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DIGITAL SOLUTIONS [INDIA]

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Team Details

- a. Team name: Quisk
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- c. Problem Statement: Road Hazard Detection & Real-Time Alerts

Current Challenges in Road Hazard Detection



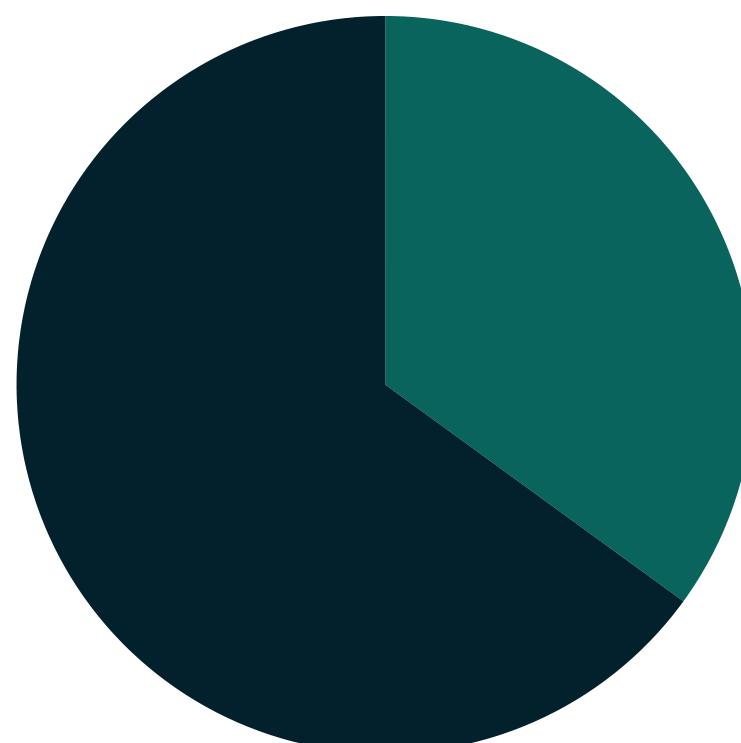
Fragmented and Manual Reporting

No unified national platform exists. Most systems rely on **manual user submissions**, leading to incomplete and delayed hazard data.

Over **1.55 lakh** people lose their lives every year on Indian roads that's **425 deaths per day**.

● Organization With Methods

● Organization Without Methods



Lack of Real-Time Detection

Existing solutions don't provide **instant notifications** to nearby drivers. Without **low-latency AI inference**, even a few seconds' delay can result in **avoidable accidents**, especially at highway speeds.

● Causes of Road Accidents in India (2023)

Dangerous driving / Overtaking

Poor road condition

Vehicle defect / stall

Distance Error

Other



Limited Infrastructure Coverage

Smart cameras cover only highways and cities. Over **70% of India's roads**; mainly rural areas lack automated monitoring.



