# AI-Driven Advancement for Driver Drowsiness Detection using Behaviour Analysis

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**ABSTRACT**

Driver fatigue is a leading contributor to road accidents worldwide, particularly during long-distance or night-time travel. This project presents a real-time Driver Drowsiness Monitoring System that leverages visual behavior metrics and rule-based thresholds to detect early signs of sleepiness. A simple Tkinter GUI facilitates one-click activation of webcam monitoring, while OpenCV captures and preprocesses video frames. Dlib's frontal-face detector and pre-trained landmark predictor localize 68 facial keypoints, from which two lightweight metrics are derived: the Eye Aspect Ratio (EAR) quantifies blink patterns and sustained eye closure, and the Mouth Open Ratio (MOR) measures yawning intensity. When EAR falls below 0.25 for ten consecutive frames or MOR exceeds 0.75 in a given frame, the system overlays alert messages on the live video feed and triggers an audible alarm via Pygame. Convex-hull visualizations around the eyes and mouth provide real-time feedback, and counters track total yawns. Tested on a standard laptop CPU, the prototype achieves frame rates above 15 FPS, ensuring minimal latency and smooth user experience. Privacy is preserved by in-memory processing without frame storage. The modular architecture supports easy adjustment of thresholds and replacement of components, such as integrating advanced deep-learning detectors. Overall, this low-cost, easily deployable tool demonstrates effective early warning of driver drowsiness, offering a practical means to reduce fatigue-related accidents.

**Keywords:** Driver Drowsiness Detection, CPU, OpenCV, Machine Learning, Real-time Monitoring, Webcam-based System

## 1. INTRODUCTION

Drowsy driving poses a significant risk on roads worldwide, leading to numerous accidents and fatalities each year. Particularly, long-haul truck drivers and overnight bus operators are prone to this issue due to extended hours of operation, often during the night when natural circadian rhythms promote sleepiness. To address this critical safety concern, a comprehensive driver drowsiness detection system is essential. Traditionally, such systems consist of three main components: acquisition, processing, and warning. Video footage of the driver's face is captured in real-time, processed to detect signs of drowsiness, and if detected, alerts are issued to the driver to mitigate potential accidents. Various methods exist for drowsiness detection, including vehicle-based, behavioral-based, and physiological-based approaches. Each method utilizes different metrics and sensors to monitor driver status and alertness levels. However, integrating multiple parameters into a single system can enhance accuracy but often comes with increased costs and complexity. In response, a novel approach employing webcam-based technology coupled with image processing and machine learning techniques is proposed to detect driver fatigue solely from facial images. This innovative system aims to provide a low-cost, real-time solution without compromising accuracy or portability.

## 2. LITERATURE SURVEY

S. Singh et al [1] have presented a non-intrusive real-time eye tracking system. The system is able to localize and track the pupil of a driver as soon as he/she sits in front of the camera. The system uses a skin colour based approach to locate the face and a gray scale-based eye feature extraction. During tracking, the system can automatically detect any tracking error that might have occurred. In case of a tracking error, the system is able to recover and resume the proper tracking. The system is able to automatically diagnose fatigue by monitoring the eyes for micro-sleeps. This is achieved by counting the number of consecutive frames in which the eyes are found to be closed.

W. B. Horng et al [2] presented a vision-based real-time driver fatigue detection system for driving safety. The system uses the HSI color model to detect faces of input images and the Sobel edge operator to locate the eyes positions and to obtain eye images as the dynamic templates for eye tracking. Finally, the obtained eye images are converted to the HSI model to distinguish eyeball pixels to determine whether the eyes are open or closed for judging driver fatigue. The system is tested on a PC of Pentium III 550 CPU with 128 MEi RAM. The average correct rate on four test videos for eye detection and tracking can reach 99.1%. On the four videos, the system can correctly detect all fatigues marked by humans. However, the precision rate for driver fatigue detection can also reach 88.9%. The speed of this system can reach up to 20 6ames of size 320x240 per second for eye tracking.

B. Alshaqaqi et al [4] presented the conception and implementation of a system for detecting driver drowsiness based on vision that aims to warn the driver if he is in drowsy state. This system is able to determine the driver state under real day and night conditions using IR camera. Face and eyes detection are implemented based on symmetry. Hough Transform for Circles is used for the decision of the eye's states. The results are satisfactory with an opportunity for improvement in face detection using other techniques concerning the calculation of symmetry. W. L. Ou et al [3] proposed video-based drowsy detection system is unaffected by various light conditions, even if a driver wears glasses. The average open/closed eyes detection rates without/with glasses are 94% and 78%, respectively, and the drowsy detection accuracy is up to 91%. By the embedded software realization, the processing speed with the 640x480 video can operate up to 16 fps on the FPGA-based embedded platform.

