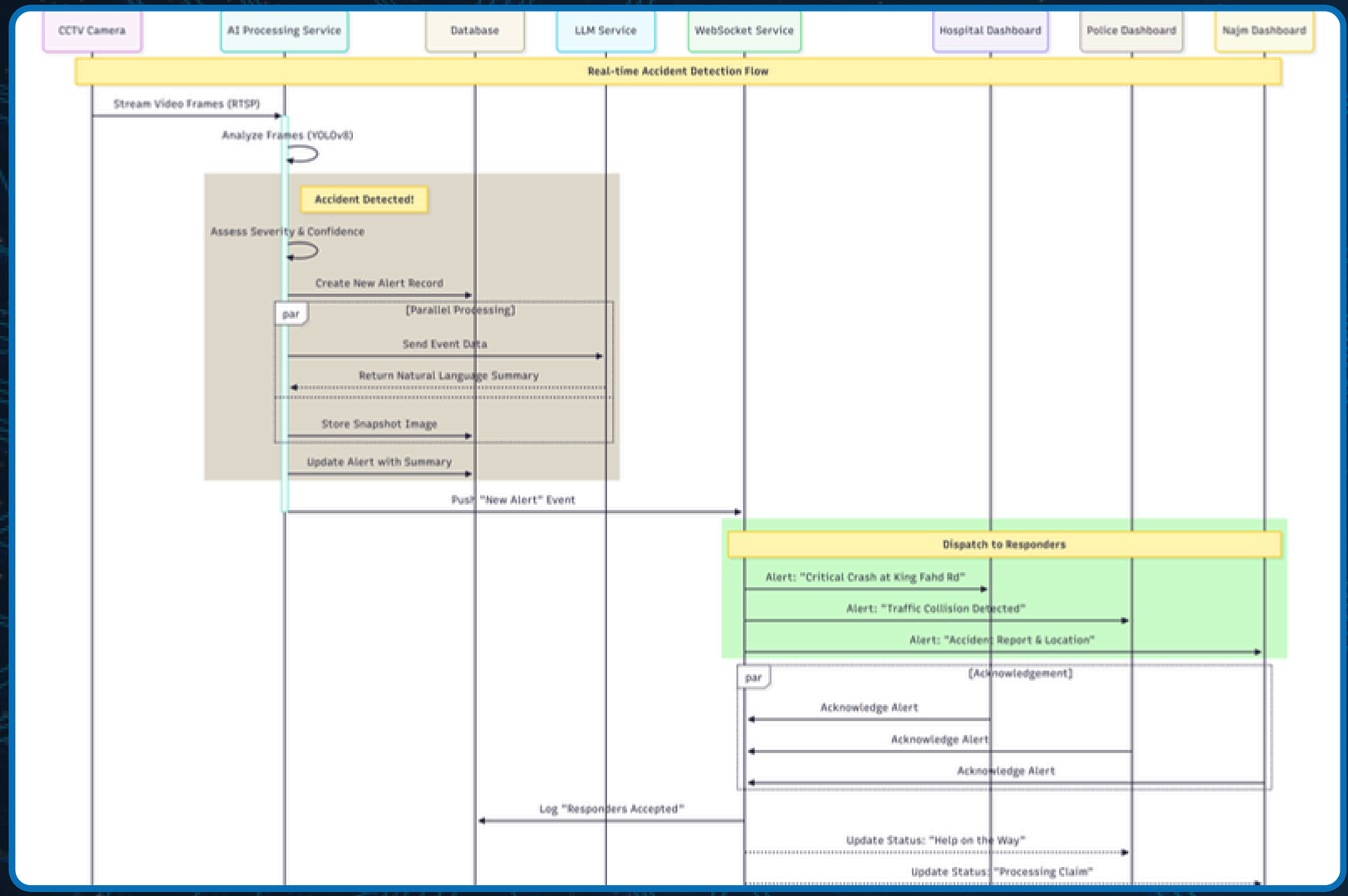
SOLUTION USING ALGORITHMS

Algorithm	Purpose	Why This	Performance
YOLOv12	Real-time detection	Fastest + most accurate	>100 FPS, <200ms latency
CNN	Pattern recognition	Learns visual features	85%+ accuracy on severity
DeepSORT	Multi-object tracking	Temporal consistency	93%+ tracking accuracy
Background Subtraction	Noise reduction	Isolates moving objects	30-40% speed boost

Why Not Alternatives?

