DRIVER MONITORING SYSTEM

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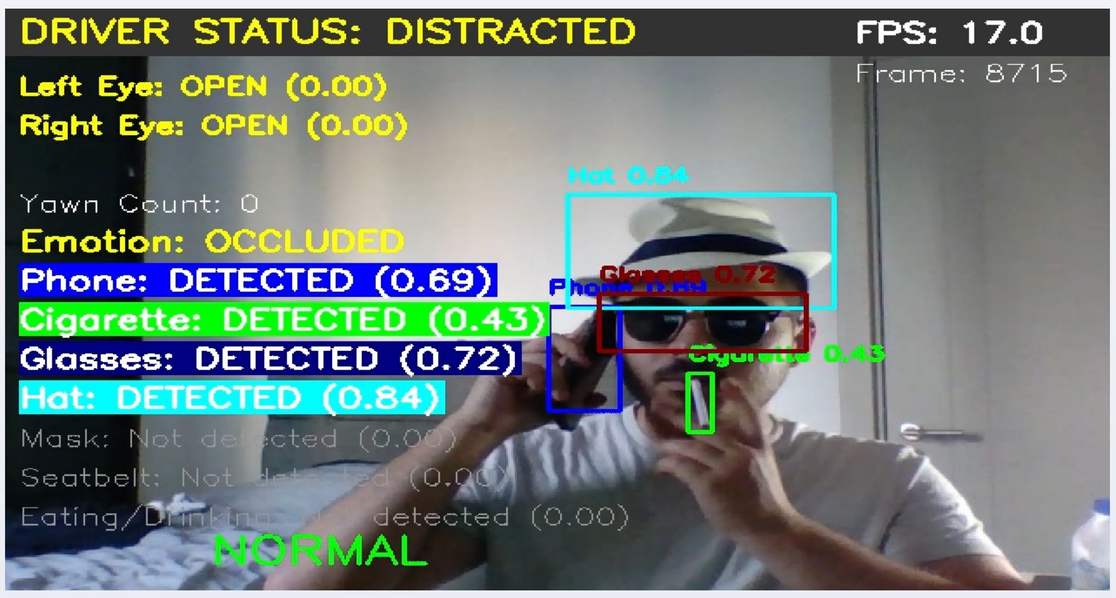
ABSTRACT



The project tries to develop a robust and camera-only Driver Monitoring System (DMS) to enhance road safety by detecting driver distraction and fatigue. It resolves critical issues contributing to traffic accidents, especially for Electric Vehicles, where energy efficiency and privacy are key. The problem addressed was the lack of accessible, efficient, and embedded DMS solutions capable of functioning reliably without additional sensors. The system identified a wide range of distractions (phone, cigarette, eating/drinking, glasses, hats, masks, seatbelt) and fatigue indicators (yawning, eye closure, pass-out) with high accuracy. A multi-signal fusion approach was introduced through the custom class to detect pass out situation.

The methodology highlighted real-time performance and privacy, where all models run locally on standard hardware (CPU) while minimizing energy consumption and eliminating expensive hardware requirements. The system was successfully tested in a simulated Linux-based environment. Our model achieves high object detection precision (e.g., average mAP@0.5 ~ 0.88115) and an adaptable architecture (both Python and C++) suitable for embedded deployment. The project demonstrates a scalable solution. Therefore, the project lays the groundwork for future integration in different real-world scenarios.