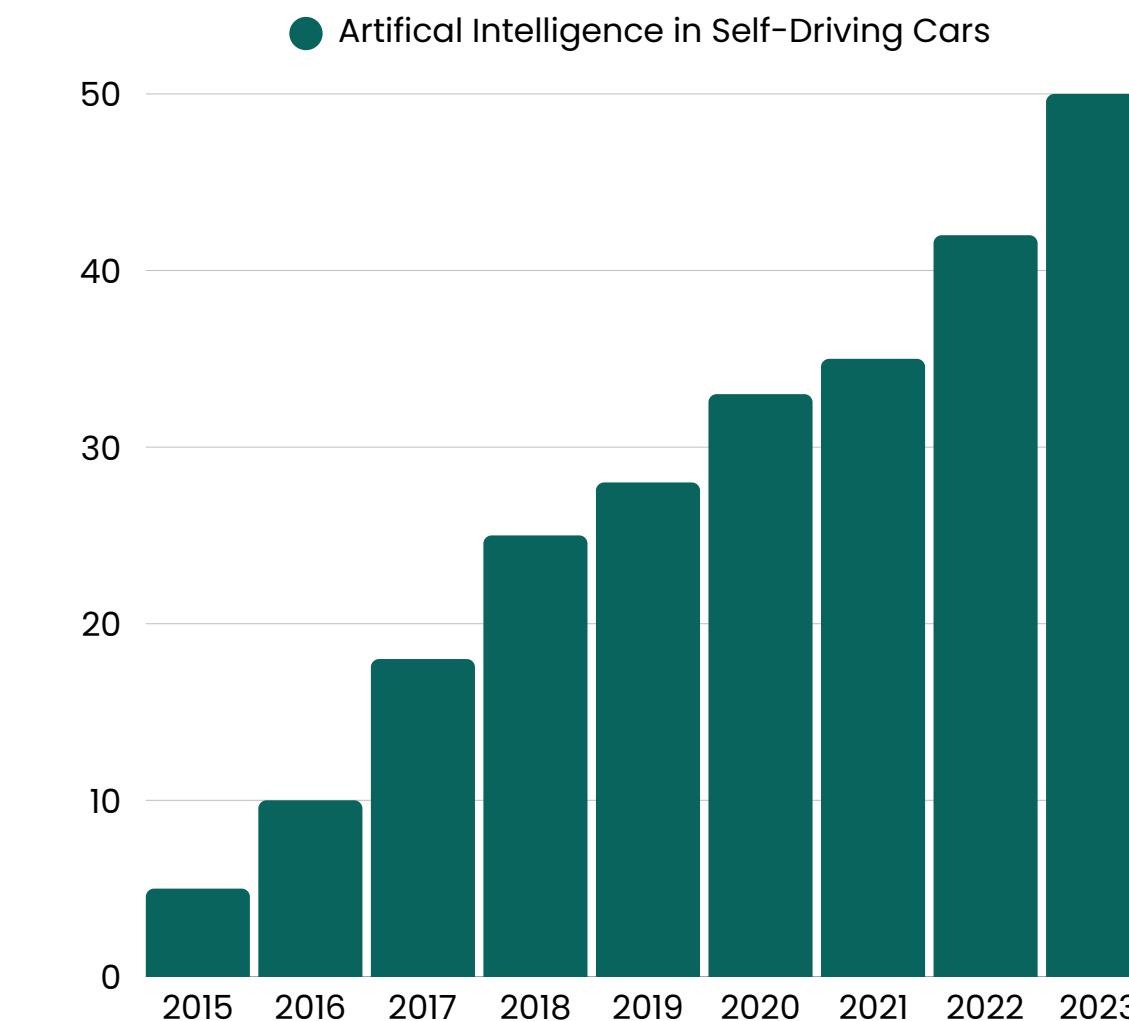
Privacy & Data Sensitivity

Dashcams capture faces and number plates. Few systems apply on-device **anonymization**, raising privacy concerns.



Duplicate Or False Alerts

Multiple vehicles may flag the same hazard, creating spam or **false positives**. No clustering or validation is used.



India loses **₹20,000+ crore** each year in productivity, logistics delays, and vehicle damage caused by poor road infrastructure.

More than **4.3 lakh** people suffer injuries annually due to crashes, often caused by potholes, debris, or stalled vehicles.

The average pothole repair time is **2-3 weeks**, even after complaints are logged.

Opportunities



1 Composite Image Stitching + Image Enhancement

- **Unified Input:** Multiple camera feeds are stitched into a single panoramic frame.
- **Reduced Load:** One composite image is analyzed per timestep.
- **Seamless Coverage:** Tiling/homography ensures smooth scene coverage.
- **Enhanced Visibility:** GAN-based dehazing and brightening handle fog, glare, and low light.
- **Improved Detection:** Hazard detection is boosted in adverse and low-visibility conditions.

2 Adaptive Key Frame Sampling And Capture Control

- **AI-Driven Selection:** AI selects keyframes based on scene changes, motion, and object appearance.
- **Dynamic Capture:** Captures only informative frames skipping static or repetitive input.
- **Efficiency Focused:** reduces unnecessary processing in slow, stop-and-go, or idle scenarios and prioritizes events at higher speeds or during rapid change.
- **Optimized Processing:** Uses a relevance-and-coverage optimization, scoring frames in real-time delivering up to 60% less compute with robust, real-time analytics and no system overload.