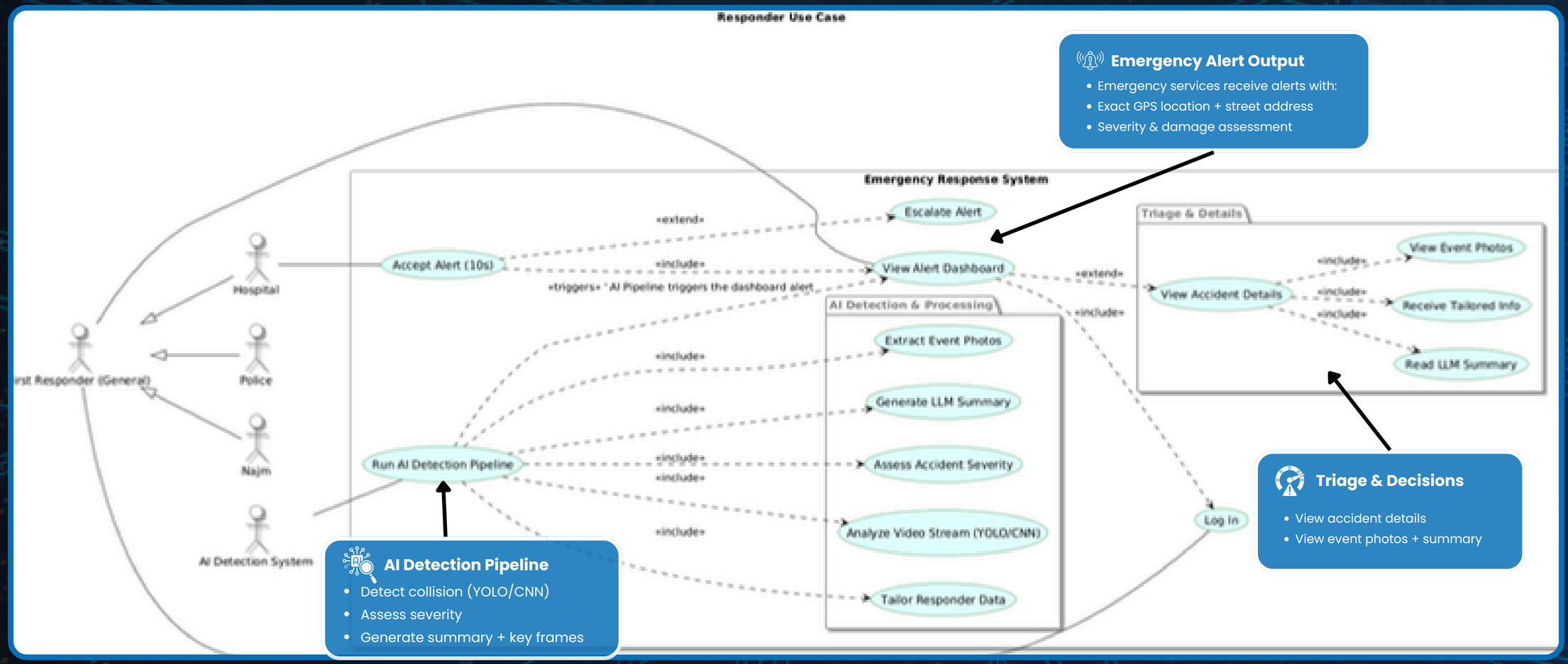
- LSTM/3D-CNN: Too slow for real-time
- Traditional CV: Only 70-75% accuracy
- Lightweight models: Sacrifice accuracy for speed (inadequate for safety)

Sequence of Interactions Across Subsystems



Responder Use Case - System Diagram

End-to-end flow: detection → alert → triage → action.



Research Foundation

We reviewed and analyzed 25+ peer-reviewed research papers and industry reports on accident detection, computer vision, and emergency response systems to establish best practices and identify innovation opportunities.

