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Motivation

- Fleet management companies lose about \$300,000/year due to vehicle downtime from accidents and delayed service [1]
- In 2017, fleet accidents in US cost employers \$59 million in losses [2]
- Distracted driving is the leading cause of vehicle crashes, present in over 50% of accidents [3]
- Fleet managers struggle to monitor and promote safe driving behaviours
- Many fleet companies ignore this significant safety and financial liability

Objective

- Design an all-in-one platform that provides analytics on driver behaviour and vehicle state and diagnostics
- Provide fleet managers with increased visibility into fleet operations with an intuitive platform
- Help reduce accidents and vehicle downtime

Design Alternatives

On-Board Vehicle Diagnostics: Initially tried using a Particle Boron LTE-M, featuring a built-in sim card, but had very limited data and data transmission speeds. Transitioned to using an ESP32 board with built-in WiFi, connected to the OBD-II via UART. This improved our costs, size, complexity, and performance.

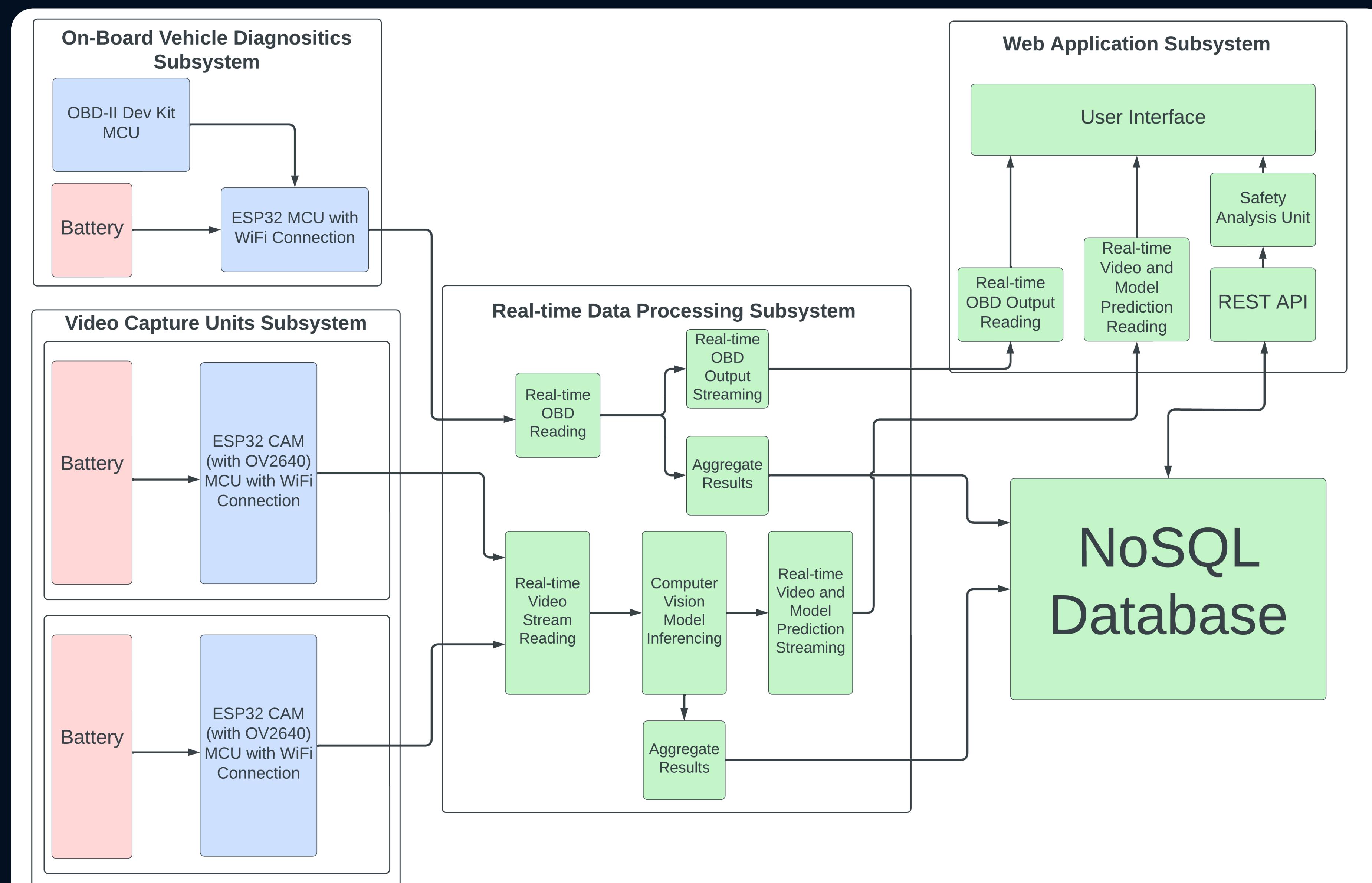
Face Feature Detection: Started by using OpenCV Haar Cascades for detecting eyes and mouth, but required multiple passes and was too slow. Switched to Dlib facial landmark detection for more accurate and faster feature extraction.