3 Efficient Backbone Neural Network

- Deploys the advanced DEIMv2-S transformer backbone for more accurate feature extraction.
- Delivers up to 51 mAP on COCO-style benchmarks; outperforming YOLOv11 by 4–8% in real-world hazard detection tasks.
- Maintains real-time performance (30–170 FPS) even on embedded GPUs or edge devices.
- Reduces false positives and improves detection of medium and large road hazards (potholes, debris) compared to older CNN models.

4 Multi-Head Inference:

- Implementing **multi-head** inference for **parallel** specialized vision tasks.
- Includes: Object Detection Head, Segmentation Head, Depth Estimation Head, Object Tracking Head, Road/Lane Mask Head, Few-Shot Hazard Head and Privacy Blur Head.

5 Fusion Engine (AI/Rule-Based):

- **Multi-Head Input:** Receives outputs from all specialized vision heads.
- **Decision Logic:** Fuses signals using rules or an ML model to validate hazards.
- **Hazard Scoring:** Produces a Hazard Confidence Score and severity level.
- **Purpose:** Ensures only true hazards are flagged, improving detection reliability.

6 On-Device Alert System

- **Visual Alert:** On-screen pop-up or AR overlay showing hazard type and distance.
- **Audio Alert:** Spoken warning or distinctive sound to grab driver attention.
- **Context-Aware:** Timing adjusts based on vehicle speed and hazard distance to ensure relevance.

7 Duplicate Alert Suppression

- **Vehicle-side logic:** Tracks recently alerted hazards by ID or location in a short-term cache.
- If a new alert matches one given in the last 5 minutes, it is ignored.
- Prevents multiple cars broadcasting the same hazard from spamming alerts.
- Cloud-side logic ensures that the same user does not receive multiple notifications for the same hazard within a specified timeframe.
- If both V2X and cloud deliver alerts, the app automatically deduplicates them.

8 Automated Data Sharing (Dual Mode)

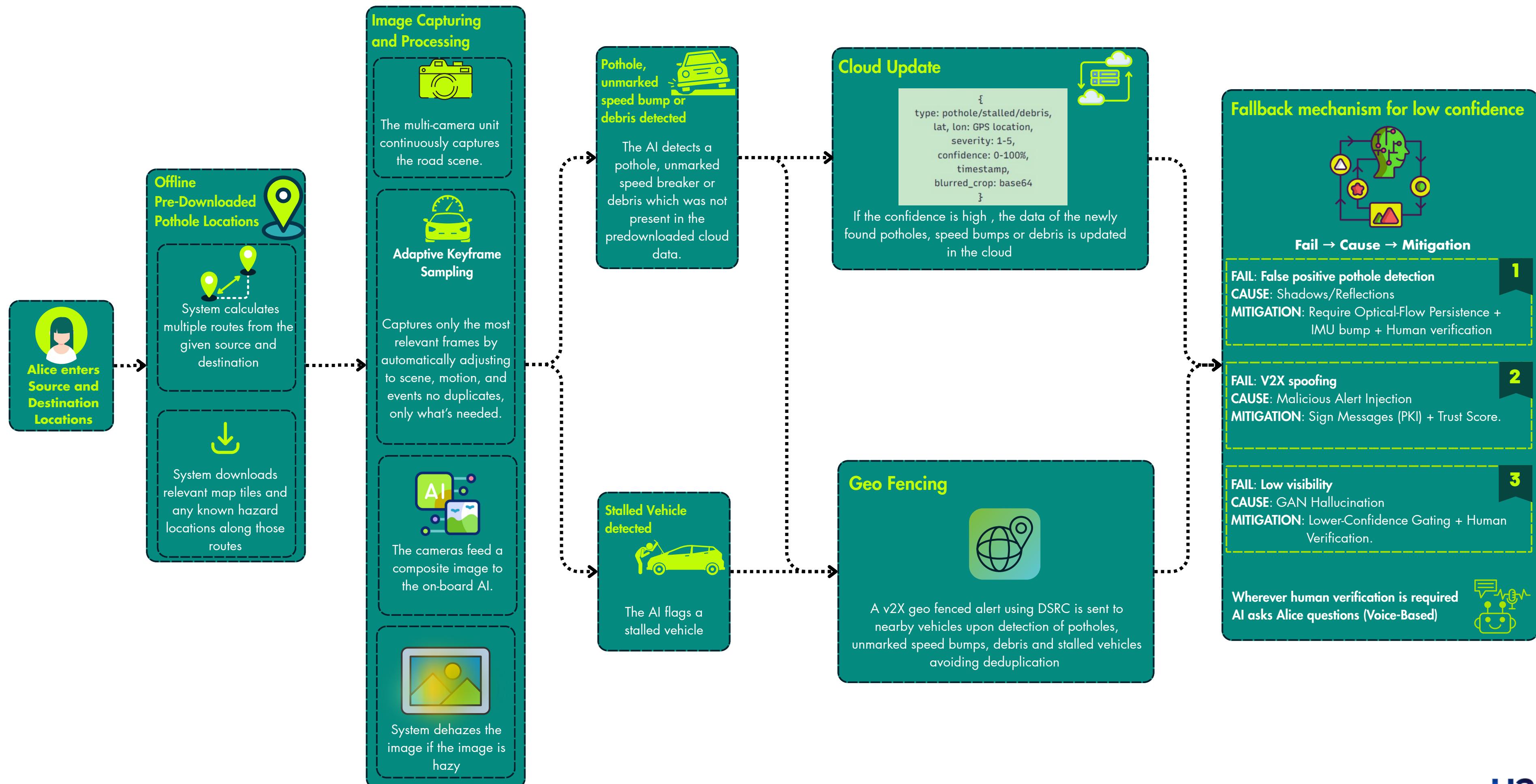
- **V2X Broadcast:** Sends hazard info to nearby vehicles (300–500m) using DSRC/C-V2X and standard format (DENM).
- **Cloud Upload:** Sends hazard ID, location, type, blurred image via HTTPS/MQTT. Minimal data allows 3 G transmission or patching later.