OBJECTIVES

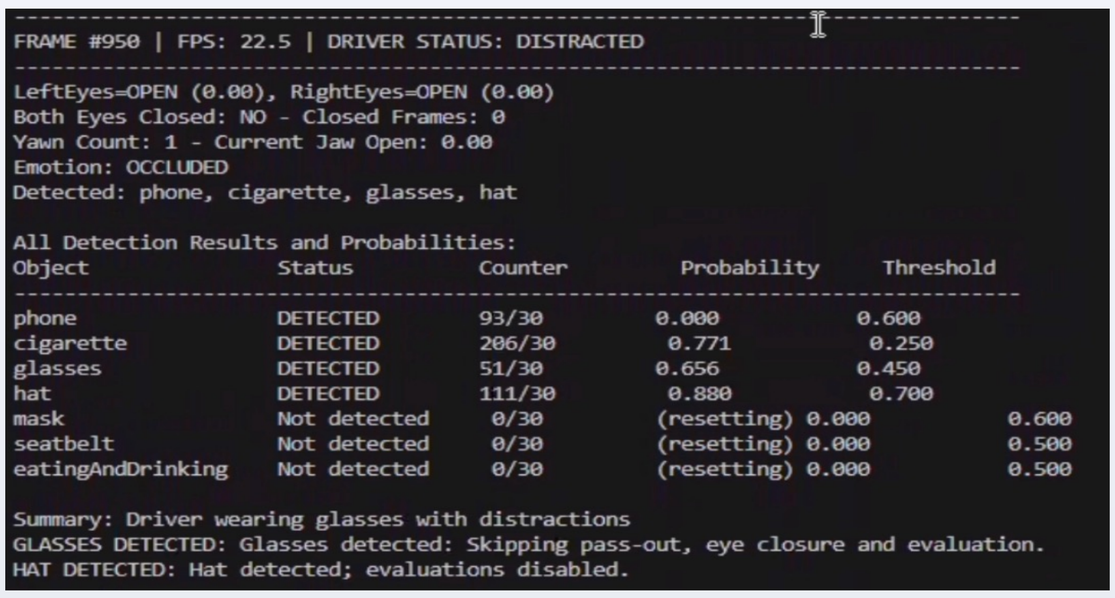
The main objective of this project was to develop a camera-only DMS that accurately detects driver distraction and fatigue in real time. It aimed to integrate open-source models into a modular and energy-efficient architecture suitable for embedded deployment in electric vehicles. Additional goals included simulating deployment in a Linux-based environment as well as on a System-on-Chip device, and implementing a custom multi-signal fatigue detection algorithm using facial and head pose data.

PROJECT DETAILS

The system monitors various visual indicators such as eye openness, head position, and the presence of objects like phones, cigarettes, glasses, hats, and seatbelts. It outputs the driver's status (e.g., "DISTRACTED", "NORMAL", or "PASSED-OUT") based on real-time object detection and fatigue classification.

Our pass out detection mechanism relies on weighted features: 60% eye closure, 20% head droop, and 20% head movement to accurately trigger pass-out warnings when critical thresholds are exceeded. As seen in the above image, the system displays overlays for detected objects, emotion status, yawns, and system speed in frames per second (FPS).

PROJECT DETAILS



The system continuously evaluates driver status in real-time using camera-based input and probabilistic thresholds. For each frame, it computes the likelihood of various distractions, including phone usage, cigarette smoking, glasses, and hats. It skips certain fatigue evaluations (like eye closure or pass-out detection) when occlusions are present. For instance, when glasses and hats are detected, the system disables eye-based assessments and emotion detection to avoid false positives. Detection counters and confidence scores are used to ensure reliable output. They are aimed at filtering out noise or temporary occlusions. The modular algorithm improves the responsiveness and robustness of distraction classification under real-world conditions.

Object	Precision	Recall	F1 Score	mAP@0.5	mAP@0.5:0.95
Phone	0.92171	0.90268	0.91215	0.95371	0.68604
Cigarettes	0.81220	0.69692	0.75002	0.77204	0.43715
FoodDrink	0.93537	0.89515	0.91478	0.94191	0.58118
Glasses	0.89157	0.72223	0.79754	0.82340	0.45404
Hat	0.94497	0.87307	0.90792	0.90863	0.75512
Mask	0.89659	0.78320	0.83578	0.87033	0.59818
Seatbelt	0.85410	0.87800	0.86590	0.89800	0.39790

CONCLUSIONS

The project successfully demonstrated the feasibility of a camera-only Driver Monitoring System capable of detecting multiple distraction types and fatigue indicators with high accuracy. Object detection models trained using advanced augmentation techniques which they achieved strong results. For instance, the project achieved outstanding results for phone, food/drink, and hat detection. These classes exhibited F1 scores exceeding 0.91 with mAP@0.5 values above 0.94. This performance places the model in the state-of-the-art range. According to COCO benchmark guidelines, mAP@0.5 above 0.90 is considered exceptionally strong, especially for object classes with high multi-class variability. The high recall for these classes (0.902 for phones, 0.91 for food/drink, and 0.873 for hats) indicates that the model is capable of capturing most true instances, where it minimizes false negatives.

The system architecture remains compatible with embedded AI environments. We offer a cost-effective and energy-efficient solution tailored for state-of-the-art electric vehicles. Overall, the project lays a solid foundation for future deployment.

REFERENCES

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