Best-Performing Models

- YOLOv8/YOLOv9 (2024-2025): 94-96% accuracy
- YOLOv5 + background subtraction (2023): 96% on severe accidents
- Hybrid detection + tracking (2022-2024): 93-98% rates

Proven Effective Approaches

- Deep neural networks for complex data
- Real-time video processing achieves best speed
- Multi-object tracking reduces false positives
- Transfer learning accelerates deployment

Common Industry Challenges Identified

- Limited accident datasets (5,700 max)
- Poor weather/low-light performance
- Difficulty deploying to edge devices
- Lack of real CCTV validation in research

Research Highlight

Overview of "**A Real-Time Computer Vision Based Approach to Detection and Classification of Traffic Incidents**" paper.

Objective

Detect and classify traffic incidents in real-time using AI to improve emergency response.

Key Results

- Vehicle tracking: 99.2% mAP
- Accident detection: 83.3% mAP
- Fire detection: 98.9% accuracy

Method

- YOLOv5 + DeepSORT: Vehicle detection & tracking
- YOLOv5: Accident detection & severity classification
- ResNet152: Post-collision fire detection

A Real-Time Computer Vision Based Approach to Detection and Classification of Traffic Incidents

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This article belongs to the Topic Big Data and Artificial Intelligence

Evaluation Metrics

To assess the effectiveness and real-time reliability of the proposed AI-based accident detection system, standard computer vision evaluation metrics will be used.

Precision

Correctness of detected accidents and false alarm reduction

Recall

Ability to detect all real accident events

F1-Score

Balanced measure of overall detection performance

mAP

Accuracy across confidence thresholds

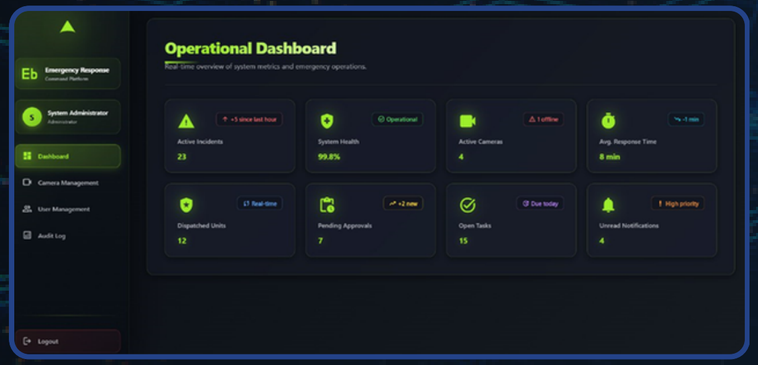
Detection Latency

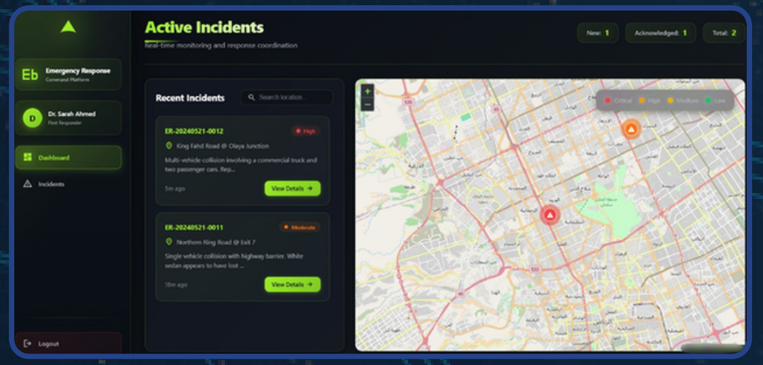
Time required to detect accidents in live video streams

USER INTERFACES & SYSTEM DESIGN

Admin Dashboard (5 Key Sections):

1. Camera Management → Add/remove/monitor cameras
2. User Administration → Manage responder accounts
3. Audit Logs → Complete activity history
4. Analytics → Performance metrics & hotspots
5. Manual Controls → Override automated decisions





LEARNING & AI PRINCIPLES

Course	New Skill Learned
ARTI 401 Artificial Intelligence Principles	Intelligent agents & decision systems
ARTI 402 Programming in AI	Real-time AI programming (YOLOv8)
ARTI 406 Machine Learning	ML model training & validation
ARTI 502 Deep Learning	CNN for pattern recognition

Thank You

FOR YOUR ATTENTION