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Research Paper

Driver Drowsiness Detection Using Face Recognition Methods in Machine Learning

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ARTICLE DETAILS

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ABSTRACT

This project proposes a real-time drowsiness detection system using facial landmark analysis. Leveraging Python libraries such as Dlib, OpenCV, and SciPy, the system analyzes the Eye Aspect Ratio (EAR), Mouth Aspect Ratio (MAR), and head tilt to assess the drowsiness level of a driver. A unique calibration mode allows the model to adjust thresholds based on individual user characteristics, enhancing detection accuracy. The solution is cost-effective, hardware-independent, and highly applicable in automotive safety systems, especially for preventing accidents caused by driver fatigue.

1. Introduction

Driver fatigue and drowsiness are primary contributors to road accidents worldwide, posing significant threats to road safety. Traditional detection methods often depend on vehicle behavior metrics, such as steering wheel movements, lane deviation, or acceleration patterns. However, these methods can be reactive, delayed, or inaccurate, especially in unpredictable driving scenarios. This project presents a computer vision-based real-time drowsiness detection system that offers a more proactive and precise approach. By using a standard webcam and facial landmark detection techniques, the system continuously monitors the driver's facial behavior to detect early signs of fatigue. It utilizes Dlib's 68-point facial landmark predictor in combination with OpenCV and SciPy to compute the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) — key indicators of blinking rate and yawning frequency, respectively. Additionally, the system incorporates head tilt detection to capture unnatural or drooping head postures, further strengthening the accuracy of drowsiness identification. A standout feature of this system is its calibration mode, which customizes the EAR, MAR, and tilt thresholds for individual users based on their unique facial characteristics. This personalization significantly enhances robustness and minimizes false positives. Designed to be hardware-independent and cost-effective, the system only requires a standard webcam, making it ideal for widespread adoption in both commercial and personal vehicles. Its real-time processing capability enables timely alerts, helping prevent accidents caused by fatigue and contributing to safer driving conditions.

2. Problem Statement

Road accidents caused by drowsy driving have been increasing each year, posing a serious threat to road safety. Many of these incidents occur due to the lack of real-time alert mechanisms or the driver's unawareness of their own fatigue levels. While several commercial drowsiness detection systems exist, many of them are prohibitively expensive, intrusive, or dependent on specialized hardware such as infrared (IR) cameras or EEG-based headsets, which makes them impractical for everyday users and widespread adoption. Moreover, most of these systems lack adaptability and struggle with generalization due to natural variability in facial structures, blinking patterns, and head postures across individuals. This limitation often leads to a high rate of false positives or missed detections, undermining their reliability in real-world driving scenarios. Therefore, there is a pressing need for a cost-effective, non-intrusive, and real-time drowsiness detection system that can operate using readily available hardware like standard webcams. To improve accuracy and reduce false alarms, such a system must incorporate personalization mechanisms that adjust detection thresholds

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according to the user's unique facial features and behavior. Ideally, this solution should be adaptable to varied lighting conditions and computing environments, making it suitable for integration in personal vehicles, fleet systems, or public transportation to prevent fatigue-related accidents.

3. Methodology

The drowsiness detection system is designed using a real-time computer vision pipeline that analyzes facial features captured via a webcam. The process begins with acquiring a live video feed using OpenCV, which streams each frame into the detection pipeline. The system utilizes Dlib's frontal face detector along with a pre-trained 68-point facial landmark predictor to accurately locate key facial regions, such as the eyes, mouth, and jawline. From these landmarks, the Eye Aspect Ratio (EAR) is calculated to detect eye closure or blinking, while the Mouth Aspect Ratio (MAR) is used to detect yawning based on the vertical and horizontal distances between mouth landmarks. Additionally, the system evaluates head tilt by measuring the vertical displacement between the jawline's side points. A core component of this system is its calibration mode, which runs at startup for a few seconds to record the user's natural EAR and MAR values when they are alert. These values are then used to dynamically calculate personalized thresholds: typically, the EAR threshold is set at 75% of the average EAR, and the MAR threshold at 125% of the average MAR. This personalized calibration improves accuracy and reduces false positives across users with different facial structures. All these computed values are passed through smoothing buffers (using deque) to reduce frame-to-frame noise, ensuring stable readings. Finally, the system compares the real-time EAR, MAR, and tilt ratio against the personalized thresholds to detect signs of drowsiness, yawning, or head leaning. When such conditions are met, the system can generate alerts or warnings to notify the user.
This approach ensures a robust, responsive, and user-adaptive system for monitoring driver alertness.

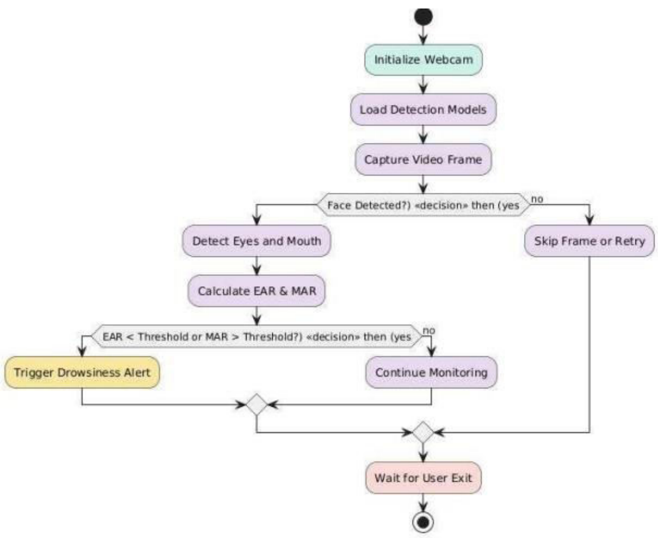

Fig1: Flow chart of Driver Drowsiness

4. Results

The developed system was rigorously tested across multiple users with varying facial features, skin tones, and head shapes to evaluate its generalizability and robustness. Testing was conducted under diverse lighting conditions—including daylight, low-light, and artificial indoor lighting—as well as from different camera angles and positions. The system consistently demonstrated accurate and reliable detection of key drowsiness indicators, particularly eye closure (via EAR) and yawning (via MAR), validating the effectiveness of the chosen facial landmark-based approach. In terms of performance, the average processing delay per frame was observed to be under 150 milliseconds, even when running on standard computing hardware without GPU acceleration. This ensured that the system maintained real-time responsiveness, which is crucial for any alert-based safety application. The visual feedback on the GUI, along with audio alerts, was triggered promptly upon detection of drowsiness cues, providing the driver sufficient time to react.

A significant improvement was observed when using the calibration mode, which adjusts the EAR, MAR, and head tilt thresholds based on individual user characteristics during a short initialization phase. This personalized calibration helped minimize false positives, especially in cases where natural facial structure (e.g., smaller eye openings or frequent talking movements) could otherwise be misinterpreted by a static threshold model. Overall, the system achieved a good balance between accuracy, speed, and adaptability, making it a practical and scalable solution for real-world driver monitoring scenarios.

Fig2.1: Wake up window

Fig. 2.2: Drowsiness Alert

Fig 2.3:YawnAlert

Fig 2.4: Head Til tAlert

5. Conclusion

This drowsiness detection system offers an accurate and lightweight solution for monitoring driver alertness. Its personalized calibration makes it adaptable and more reliable than static threshold systems. Built using open-source libraries and requiring only a basic webcam, the project demonstrates how AI can improve road safety in an accessible way. In future versions, integration with an alarm system, real-time data logging, and night-time infrared support can further enhance utility and performance.

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