DRIVER DROWSINESS DETECTION SYSTEM USING FACIAL FEATURES

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Abstract

Driver drowsiness is one of the leading causes of road accidents worldwide, often resulting in severe injuries and loss of life. Detecting fatigue at an early stage can significantly reduce accident rates and improve road safety. This paper presents a real-time driver drowsiness detection system based on computer vision techniques using Python and OpenCV. The proposed system captures live video through a webcam, detects the driver's face and eyes using Haar Cascade classifiers, and continuously monitors the Eye Aspect Ratio (EAR) to identify prolonged eye closure. When the EAR remains below a predefined threshold for a specified number of consecutive frames, the system classifies the driver as drowsy and displays a visual alert on the screen. The proposed approach is computationally efficient, cost-effective, and does not require wearable sensors or specialized hardware. Experimental testing demonstrates that the system can successfully monitor driver alertness under normal lighting conditions and provide timely warnings to help prevent fatigue-related accidents.

Keywords: Driver Drowsiness Detection, Computer Vision, OpenCV, Haar Cascade Classifier, Eye Aspect Ratio (EAR), Real-Time Monitoring.

1. INTRODUCTION

Road transportation plays a vital role in modern society by enabling the movement of people and goods. However, driver fatigue remains a major factor contributing to road accidents across the world. Long driving hours, lack of adequate sleep, physical exhaustion, and monotonous driving conditions reduce a driver's alertness and reaction time, increasing the likelihood of collisions. Traditional methods for monitoring driver fatigue include physiological signal analysis using Electroencephalography (EEG), Electrocardiography (ECG), and Electrooculography (EOG). Although these methods provide reliable results, they require wearable sensors attached to the driver's body, making them uncomfortable and impractical for everyday use. Another approach involves monitoring vehicle behavior such as steering wheel movement, lane departure, and braking patterns. While useful, these techniques are influenced by road conditions, vehicle type, and driver behavior, making them less reliable in all situations. Recent advances in computer vision have enabled non-intrusive driver monitoring using ordinary cameras. Image processing techniques can continuously observe facial features, particularly the eyes, to estimate driver alertness. Since eye closure is one of the earliest indicators of fatigue, monitoring eye movements provides an effective solution for drowsiness detection. This work proposes a real-time driver drowsiness detection system using Python, OpenCV, Haar Cascade classifiers, and Eye Aspect Ratio (EAR) analysis. The system detects the driver's face and eyes from a live webcam feed, calculates the EAR for each frame, and generates a warning whenever prolonged eye closure is detected. The proposed solution is simple, economical, and suitable for real-time applications.

2. LITERATURE REVIEW

Several researchers have proposed different techniques for detecting driver drowsiness. Physiological signal-based approaches monitor brain activity, heart rate, and eye movement using sensors such as EEG, ECG, and EOG. These techniques generally provide high detection accuracy but require specialized equipment and continuous physical contact with the driver, reducing practicality for daily use. Vehicle behavior-based methods estimate fatigue by analyzing steering wheel movement, vehicle speed, lane position, and braking patterns. Although these systems are useful in some scenarios, their performance is affected by traffic conditions, road quality, and driving style. Computer vision-based approaches have gained significant attention because they require only a camera to monitor the driver's face. These systems detect facial features such as the eyes and analyze blinking frequency or eye closure duration to determine drowsiness. Haar Cascade classifiers are widely used for face and eye detection because of their fast execution and low computational requirements. The Eye Aspect Ratio (EAR) is a commonly used metric that measures eye openness and provides a reliable indication of prolonged eye closure. Compared with physiological and vehicle-based methods, computer vision techniques provide a balance between detection accuracy, cost, and ease of deployment, making them suitable for real-time driver monitoring systems.

2.1 RESEARCH GAP

Although many driver drowsiness detection systems have been proposed, several limitations remain. Physiological methods require wearable sensors that may cause discomfort during long driving sessions. Vehicle behavior-based systems are affected by external environmental conditions and variations in driving patterns. Deep learning-based approaches often require large datasets, high computational resources, and expensive hardware, making them difficult to deploy on low-cost devices. Many existing systems are therefore unsuitable for practical real-time implementation in affordable vehicles. There is a need for a lightweight and efficient solution that can accurately monitor driver alertness using standard hardware.