9 Cloud-Based Hazard Aggregation

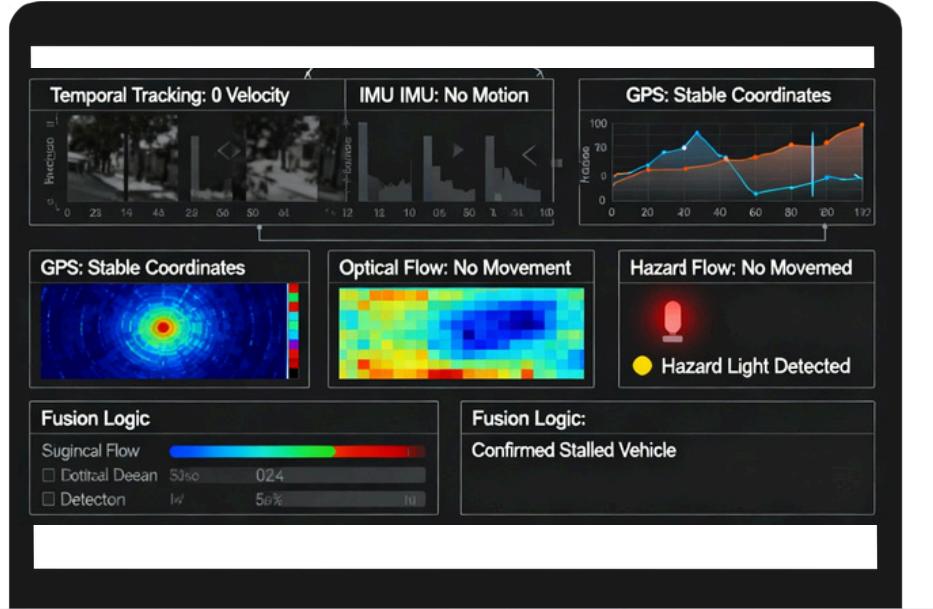
- **Clustering & Filtering:** Groups hazard reports by location and time to remove duplicates and flag unverified hazards.
- **Hazard Database & Map:** Maintains real-time info on hazards, including status (active/fixed/verified), severity, last seen, and number of confirmations.
- **Swarm Verification:** Confirms hazards after 2+ independent reports; critical hazards can trigger alerts immediately.
- **Distribution:** Pushes verified hazard info to approaching drivers as a backup to V2X, ensuring long-range awareness and safety.