AI Models: Transitioned from fully custom CNN models (MoileNet V2/V3 and EfficientNet) to a pretrained CLIP-based approach, boosting speed and accuracy.

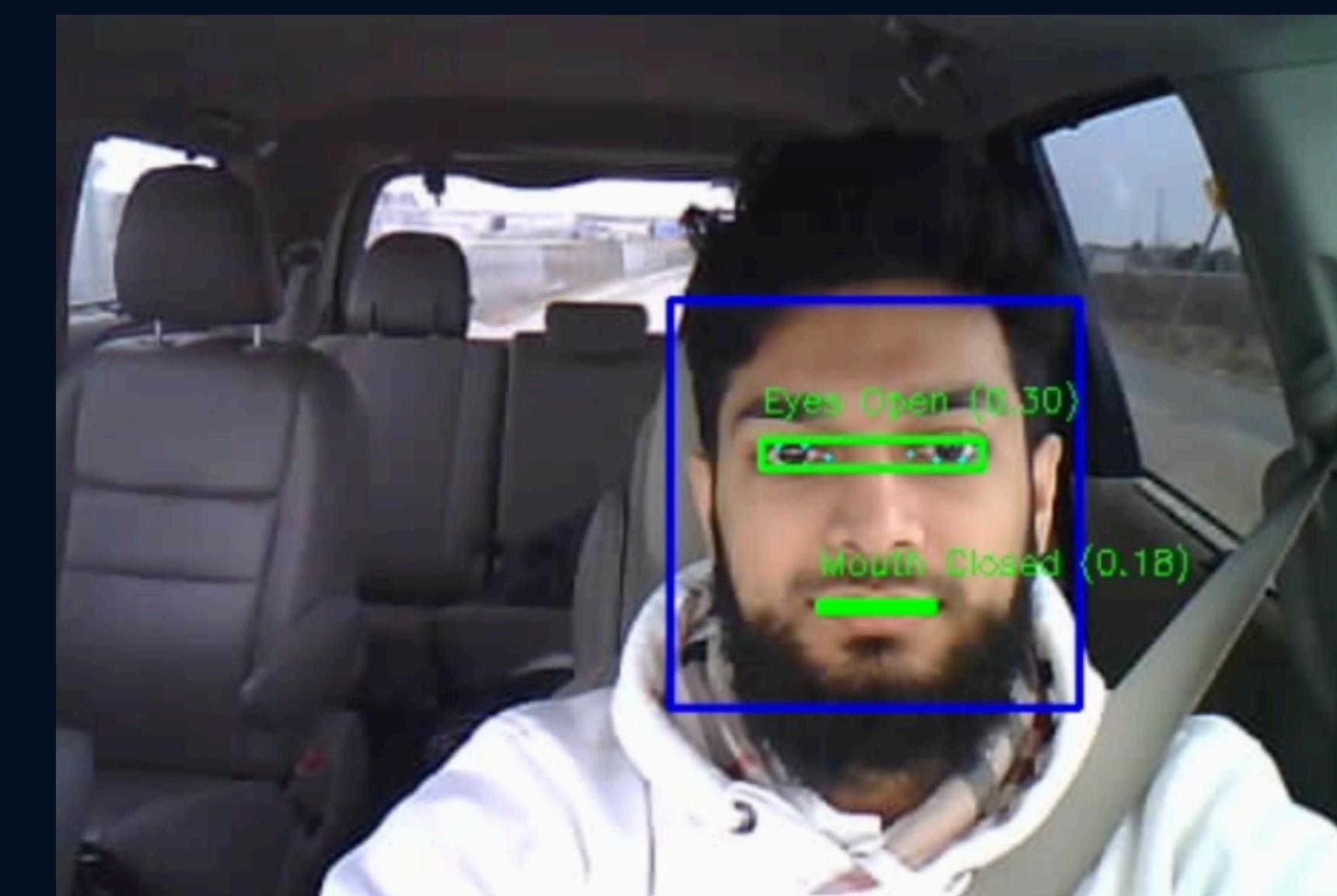
Data Synchronization & Streaming: First approach was using cloud-hosted processing, but faced IP assignment issues. Switched to using mDNS for ESP32 local discovery and ngrok for stable remote connections.