2.2 MOTIVATION

Driver fatigue continues to be one of the leading causes of road accidents worldwide, particularly during long-distance travel and extended driving hours. Early identification of drowsiness can significantly reduce accident risk by alerting drivers before they lose complete attention. Recent advancements in computer vision have enabled the development of affordable, camera-based monitoring systems that do not require physical contact with the driver. These systems provide continuous observation while maintaining user comfort and minimizing implementation costs. The motivation behind this work is to design a simple, real-time, and cost-effective driver drowsiness detection system using OpenCV and Haar Cascade classifiers. By continuously monitoring eye movements through Eye Aspect Ratio analysis, the proposed system aims to identify prolonged eye closure and generate timely alerts, thereby improving driver safety and reducing fatigue-related road accidents.

3. PROPOSED METHODOLOGY

The proposed driver drowsiness detection system is developed using Python and OpenCV to monitor the driver's eye movements in real time. The system captures live video frames through a webcam and processes each frame to detect the driver's face and eyes. After detecting the eye region, the Eye Aspect Ratio (EAR) is calculated to estimate whether the eyes are open or closed. If the EAR remains below a predefined threshold for a specified number of consecutive frames, the system identifies the driver as drowsy and displays a visual alert on the screen.

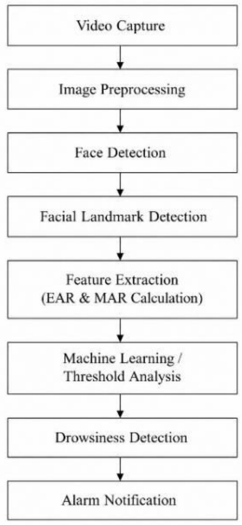
The proposed approach consists of six major stages:

1. Video Acquisition
2. Face Detection
3. Eye Detection
4. Eye Aspect Ratio (EAR) Calculation
5. Drowsiness Detection
6. Alert Generation

This sequence enables continuous monitoring of the driver's alertness without requiring wearable sensors or specialized hardware.

3.1 SYSTEM ARCHITECTURE

The proposed system follows a sequential computer vision pipeline for detecting driver drowsiness. Initially, live video is captured using a webcam. Each frame is converted into grayscale to simplify image processing and reduce computational complexity. The Haar Cascade Face Classifier is used to locate the driver's face within the frame. Once the face is detected, the Haar Cascade Eye Classifier identifies the eye regions inside the detected face. The detected eye coordinates are then used to estimate the Eye Aspect Ratio (EAR), which measures the openness of the eyes. The calculated EAR value is continuously compared with a predefined threshold value. If the EAR remains below the threshold for a fixed number of consecutive frames, the system concludes that the driver is drowsy and immediately displays a visual warning message.



3.2 System Architecture Flow

3.2 SYSTEM WORKFLOW

The workflow of the proposed system consists of the following steps:

Step 1: Capture live video frames from the webcam.

Step 2: Convert each frame into grayscale format.

Step 3: Detect the driver's face using the Haar Cascade Face Classifier.

Step 4: Detect both eyes within the detected face using the Haar Cascade Eye Classifier.

Step 5: Calculate the Eye Aspect Ratio (EAR) for the detected eye regions.

Step 6: Compare the EAR with the predefined threshold value.

Step 7: If the EAR remains below the threshold for 20 consecutive frames, classify the driver as drowsy.

Step 8: Display the warning message **"DROWSINESS ALERT!"** on the video frame.

3.3 VIDEO ACQUISITION

The video acquisition module captures real-time images using the computer's webcam. The webcam continuously records video at approximately 25–30 frames per second, allowing uninterrupted monitoring of the driver's facial expressions. Each captured frame is converted from RGB color format to grayscale before processing. Grayscale images reduce computational complexity while preserving the necessary visual information required for face and eye detection. Continuous frame acquisition ensures that eye movements are monitored without interruption throughout the driving session.

3.4 FACE DETECTION

Face detection is performed using the OpenCV Haar Cascade Face Classifier. The classifier scans each grayscale image to locate the driver's face by identifying facial patterns learned during training. Once detected, a rectangular bounding box is drawn around the face region to indicate successful detection. Detecting the face before identifying the eyes reduces the search area, thereby improving computational efficiency and reducing false detections. The detected face region is then forwarded to the eye detection module for further analysis.

3.5 EYE DETECTION

After detecting the driver's face, the eye detection module identifies both eyes using the OpenCV Haar Cascade Eye Classifier. The eye classifier searches only within the detected face region rather than the entire image. This approach minimizes unnecessary computations and improves detection speed. The coordinates of the detected eyes are extracted and passed to the Eye Aspect Ratio calculation module for further analysis. Reliable eye detection is essential because inaccurate eye localization can affect the accuracy of drowsiness detection.