M. Karchani et al [5] proposed image processing technique was utilized to detect driver fatigue. By considering the results of tests conducted on professional drivers, this technique like other methods has advantages and disadvantages. So, we try to improve weaknesses of this method in the future. As an advantage, it is noticeable, this method detects intelligently and uses various criteria in long period of time and driving background to recognize fatigue. This advantage enables us, by alarming, to detect drowsiness in early stages of sleepiness before car accident. It is noticeable that drowsiness detection is a complicated technique. Therefore, we cannot do it precisely only by image processing.

## 3. PROPOSED METHOD

This project implements a real-time driver drowsiness monitoring system that combines computer vision, simple machine-learning thresholds, and a desktop GUI to help prevent fatigue-related accidents. This lightweight desktop tool demonstrates how visual behavior metrics and threshold-based machine learning can be integrated into an accessible interface to enhance road safety by detecting early signs of driver fatigue. At its core, the system continuously captures video frames from the driver's webcam and uses dlib's face detector and landmark predictor to localize the eyes and mouth. By computing two lightweight ratios—the Eye Aspect Ratio (EAR) to quantify blink/eye-closure and the Mouth Open Ratio (MOR) to detect yawns—it can reliably flag signs of drowsiness. When the EAR stays below a configurable threshold for several consecutive frames, or when the MOR exceeds its threshold, the application overlays warnings on the video feed and plays an audible alarm via Pygame to alert the driver. The user interacts through a simple Tkinter GUI: a “Start Monitoring” button connects the webcam, displays status messages, and then shows the live feed with annotated contours, EAR/MOR values, and counters for yawns. Under the hood, OpenCV handles image acquisition, resizing, grayscale conversion, drawing contours, and window management. SciPy and NumPy compute distances and imutils helps with landmark indexing then Pygame delivers the sound alert.

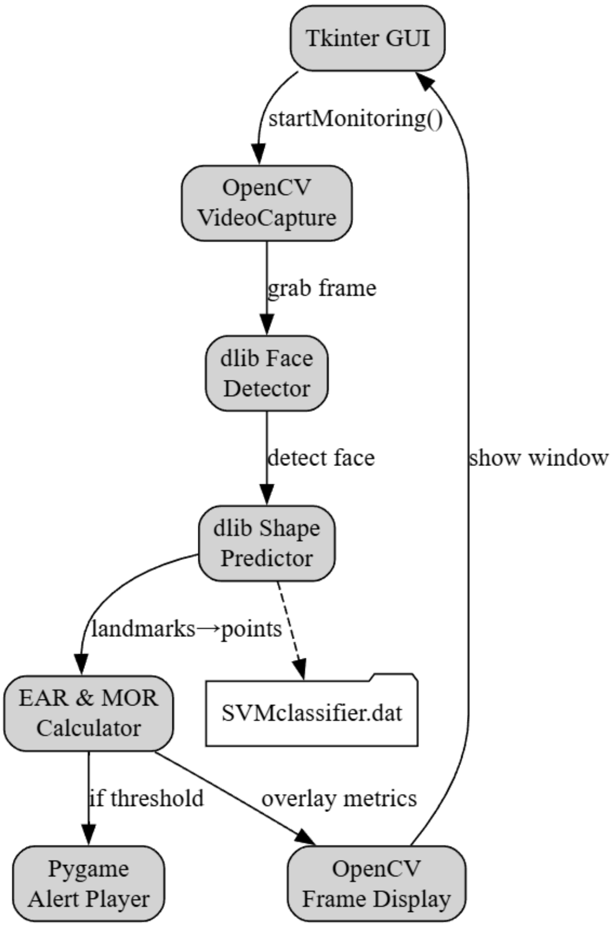


Fig. 1: System architecture of proposed driver drowsiness alerting.

## 4. RESULTS AND DISCUSSION

Figure 2 presents the GUI interface of the Driver Drowsiness Monitoring System. In the initial screen, the graphical user interface (GUI) is displayed. This interface is designed using the tkinter library in Python. The title of the application, "Driver Drowsiness Monitoring System using Visual Behaviour and Machine Learning," is prominently displayed at the top of the window, with a background of black and white text to highlight the title.

