Team Name : Virtus Synergia

Team Leader Name : SUJESH V

Problem Statement : AI-Enhanced Driver Wellness Monitoring

Brief about the Idea:

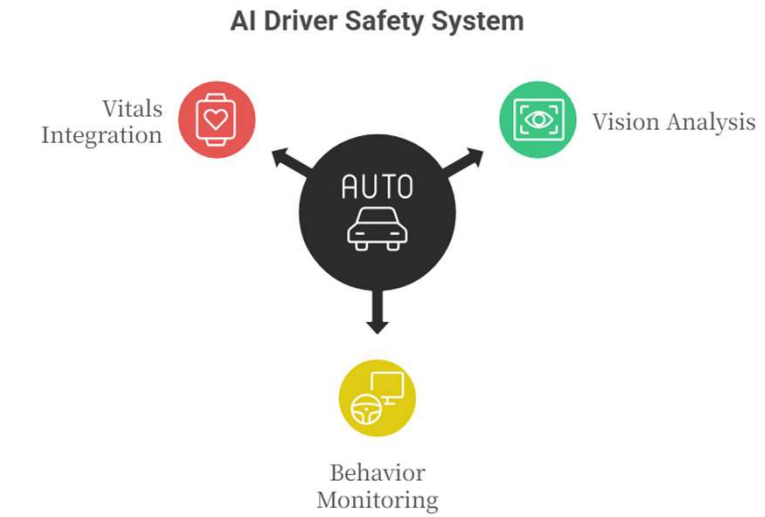
Our solution is a **privacy-first, multi-modal AI co-pilot** designed to enhance driver safety by continuously monitoring **fatigue, stress, and distraction** in real time.
The system fuses three complementary data streams:

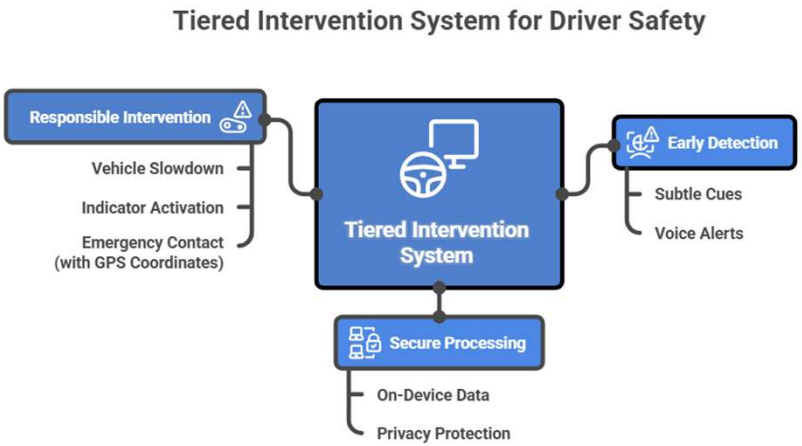
- **Vision (Camera):** Tracks facial landmarks such as **eye closure (PERCLOS)**, **gaze direction**, and **yawning** to detect drowsiness.
- **Behavior (Vehicle):** Monitors **steering wheel activity** (via potentiometer sensor) to identify erratic or inactive driving patterns.
- **Vitals (Wearable):** Integrates with a **smartwatch or simulated sensor** to measure **heart rate and stress indicators**.

All processing is done **locally on the edge device (Raspberry Pi 4)** — ensuring **privacy-first analysis** without cloud dependency. For optional fleet analytics, any shared data is **anonymized and face-blurred**, guaranteeing complete driver identity protection.
When risk is detected, the **Tiered Intervention System** automatically activates:

- Subtle audio or visual cues to regain driver attention.
- Voice-based alerts prompting rest or focus.
- Intelligent assistance (e.g., **vehicle slowdown**, **indicator activation**, and **emergency contact notifications with GPS**).

This multi-modal, on-device approach ensures **early detection**, **secure processing**, and **responsible intervention**, significantly reducing fatigue-related road accidents.



