# Driver Monitoring System: Enhancing In-cabin Safety with AI-Powered Vision

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## 1. ABSTRACT

Driver Monitoring Systems (DMS) have garnered significant attention due to the growing demand for enhanced in-cabin safety and autonomous vehicle technologies.

This paper presents a comprehensive Driver Monitoring System (DMS) that leverages advanced AI and computer vision techniques to enhance in-cabin safety and reduce road accidents.

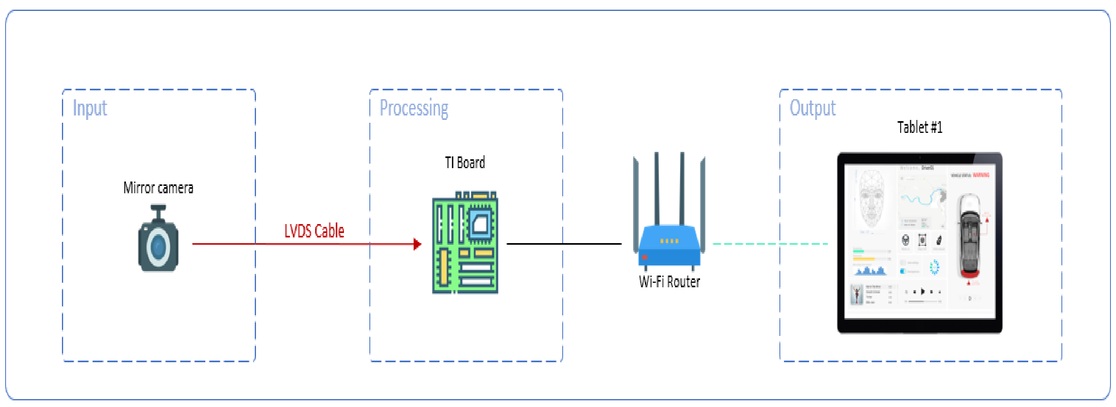
By integrating features such as drowsiness detection, behavior analysis, distraction detection, seatbelt compliance, and steering wheel interaction monitoring, the system addresses critical safety concerns in real-time.

Utilizing a single in-cabin camera, the DMS captures high-resolution images and processes them in real-time using advanced models like YOLOX, facial landmarks, and eye gaze estimation algorithms.

## 2. Architecture and Methodology

Main Components of the System

Architecture Topology




**1. Drowsiness Detection**

The drowsiness detection feature uses facial landmark models to assess the driver's alertness. It tracks eye openness and calculates thresholds for categorizing the driver as awake, drowsy, or asleep.

**2. Behavior Detection**

Using the YOLOX object detection model, the system detects relevant objects, including phones, cups, or food, within the predicted hand areas derived from body keypoints.

**3. Distraction Detection**

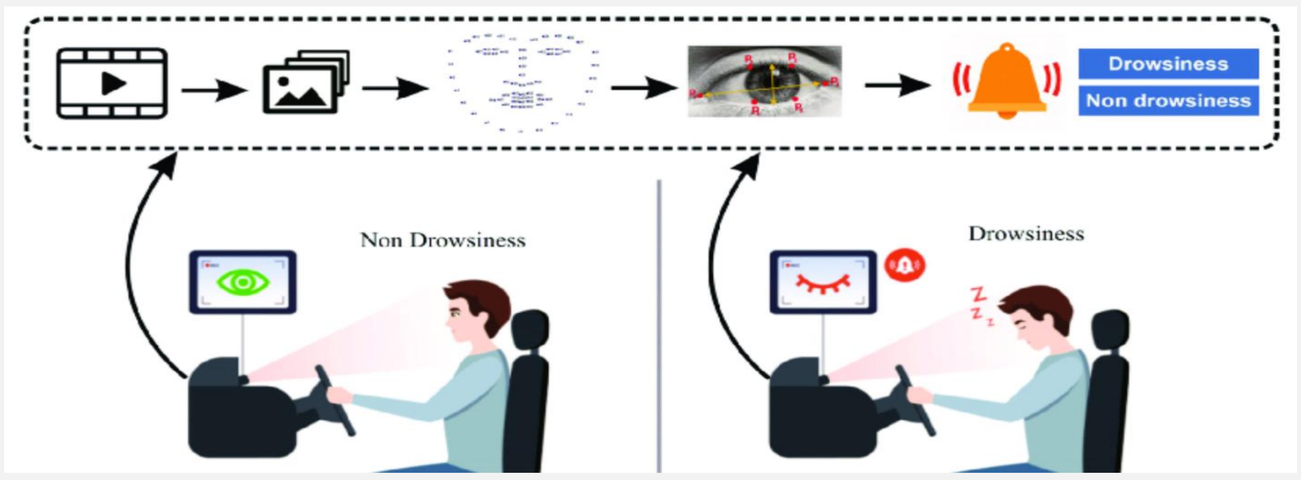
Distraction detection involves gaze estimation, eye estimation, and head pose analysis.