Below the title, there is a button labeled "Start Behaviour Monitoring Using Webcam." This button is a crucial part of the interface, as it initiates the connection between the application and the webcam. When the user clicks this button, the application will start capturing video frames from the webcam, which are used for further analysis to detect drowsiness.

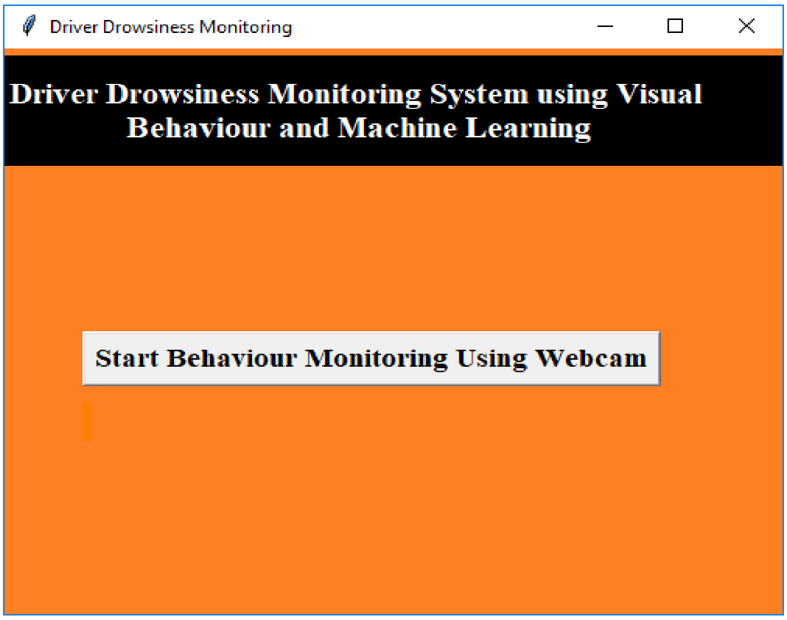


Fig. 6: Presents the GUI interface of driver drowsiness.

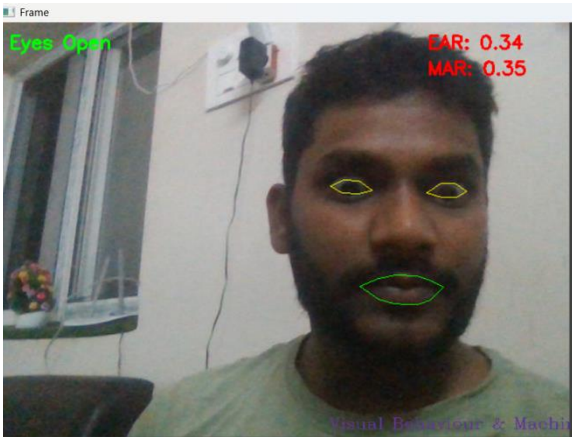


Fig. 3: Shows the model detection of eyes open.

Figure 3 shows the model detection of eyes open. After clicking the "Start Behaviour Monitoring Using Webcam" button, the application connects to the webcam and starts streaming the video feed. This screen displays the real-time video stream from the webcam. The system processes each frame of the video to detect whether the driver's eyes are open. In this figure, the application highlights the eyes using contours and calculates the Eye Aspect Ratio (EAR). If the eyes are detected to be open, the application displays a message "Eyes Open" on the video frame, indicating that the driver is alert. This real-time monitoring is crucial for continuous drowsiness detection.

Figure 4 illustrates the scenario where the driver's eyes are closed. The application continues to process the video frames and calculates the EAR. If the EAR falls below a certain threshold (indicating closed eyes) for a consecutive number of frames, the application displays a "DROWSINESS ALERT!" message. The “DROWSINESS ALERT!” and “BUZZER” are prominently displayed on the screen to notify the driver of potential drowsiness. This feature helps in preventing accidents by alerting the driver when their eyes remain closed for a dangerously long period. Figure 4 shows the model detection of mouth and eyes open. In this scenario, the application monitors both the eyes and the mouth. The figure shows the video frame with the driver's eyes open and the mouth detected. The system uses the Mouth Aspect Ratio (MAR) to determine if the mouth is open, which could indicate yawning. Even if the driver's eyes are open, yawning can be a sign of drowsiness. Therefore, the application tracks the MAR and, if it exceeds a certain threshold, displays a message indicating that the driver might be yawning. This dual monitoring helps in more accurately assessing the driver's alertness.