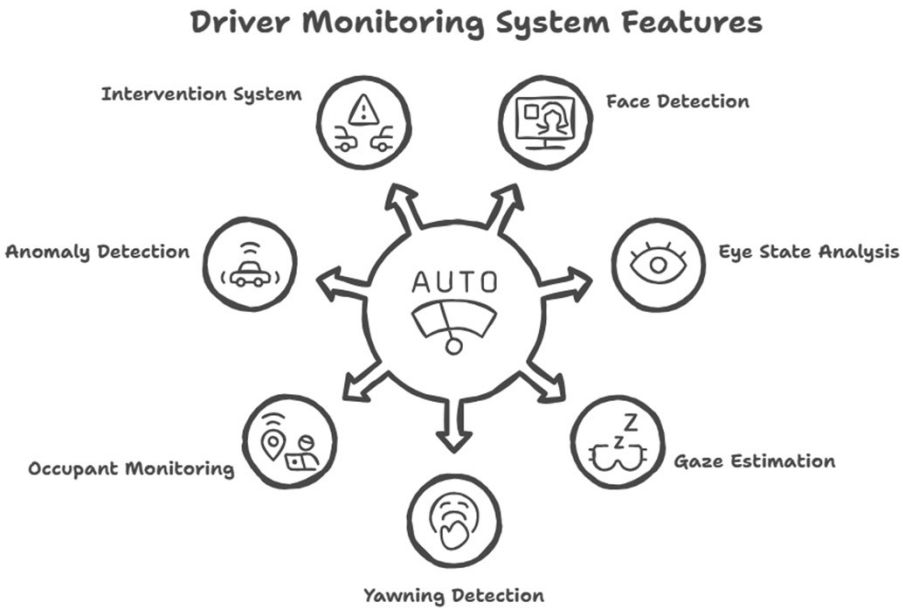


Opportunity should be able to explain the following:

- **Privacy-first, multi-modal AI co-pilot** that fuses data from vision, steering behavior, and vitals to monitor driver wellness in real time.
- Detects **fatigue, distraction, and stress** early, enabling proactive accident prevention.
- Ensures **consistent performance** across all conditions — day, night, or when the driver's face is partially covered.
- Executes **on-device edge processing** on Raspberry Pi, guaranteeing **data privacy, low latency, and offline functionality.**
- Integrates **a tiered intervention system** with escalating responses — from subtle alerts to **automatic vehicle control and GPS-based emergency notifications.**
- Uses **lightweight AI models** (MediaPipe, TensorFlow Lite) optimized for low-power, embedded systems.
- Employs **face-blurring and anonymization** for any optional analytics, maintaining privacy even in fleet environments.
- Designed for **low-cost scalability**, making it feasible for **commercial fleets, personal vehicles, and public transport.**
- Provides a **holistic safety net** that combines intelligent detection, real-time decision-making, and human-centered intervention.

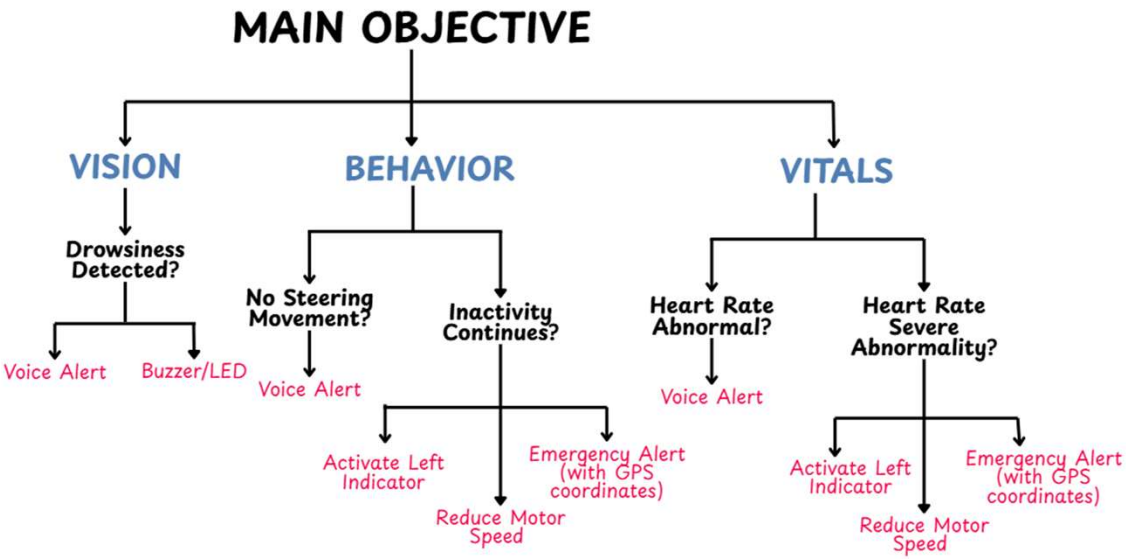
List of features offered by the solution:

1. **Face Detection**: Detects and aligns faces using Medium pipe and opencv.
2. **Eye State / Blink Analysis:** Computes PERCLOS and uses a CNN to classify eye state.
3. **Gaze & Head Pose Estimation:** Tracks head orientation to detect prolonged downward gaze.
4. **Yawning Detection:** Uses a sequence-aware model to distinguish yawns from talking.
5. **Occupant Monitoring:** Detects phone use and hands-off-wheel behavior.
6. **Driving Anomaly Detection:** Monitors steering wheel data via OBD-II to detect erratic movements and lane weaving, acting as a non-visual confirmation of fatigue or stress.
7. **Tiered Intervention System:** Four-level alert system that escalates from subtle chimes to proactive voice guidance (e.g., “Please Take a break & Calm Down") using TTS and Maps APIs.



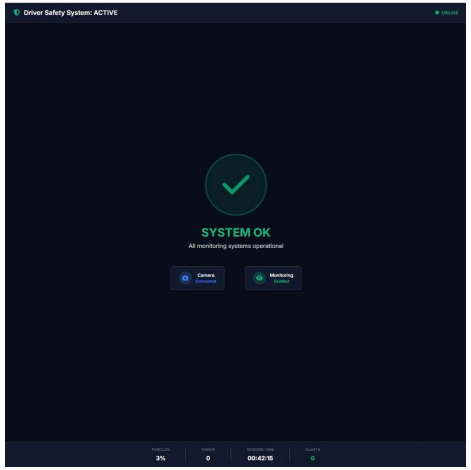
Process flow diagram or Use-case diagram:

1. **Data Collection:** The system continuously collects parallel streams of data from the cabin camera, the vehicle's steering wheel, and an optional wearable (smartwatch).
2. **Edge Compute Processing:** All data is processed locally on the edge device. This includes video preprocessing, running AI perception models, and fusing all sensor data.
3. **Decision Engine:** The fusion engine weighs the inputs and makes a real-time decision on the driver's state (Alert, Drowsy, or Stressed).
4. **Trigger Intervention:** If a high-risk state is confirmed (e.g., high PERCLOS + steering anomaly), the system triggers the appropriate-level alert from the Tiered Intervention System.
5. **Feedback Loop (Cloud):** For fleet customers, the system sends a 100% anonymized, face-blurred data packet (e.g., 'Drowsy event, 10:30 PM, Hwy 44') to the cloud for long-term analytics and model improvement.

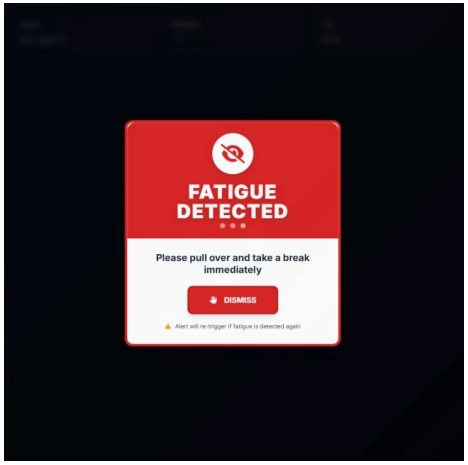


Wireframes/Mock diagrams of the proposed solution

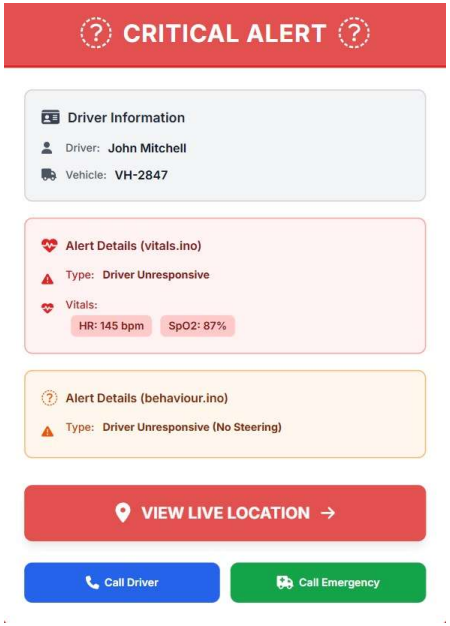
1. The Main Dashboard (Calm State)