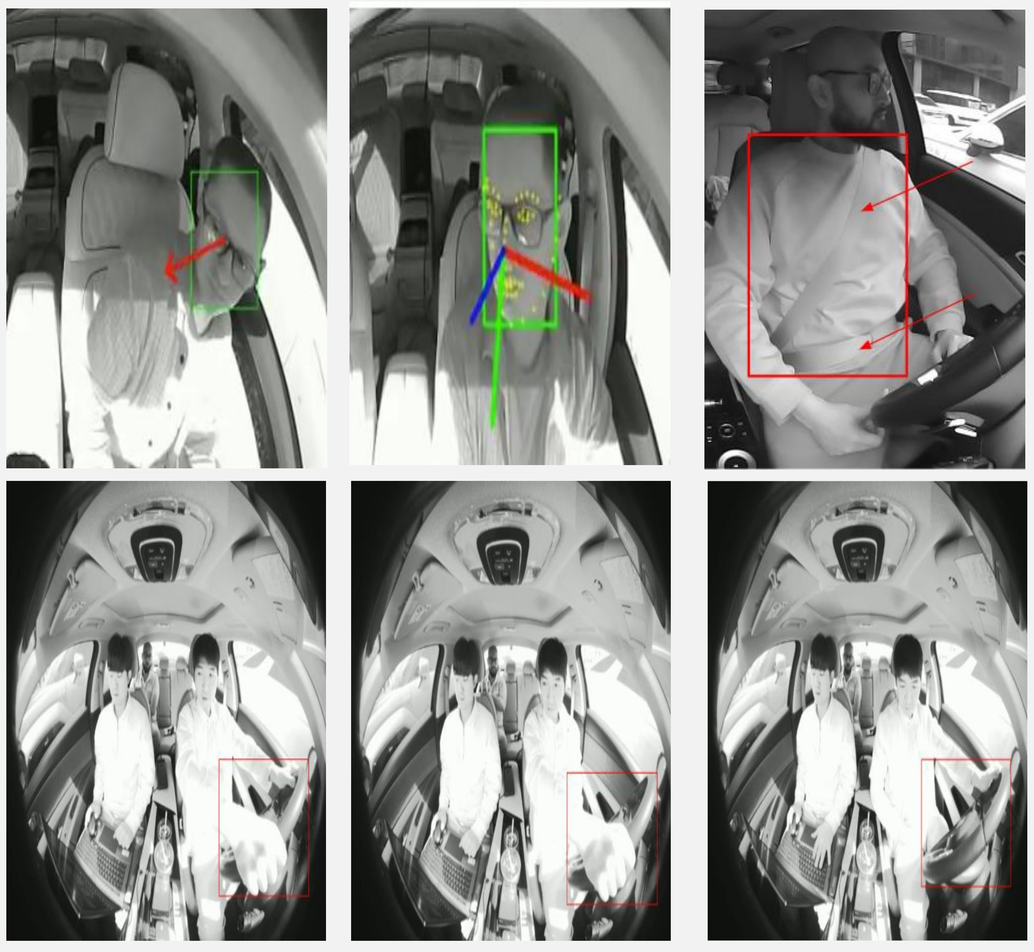
**4. Seat Belt Detection**

The system relies on YOLOX and ROI settings for precise the driver's seatbelt status based on the detection result of two classes: seat belt on, and seat belt off.

**5. Steering Wheel Interaction**

If the driver is detected, we will classify hand positions as both hands on, left-hand on, right-hand on, or hands off.



## 3. H/W setup and Dataset

- **Board details**: The TDA4VH is an automotive System-on-Chip (SoC) from Texas Instruments' Jacinto™ 7 processor family.
- Over **100,000 images** were collected in total, and they were annotated using various annotation tools.

| | ELP | Leopard |
|---|---|---|
| **Model name** | CMOS OV2710 | LI-OX05B1S-VCSEL-OMS-9295-200H |
| **Resolution** | 1920 x 1080<br>2MP | 2592 x 1944<br>5MP |
| **FPS** | 30 | 60 |
| **Chromaticity** | RGB / NIR | RGB - IR |
| **Field of View (FoV)** | 180° horizontal. | 200° horizontal |

## 4. Conclusion

The utilization of robust models like YOLOX and gaze estimation algorithms, coupled with a single in-cabin camera setup, ensures high accuracy and efficiency across diverse operational scenarios.

Robust methodologies and comprehensive datasets ensure system reliability across diverse lighting conditions, occlusions, and edge cases. Evaluation results demonstrate high accuracy rates.

Future work will focus on incorporating multi-camera systems and In-Cabin Monitoring Systems (**ICMS**) to extend its capabilities to include monitoring all occupants and their interactions within the vehicle cabin.