Body & Face Cameras: Tested with both AI-Thinker and Wrover ESP32-CAM boards, but Wrover boards would slow down after continuous use. AI-Thinkers featured antenna add-ons for better performance and size.

System Architecture



Analysis Results



Face Stream Image Annotated
with EAR and MAR



Body Stream Image Annotated
with Classification

Model Classifications

Face Stream Classifications:

- Eyes (open or closed)
- Mouth (whether they are open or closed, in order to detect yawning)

Body Stream Classifications:

- Driving safely
- Drinking or eating
- Adjusting hair or makeup
- Talking on phone
- Reaching beside or behind
- Talking to passenger
- Texting or using phone
- Yawning

Features

Hardware Components:

- AI Thinker ESP32-CAM (OV2640 camera)
- OBD-II CAN Bus GPS Dev Kit - Longan Labs
- ESP-WROOM-32 (WiFi + BT)

Software Components:

- OpenCV image processing
- Eye Aspect Ratio and Mouth Aspect Ratio
- Server-Sent Events for real-time data transmission
- UART communication between OBD-II and ESP32
- HTTP POST real-time data transmission
- PyTorch ML models for image classifications
- CLIP Vision Transformer for body stream processing
- Firestore NoSQL database
- REST API for database interaction
- Safety Analysis for driver behaviour evaluation

Competitive Advantage

- All-in-One Platform: Captures both driver behaviour and vehicle health in one interface, unlike most existing solutions that split these into separate systems
- Real-Time Alerts and Analytics: Delivers real-time notifications on unsafe driving and vehicle issues, whereas many competing tools only offer post-trip reports
- User-Friendly Management: Presents comprehensive metrics through an easily accessible web app, simplifying oversight for fleet managers

References

- [1] "What is the true cost of vehicle downtime in your fleet?," CerebrumX, [Online]. Available: <https://cerebrumx.ai/what-is-the-true-cost-of-vehicle-downtime-in-your-fleet/>
- [2] Fleet Owner Staff, "Vehicle accidents cost companies \$57B in 2017," FleetOwner, [Online]. Available: <https://www.fleetowner.com/safety/article/21702332/vehicle-accidents-cost-companies-57b-in-2017>
- [3] "Understanding the problem," NHTSA, [Online]. Available: <https://www.nhtsa.gov/book/countermeasures-that-work/distracted-driving/understanding-problem>