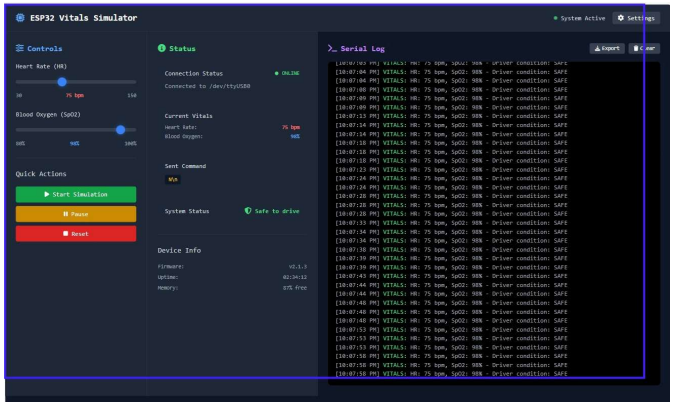
2. Fatigue Alert (Microsleep)



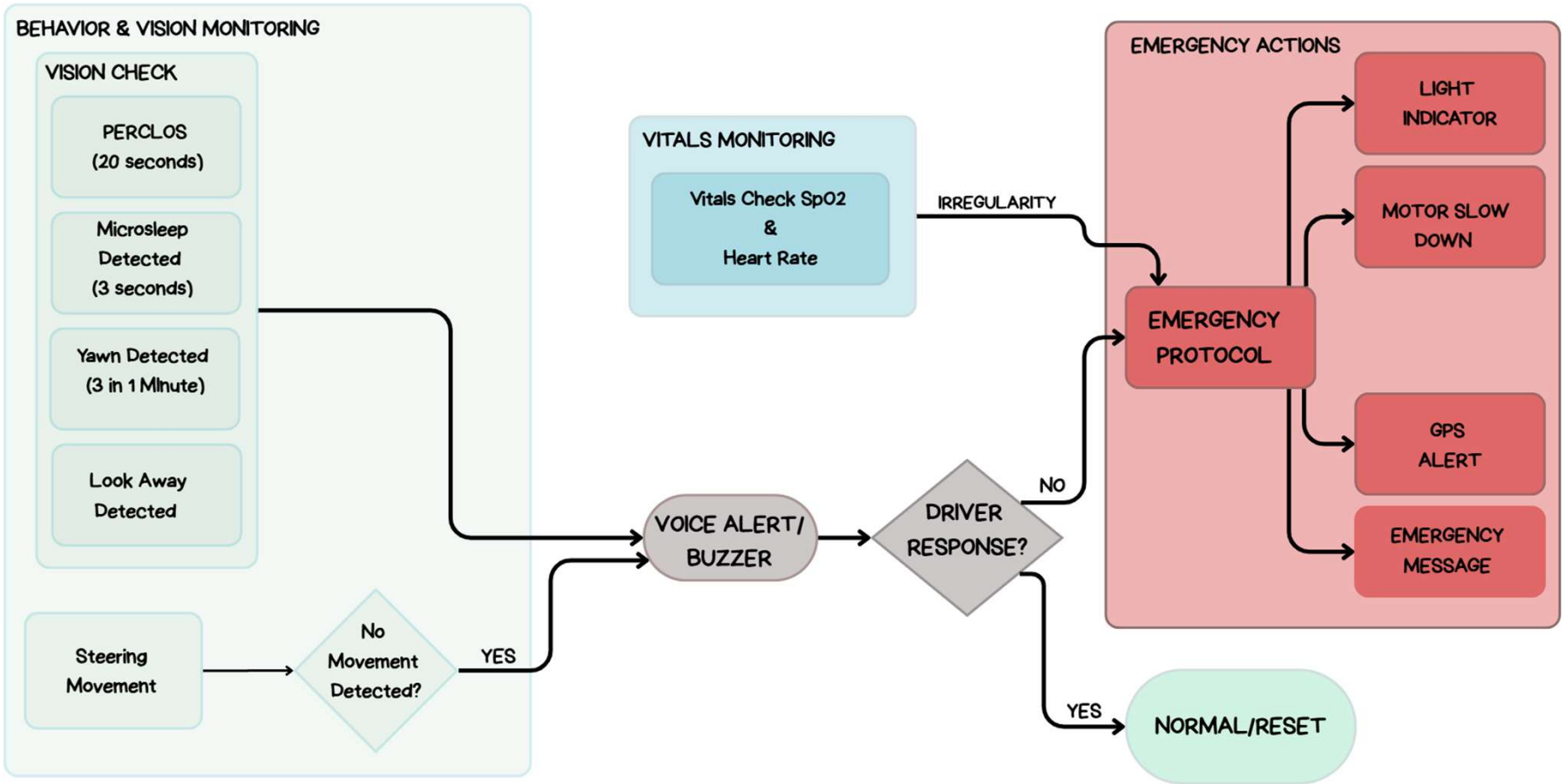
3. The Emergency Alert (Incoming)