10 Offline Hazard Caching

- If a destination is set, the app can download hazard info along the route.
- Works even if connectivity drops, ensuring drivers still receive alerts.
- Uses predictive caching of map tiles and hazard points (similar to offline Google Maps).
- Provides continuous service in low-signal or offline areas.



Real-Time Detection & Fusion Logic (Edge AI Dashboard)



- **Temporal Tracking:** Monitors motion consistency detects stalled objects by zero velocity across frames.
 - **Inertial Measurement Unit (IMU) + GPS Stability:** Validates no ego movement drift; ensures positional accuracy.
 - **Optical Flow Map:** Confirms static or dynamic scene via pixel flow heatmap.
 - **Fusion Logic:** Combines optical flow, IMU, GPS, and visual detections to eliminate false positives.
 - **Hazard Detection:** Detects signal pattern changes e.g., blinking tail lights or obstacle persistence.
 - **Output:** “Confirmed Stalled Vehicle” or “Pothole Detected” with severity confidence.
 - **Multi-sensor fusion filters noise from raw detections** → ensures high-confidence, low-latency hazard classification before any alert broadcast.

Connected Cloud & V2X System Tabs

Edge Alert Broadcast:

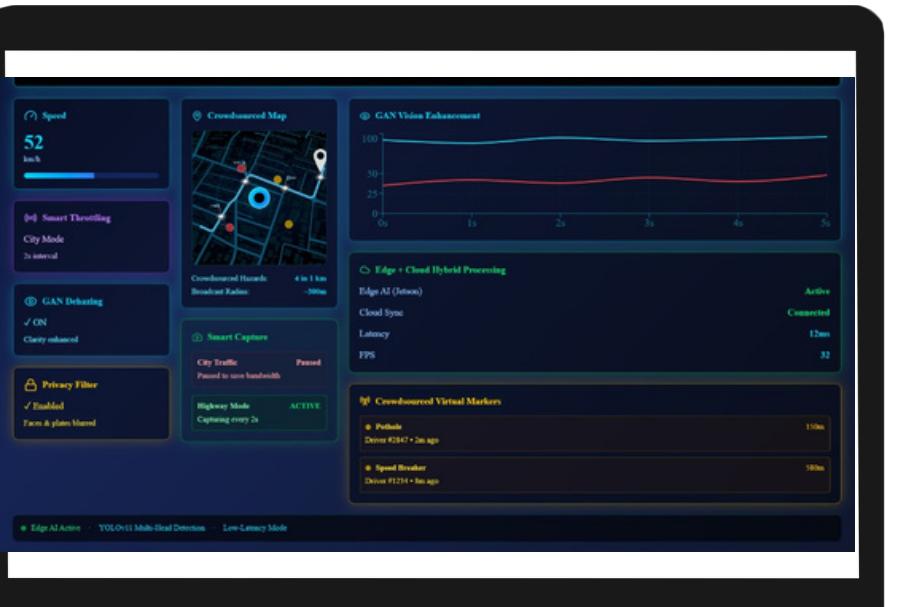
- Instantly shares verified hazards via **DSRC/C-V2X (DENM)**
 - Local alerts < 100 ms, even offline

Features:

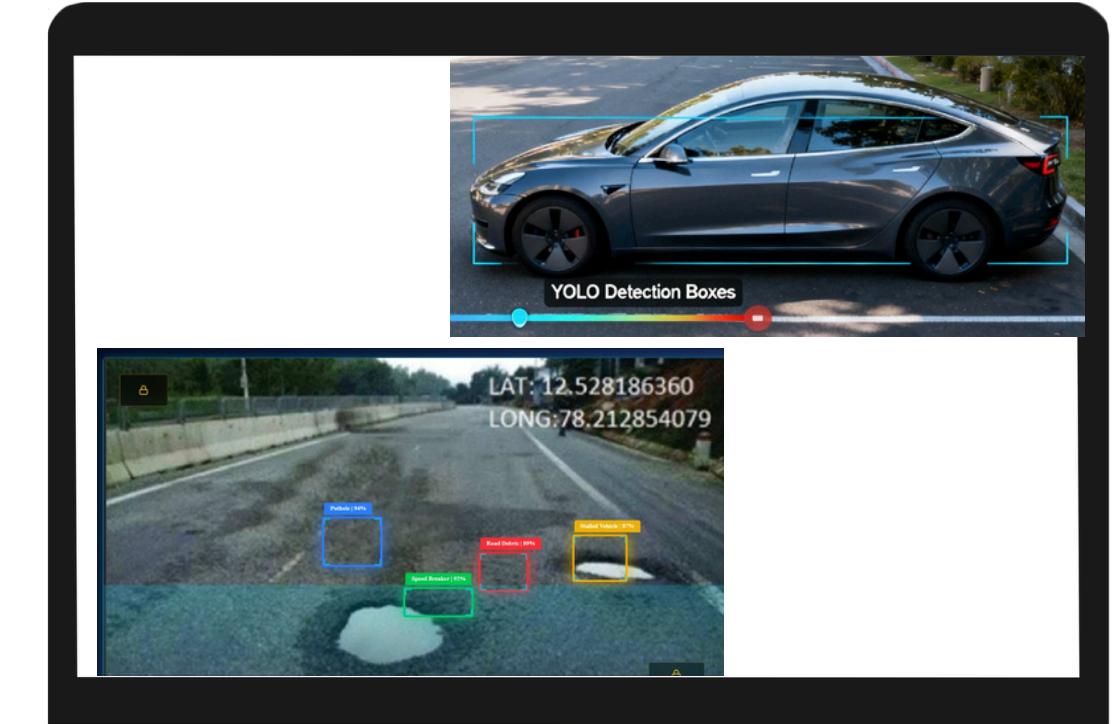
- **GAN-Based Image Enhancement:** Low-quality or low-light frames are auto-enhanced using a GAN dehazing module, ensuring reliable hazard detection in fog, rain, or night-time.
 - **Duplicate Detection via Clustering:** The cloud backend performs spatial-temporal clustering of hazard events using GeoHash + timestamp proximity, merging multiple reports of the same object.
 - **Smart Notification & Caching Engine:** Adaptive logic prevents repeated alerts for the same hazard using on-device caches and cooldown windows, while geofenced caching enables offline alerts in poor connectivity zones.

Benefits: [View Details >](#) [Call 800-345-2222](#)

- **Duplicate Detection via Clustering:** The cloud backend performs **spatial-temporal clustering** of hazard events using **GeoHash + timestamp proximity**, **merging multiple reports** of the same object.
 - **Smart Notification & Caching Engine:** Adaptive logic **prevents repeated alerts** for the same hazard using **on-device caches** and **cooldown windows**, while geofenced caching **enables offline alerts** in poor
 - **Higher Detection Confidence:** GAN enhancement improves visual clarity, boosting model accuracy in adverse conditions.
 - **Reduced Network Load:** Event clustering and deduplication minimize redundant transmissions and cloud storage use.
 - **Consistent, Noise-Free Alerts:** Cached and geofenced logic ensures drivers receive only fresh, route-relevant warnings.



Hazard Classification and Geotagging Pipeline



Features

- **Multi-Head Object Detection:** DEIMv2 identifies potholes, debris, and stalled vehicles within ~10 ms.
 - **Confidence Tagging:** Each object includes label + confidence score.
 - **GPS Geotagging:** Auto-embeds lat-long, heading & timestamp per frame.
 - **On-Device Privacy Filter:** Blurs faces & license plates before sharing.
 - **Light JSON Alerts:** Packs hazard type, severity & coordinates for fast V2X/cloud sync.
 - **V2X-Ready Output:** Generates standardized hazard messages ready for DSRC/C-V2X broadcast.

Benefits

- Accurate, Real-Time Awareness:** Real-time hazard detection improves driver response.
 - Precise Localization:** GPS data pins hazards precisely on map.
 - Privacy & Compliance:** No personal data ever leaves the device.
 - Low Latency, High Efficiency:** Lightweight packets cut network load.