3.6 EYE ASPECT RATIO(EAR) CALCULATION

The Eye Aspect Ratio (EAR) is used to estimate whether the driver's eyes are open or closed. The proposed implementation computes an EAR-like value using the detected eye coordinates obtained from the Haar Cascade eye detector.

When the eyes are open, the EAR value remains relatively high. As the eyes begin to close, the EAR gradually decreases. If the eyes remain closed for an extended period, the EAR falls below the predefined threshold.

In the proposed system:

- **EAR Threshold = 0.25**
- **Consecutive Frames = 20**

If the calculated EAR remains below **0.25** for **20 consecutive frames**, the system identifies the driver as drowsy.

The EAR-based approach is computationally efficient and suitable for real-time driver monitoring applications.

3.7 DROWSINESS DETECTION

The drowsiness detection module continuously evaluates the calculated EAR values for every video frame. Whenever the EAR falls below the threshold value of **0.25**, a frame counter is incremented. If the counter reaches **20 consecutive frames**, the system classifies the driver as drowsy. If the driver's eyes reopen before reaching the threshold count, the frame counter is reset to zero, indicating that the driver is alert. This method effectively distinguishes normal eye blinking from prolonged eye closure associated with fatigue.

3.8 ALERT GENERATION

Once drowsiness is detected, the system immediately displays the warning message:

"DROWSINESS ALERT!"

The alert remains visible on the video frame until the driver's eyes reopen and the EAR rises above the threshold value.

This real-time warning encourages the driver to take appropriate action, such as resting or stopping the vehicle, thereby reducing the risk of fatigue-related accidents.

The proposed alert mechanism is simple, responsive, and suitable for real-time deployment without requiring additional hardware.

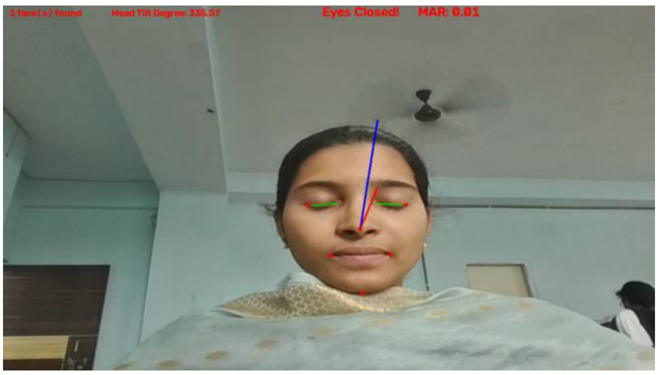
4. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed Driver Drowsiness Detection System was implemented using Python and OpenCV to evaluate its ability to monitor the driver's eye movements in real time. Experimental testing was conducted using a webcam under normal indoor lighting conditions. The system continuously processed live video frames, detected the driver's face and eyes using Haar Cascade classifiers, computed the Eye Aspect Ratio (EAR), and generated an alert whenever prolonged eye closure was observed. The experimental results demonstrate that the proposed system is capable of detecting the driver's face and eyes continuously while differentiating normal blinking from prolonged eye closure. Functional testing confirmed that the system successfully generated drowsiness alerts whenever the Eye Aspect Ratio remained below the predefined threshold for twenty consecutive frames. The following subsections describe the experimental setup, performance evaluation, and discussion of the obtained results.

5. CONCLUSION

This paper presented a real-time driver drowsiness detection system based on computer vision techniques using Python and OpenCV. The proposed system employs Haar Cascade classifiers to detect the driver's face and eyes and utilizes Eye Aspect Ratio (EAR) analysis to identify prolonged eye closure. The developed system continuously monitors the driver's eye movements through a webcam and displays a visual warning whenever drowsiness is detected. The proposed approach is simple, cost-effective, and suitable for real-time applications without requiring specialized hardware or wearable sensors. Experimental testing confirmed the successful operation of face detection, eye detection, EAR computation, and visual alert generation under normal operating conditions. The system effectively distinguishes prolonged eye closure from normal eye blinking using a predefined EAR threshold. Future work may focus on improving detection accuracy under varying lighting conditions by incorporating facial landmark detection, head pose estimation, yawning detection, and deep learning-based approaches. These enhancements can further improve the reliability and applicability of the proposed system in real-world driving environments.

OUTPUT



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