4. The Developer/Tester Control Panel



Architecture diagram of the proposed solution



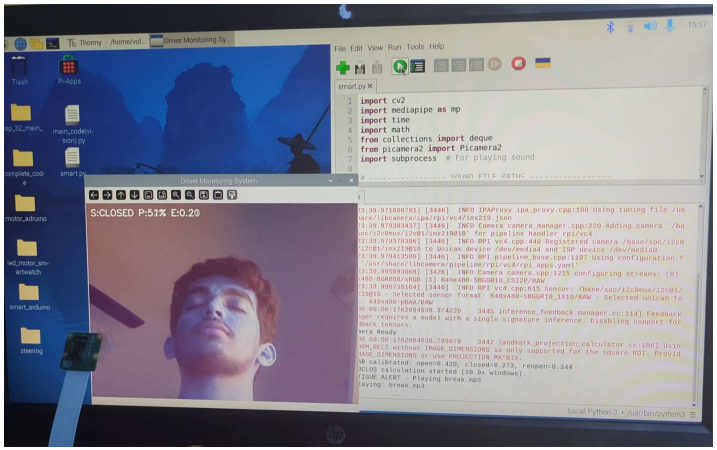
Technologies to be used in the solution:

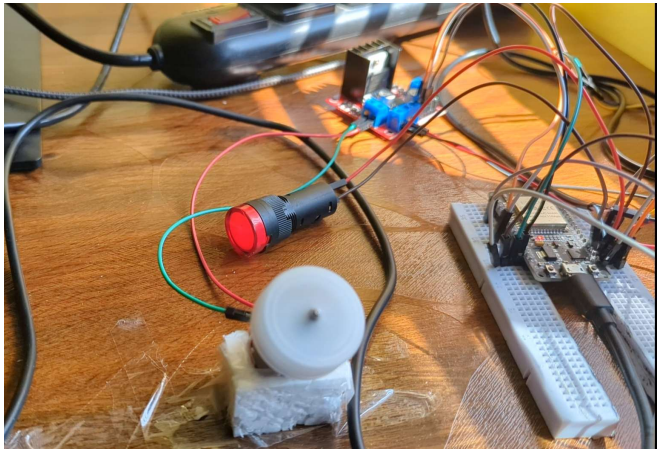
- **Hardware (Edge Compute):**
  - Raspberry Pi 4
  - Raspberry Pi Camera Module v2
  - 10k rotatory potentiometer
  - DC Motor
  - Motor Driver Module
  - Neo-6M GPS Module
  - ESP32
  - Micro SD card
  - Buzzer
  - LED Indicator
- **Software & AI Models:**
  - Python
  - OpenCV
  - Mediapipe
  - Arduino IDE
  - Tkinter
  - Pyserial
- **APIs & Cloud Services:**
  - Twilio APIs
- **Development Tools:**
  - GitHub: For version control.