References

DEIMv2 (Object Detection Backbone)

- Huang, S. et al. (2025). Real-Time Object Detection Meets DINOv3. arXiv:2509.20787.
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Adaptive Keyframe Sampling (AKS)

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[PDF](#)

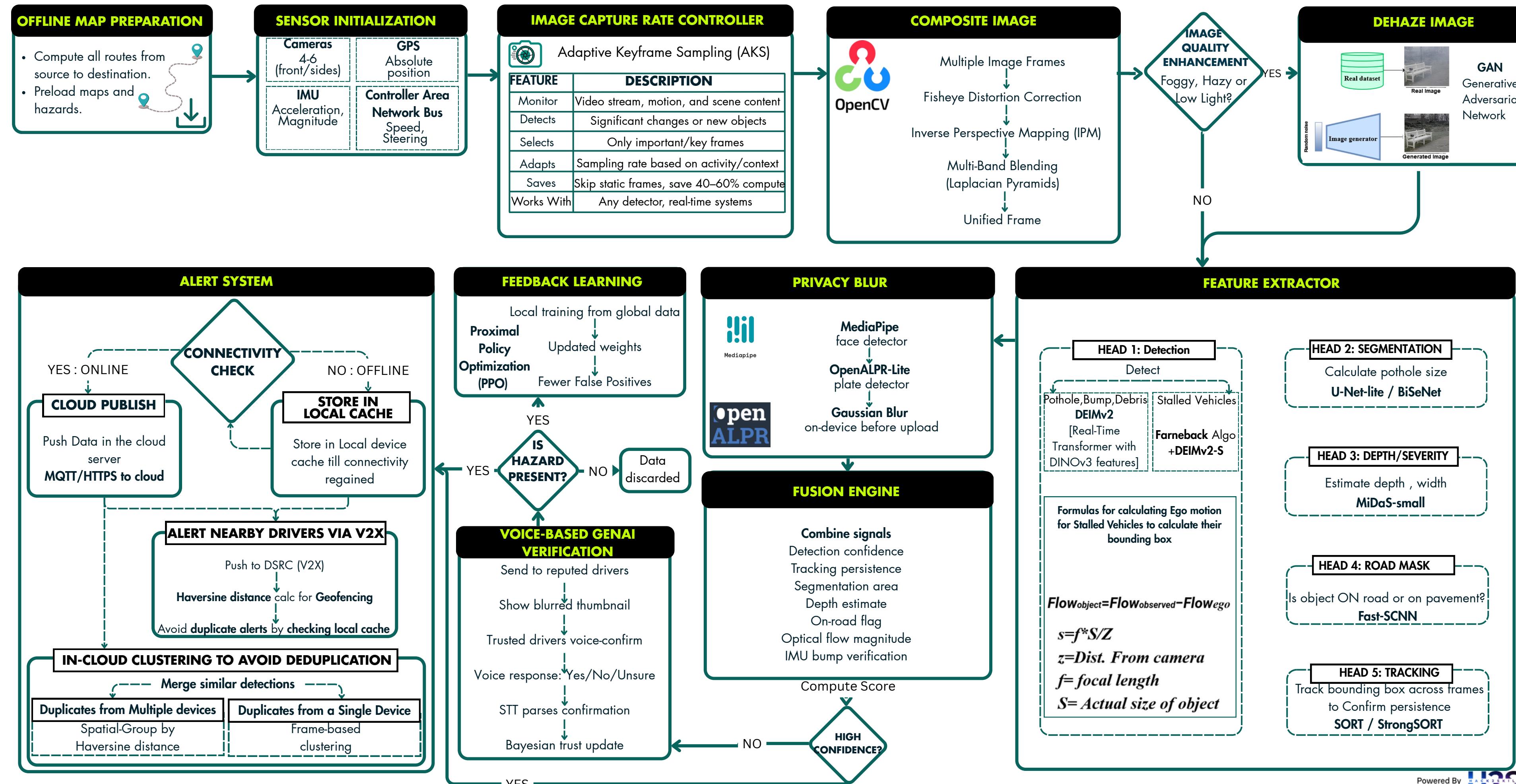