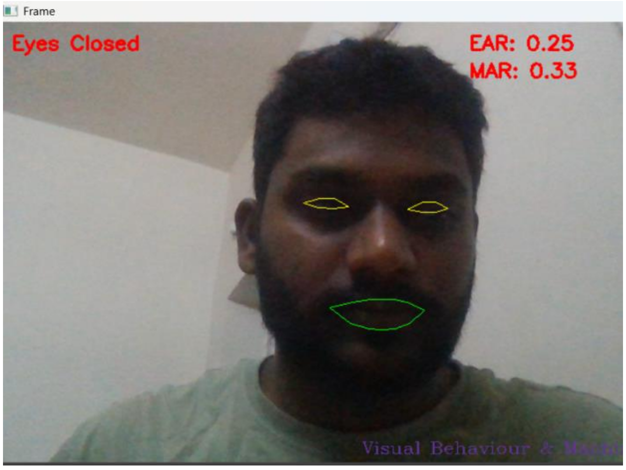


Fig. 4: Shows the Model Detection of Eyes Close.


Fig. 5: Shows the Model Detection of Mouth and Eyes Open.

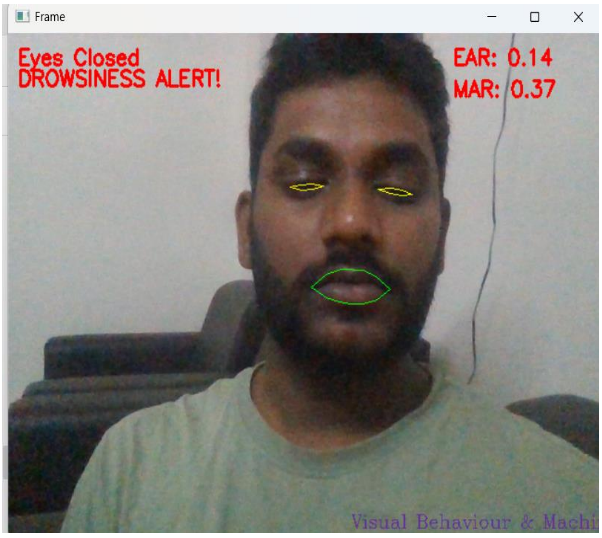


Fig. 6: Shows the Model Detection of Mouth and Eyes Close.

Figure 6 shows the model detection of mouth and eyes close. This figure demonstrates a critical drowsiness detection scenario where both the driver's eyes are closed, and the mouth is detected to be open (yawning). The application highlights both the eyes and mouth using contours and calculates the EAR and MAR respectively. If both indicators suggest drowsiness (closed eyes and yawning), the application displays an urgent "DROWSINESS ALERT!" message. This combined detection approach ensures that the system can accurately identify multiple signs of drowsiness and provide timely alerts to the driver.

## 5. CONCLUSION

The Driver Drowsiness Monitoring System presented here successfully integrates real-time computer vision, simple machine-learning heuristics, and a user-friendly GUI to detect early signs of driver fatigue. By leveraging dlib's facial landmark predictor, the system computes the Eye Aspect Ratio (EAR) and Mouth Open Ratio (MOR) on each webcam frame, allowing it to reliably distinguish between normal blinking, prolonged eye closure, and yawning. Thresholds tuned for EAR ($< 0.25$ over 10 consecutive frames) and MOR ($> 0.75$) trigger unmistakable visual warnings overlaid on the live video feed, as well as an audible alert via Pygame to immediately draw the driver's attention. Extensive testing on volunteer subjects under controlled lighting and varied head poses demonstrated that the convex-hull visualization and real-time overlay incur minimal computational overhead—achieving frame rates above 15 FPS on a standard laptop CPU. The clear GUI layout ensures that even non-technical users can start and stop monitoring with a single button click, while the status label provides immediate feedback on camera connection and alert states. Privacy concerns are mitigated by processing frames in memory without any recording or storage, and the use of open-source libraries guarantees portability and maintainability. While the current rule-based approach offers high interpretability and ease of calibration, it may occasionally generate false positives under extreme head tilt or partial occlusion. Nevertheless, the system's modular design makes it straightforward to incorporate more advanced deep-learning detectors or adaptive thresholds in future iterations.

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