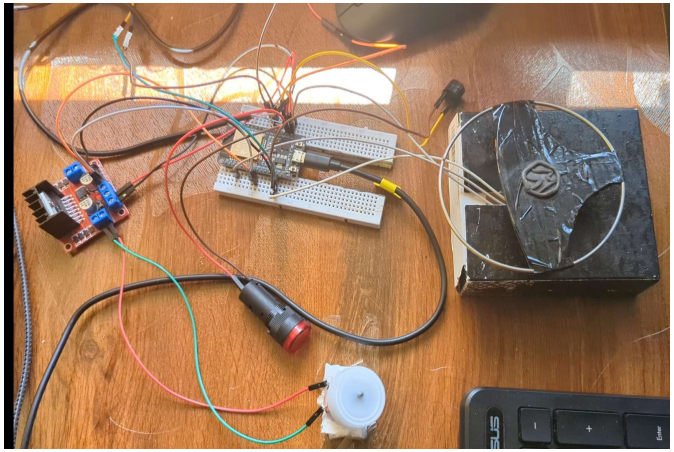
Estimated implementation cost (optional):

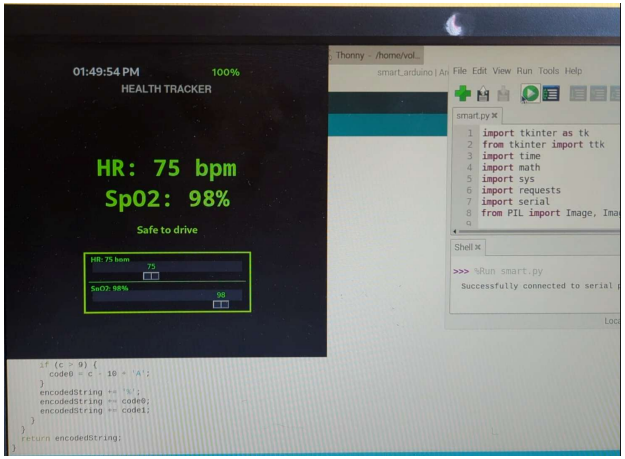
Cost Component	Estimated Cost (INR)	Key Points
Hardware	₹8,000 – ₹10,000	▪ Covers essential hardware for development and testing. ▪ Includes a device like a Raspberry Pi for edge computing, a quality webcam, and a smartphone mount.
Cloud Services & APIs	₹0 – ₹1,000	▪ This cost is allocated specifically for Twilio API usage (e.g., for sending SMS alerts). ▪ The budget suits Twilio's pay-as-you-go model, with free tiers covering initial testing.
Miscellaneous	₹0 – ₹2,000	▪ A small buffer for unforeseen expenses, online course materials, or minor subscriptions.
Total Estimated MVP Cost	₹8,000 – ₹13,000	▪ This represents a realistic, lean budget to get a functional and impressive prototype ready for a hackathon or university project.