Segmentation Multi-Heads

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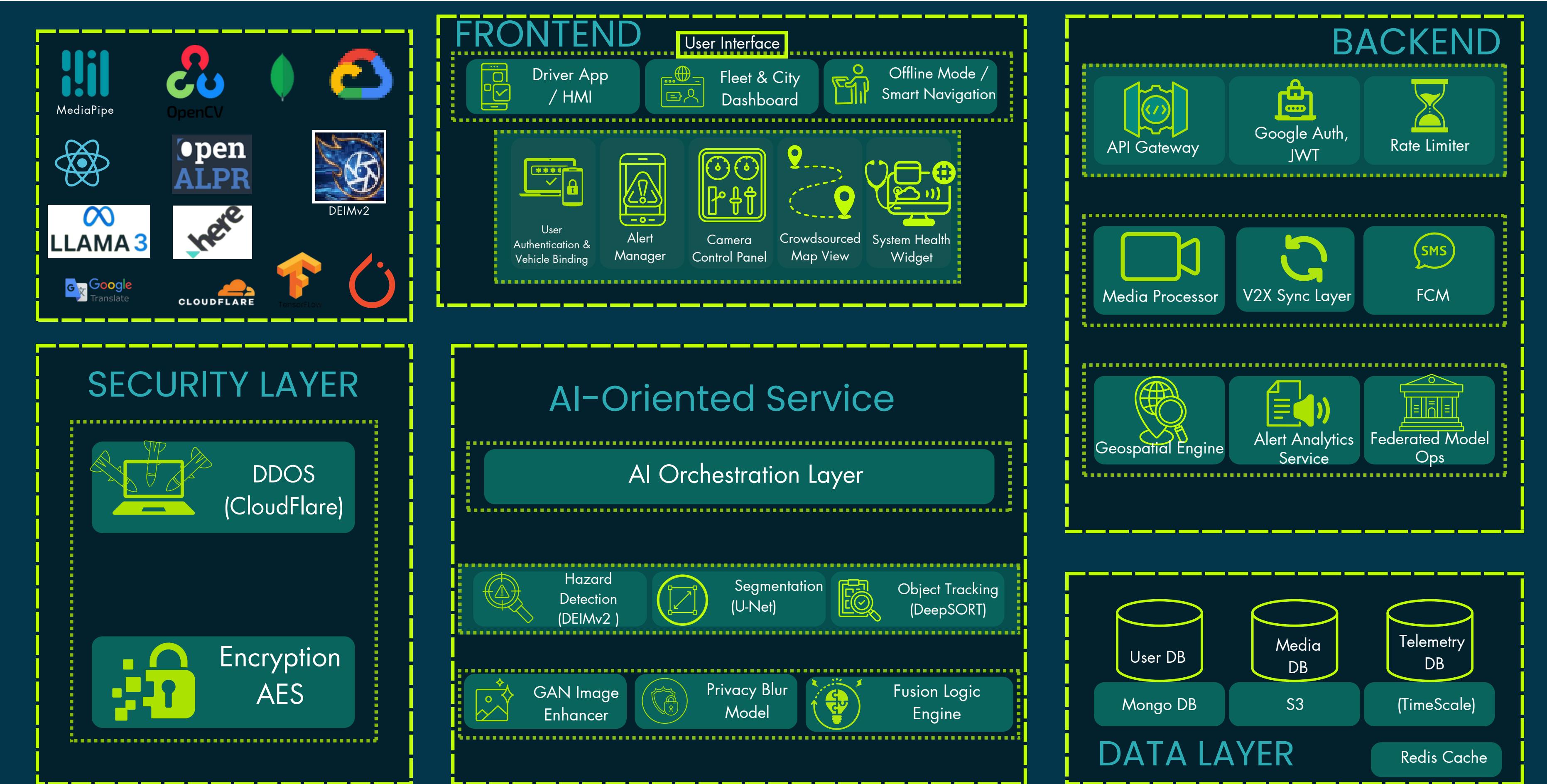
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Architecture Diagram



Technologies To Be Used In The Solution



Estimated Implementation cost





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