PROVIDENCE: AI-Powered Traffic Incident Management Support System

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

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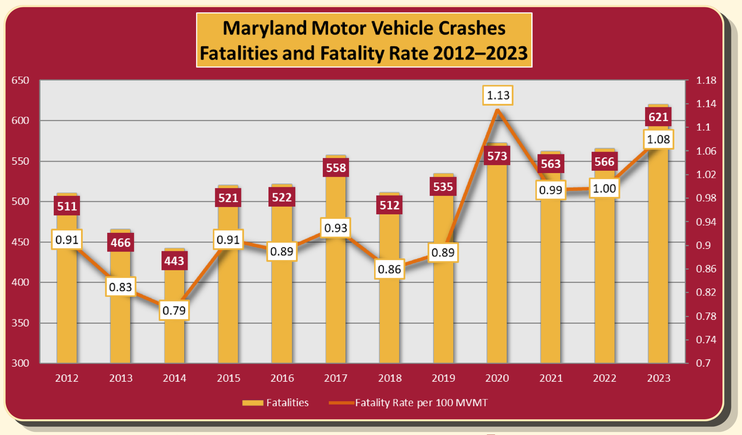
Problem Defined

Traffic incidents are a major cause of congestion, delayed emergency response, and secondary crashes. Current management systems rely heavily on:

- manual monitoring of camera feeds
- phone reports from the public or responders
- operator experience to assess severity

According to the FHWA, in 2023 alone, Maryland saw more than 110K crashes, 22K of which are secondary crashes. According to the MDOT's Coordinates Highways Action Response Team (CHART), fatality rates have been on the rise since 2012



Opportunity

Streamlining traffic incident management using a multi-stage language model to accelerate detection, verification, and alerting aiding faster decision making and lowering secondary crash rates.

Stakeholder Analysis

From a sample of 170 Maryland commuters, 98% indicated they have experienced incident-related delays, and 35% experience such delays every week, adding an average of 10–20 minutes to their commute.

CHART Systems Division's Chief further clarified current incident management needs include: automatic incident characterizations including severity, number and types of vehicles involved, and number of lanes blocked.

Model Research

YOLO Vision: Uses a single-pass neural network to identify and localize objects in real-time.

LLM Logic: Employs Transformer attention to map visual data into structured JSON reports.

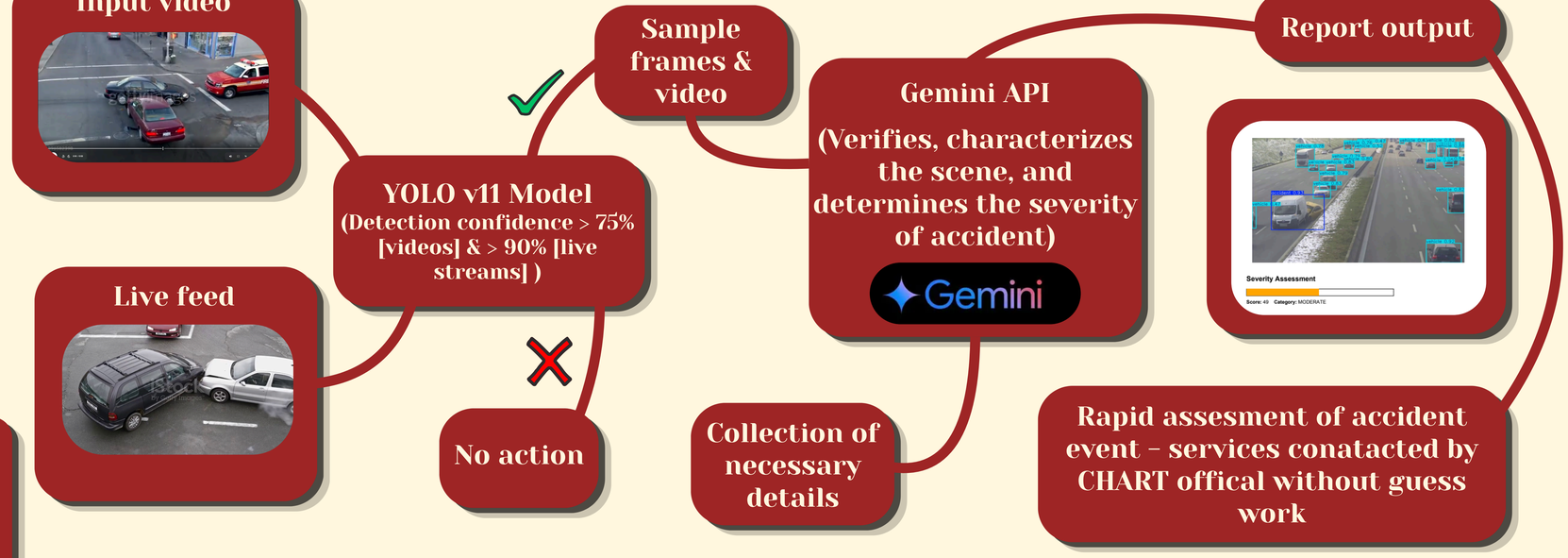
API Engine: Secure, low-latency automation for live Maryland traffic feed retrieval.

Guardrails: PII privacy compliance and physical/environmental sensor limitations.

Methodology

- **PHASE 1** Stakeholder Analysis & Literature Review
- **PHASE 2** Prompt & Logic Development
- **PHASE 3** Report Generation & YOLO Testing
- **PHASE 4** API & Live Camera Feed Integration
- **PHASE 5** Full Model Testing & Refinement

Model Architecture



Model Output

Frame with the highest accident confidence score detected by YOLO model

View examples of generated reports

Recommendations & Future Work

- Upgrade road cameras for better resolutions
- Construct a physical database to retain model information
- Acquire your own API key for model processing
- Optimize processing hardware – high end NVIDIA GPU