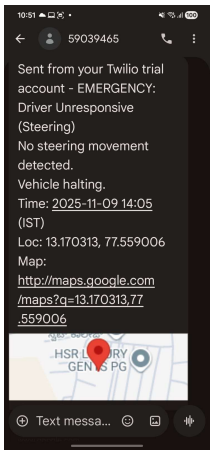
Snapshots of the Prototype

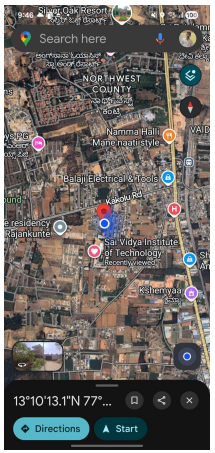




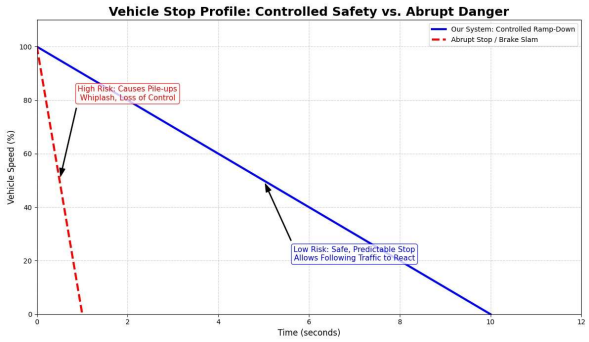


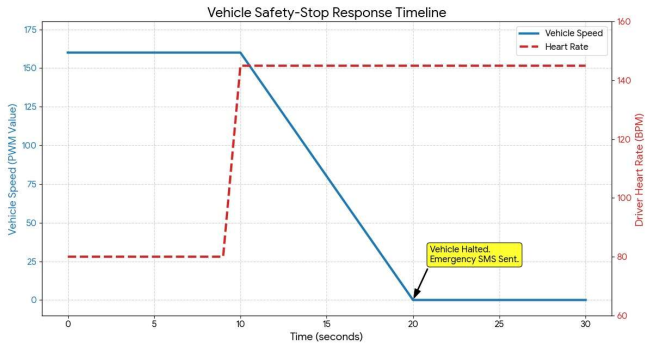






Prototype Performance report/Benchmarking





Feature	Drowsiness detection in real-time via convolutional neural networks and transfer learning , Salem & Waleed, 2024	A systematic review on detection and prediction of driver drowsiness , Md. Ebrahim Shaik, 2023	Our proposed solution
Eye state detection (open/closed)	✓	✓	✓
Blink detection (PERCLOS/MAR)	✓	✓	✓
Yawn detection	✓	✓	✓
Head pose / gaze estimation	✓	✓	✓
Steering / vehicle data fusion	✗	✗	✓
Physiological signals (heart rate, SpO2)	Rare / ✗	✗	✓
Multi-class drowsiness states (beyond binary)	✓	✓	✓
Real-time on-device processing	Limited / Partial	Limited	✓
Tiered intervention alerts	✗	✗	✓
Privacy-focused on-device inference	Limited	Limited	✓
Alert escalation (audio, SMS)	Basic alerting	Basic alerting	✓
Landmark detection	✓	✓	✓

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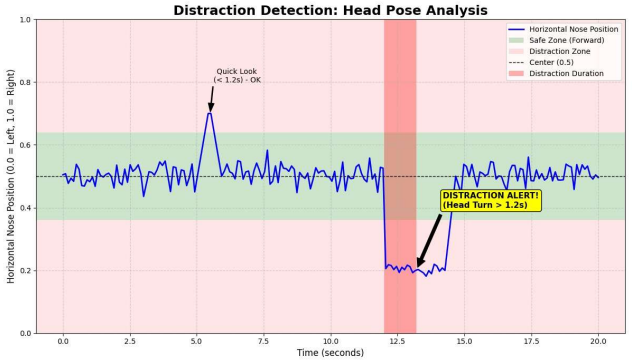

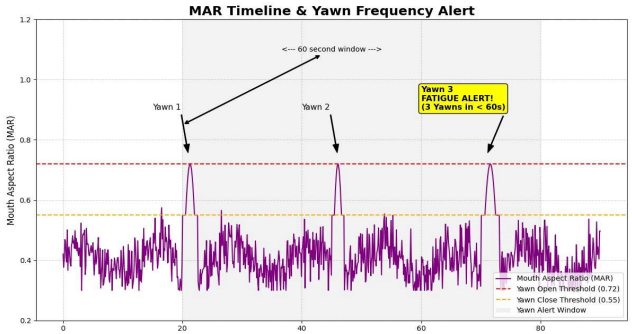

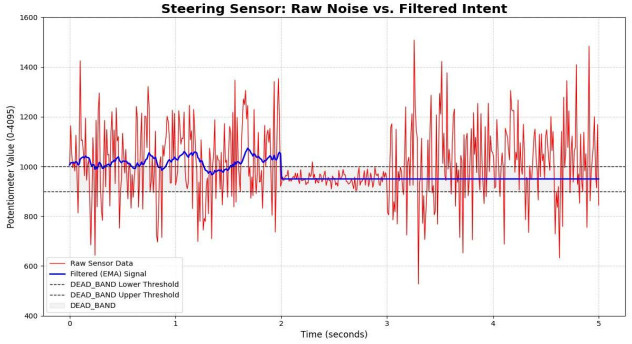

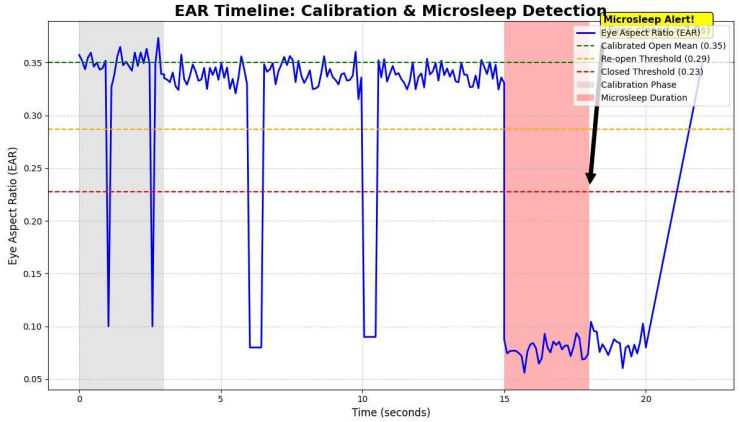

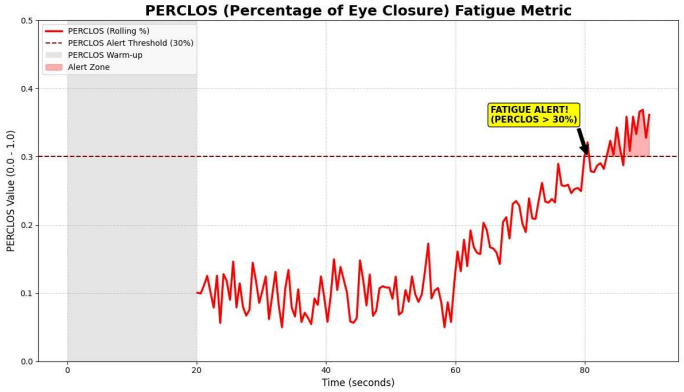

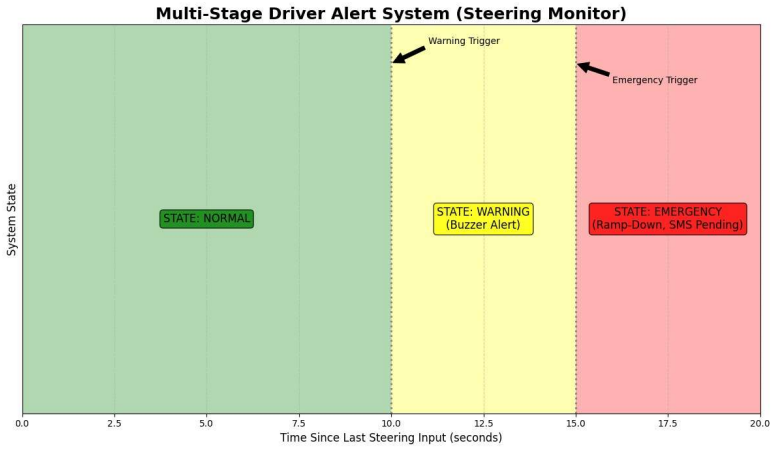

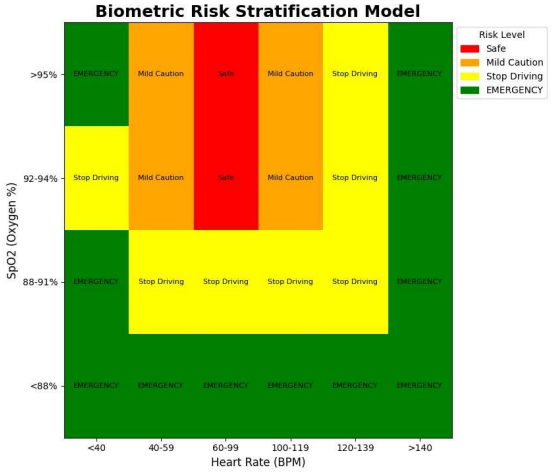

Additional Details/Future Development (if any)

Future Enhancements:

- **Direct Phone Integration:** Wireless connection enables automatic emergency contact with GPS location
- **Emergency Notifications:** Alerts sent to nearby emergency services and designated contacts
- **Multi-Modal Sensing:** Combines vision data with physiological signals(heart rate variability, skin conductance) and behavior (Steering movement)
- **Advanced AI:** Machine learning models for reducing false alarms and contextual awareness
- **Connected Safety Ecosystem:** Vehicle-to-Everything (V2X) communication to warn nearby vehicles of driver state
- **Privacy :** To protect user privacy, faces are automatically blurred before images are stored in the cloud.

Benefits:

- Improved real-world robustness with infrared cameras
- Personalized calibration for driver variability
- Integration with Advanced Driver Assistance Systems (ADAS)
- Fleet management support with data logging and analytics

GitHub & Demo video URL:

Live Explanation Link :
https://vimeo.com/1129246490?fl=ip&fe=ec

Prototype/ Demo Video URL -
https://vimeo.com/1135088291?share=copy&fl=sv&fe=ci

GitHub URL –
https://github.com/Sjsh007/imobilothon5.0-virtus-synergie


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