

AI-Driven Drowsiness Detection System with Voice Activated Auto Breaking

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Abstract: Falling asleep at the wheel happens more than you think, especially after long stretches behind the wheel or when darkness wraps around you. This work tackles that problem head-on: one tool watches for signs of tiredness, linking straight to an alert system that pauses everything or stops motion entirely just by speaking. Camera power does not come from an external gadget but from a standard laptop, which is always on and always scanning. Using tools such as OpenCV and Haar cascades, working alongside facial landmark tracking, the setup measures eye and mouth characteristics and turns them into metrics such as EAR. From these values, clues emerge about fatigue: signs include prolonged eye shutting and repeated yawning episodes.

A warning sound is triggered when sleepiness is detected, and Py-game handles the voice message. Then, a message is sent over the serial link to an Arduino Nano, making things happen quickly. A motor kicks in, like brakes engaging or power cutting off, owing to a switch operated by the code. Alarms ring through a buzzer, and lighting changes on LEDs reveal what is happening behind the scenes. A shaking sensation is generated by a small vibrator designed to reach the driver directly. The use of computer vision, AI, and compact electronics creates a practical and budget-friendly safety tool. This setup helps drivers stay alert and is suitable for self-driving cars, heavy trucks, or extended road journeys.

Keywords: driver fatigue monitoring, facial behavior analysis, eye aspect ratio (EAR), mouth opening ratio (MOR), nose length-based facial feature ratio.

1.INTRODUCTION

Reports from police departments and hospitals in 2017 indicated that the National Highway Traffic Safety Administration (NHTSA) recorded approximately 91,000 traffic accidents caused by driver fatigue, leading to nearly 50,000 injuries. In 2019, drowsy driving was associated with 697 fatalities in the United States. The NHTSA also stated that identifying fatigue-related crashes is difficult, meaning that the actual number of such incidents is likely much higher than reported. Supporting this, research by the American Automobile Association (AAA) Foundation for Traffic Safety estimated that more than 320,000 crashes occur annually due to driver sleepiness, including approximately 6,400 fatal accidents. These figures clearly

show that drowsy driving is a major road safety issue that requires effective preventive measures.

Drowsiness is a state of reduced alertness and an increased tendency to fall asleep, often occurring in situations where full attention is required. Although this condition may last for a short duration, its impact can be severe, particularly during driving. Fatigue is the primary cause of drowsiness, as it lowers the concentration level and slows reaction time. Drivers are more likely to feel drowsy when they have not slept enough, drive for extended periods without breaks, or drive during normal sleeping hours. Under these conditions, the driver's ability to respond quickly to road events is significantly reduced.

The early detection of driver drowsiness can help prevent accidents. Common signs include frequent yawning, prolonged eye closure, and unintentional lane drifting by the driver. In recent years, extensive research has been conducted to develop driver drowsiness detection systems. Many methods have been proposed to monitor these warning signs and alert drivers before dangerous situations occur.



2. LITERATURE REVIEW

Driver fatigue is a major cause of road accidents worldwide. Researchers and automotive engineers have investigated several techniques to identify drowsy drivers and prevent crashes. Over the years, the focus has shifted from traditional monitoring methods to intelligent real-time detection systems that use advanced sensing and computing technology.

Early research in this field concentrated on physiological measurements to assess drivers' levels of alertness. Techniques such as electroencephalography (EEG), heart rate monitoring, and electromyography (EMG) were used to measure brain activity, heart signals, and muscle movement. Although these approaches provide accurate results, they require sensors to be attached directly to the driver's body. This makes the systems uncomfortable and impractical for everyday driving, especially for long-distance travelers. In addition, the equipment is expensive and complex, which limits its use in real-world applications.

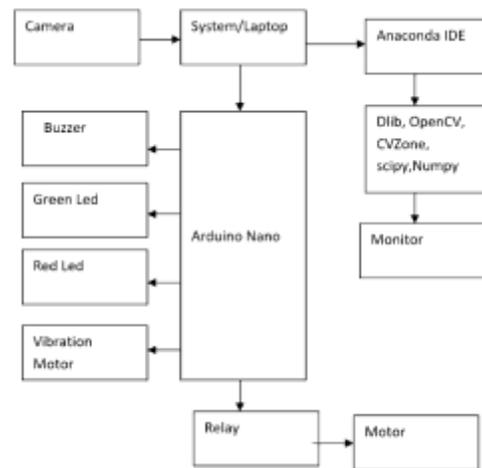
To overcome these limitations, researchers have begun to explore vehicle-based detection methods. These systems analyze driving behaviors, such as steering patterns, lane position, braking frequency, and speed variations, to identify abnormal driving patterns associated with fatigue. Although these methods do not interfere with the driver, their accuracy can be affected by external factors such as road conditions, traffic density, and individual driving styles. Consequently, it is difficult to distinguish between normal driving behavior and actual drowsiness.

In recent years, vision-based approaches have become one of the most effective techniques for detecting driver fatigue. These systems use cameras to continuously monitor the facial features and eye movements of the driver. Parameters such as blinking frequency, eye closure duration, and yawning frequency were analyzed to determine the driver's level of alertness. Facial landmark detection techniques are used to locate key regions, such as the eyes and mouth. Metrics such as the Eye Aspect Ratio (EAR) are commonly used to detect prolonged eye closure, which is a strong indicator of drowsiness. Advances in artificial intelligence and image processing have significantly improved the accuracy and reliability of these diagnostic systems.

3. METHODOLOGY

This study proposes a real-time driver drowsiness detection system based on facial feature analysis using a camera and image processing techniques. The system continuously monitors the driver's face and identifies signs of fatigue, such as prolonged eye closure and frequent yawning. When drowsiness is detected, an alert is generated to warn the driver of the vehicle.

3.1 System Overview



The proposed system comprises four main stages.

- Image acquisition
- Face and facial feature detection
- Drowsiness feature extraction
- Alert generation

A camera mounted on the dashboard captured a live video of the driver. The captured frames were processed to detect the face, eyes, and mouth. Based on the extracted features, the system determines whether the driver is alert or drowsy.

3.2 Image Acquisition

A standard webcam or infrared camera was used to capture a real-time video of the driver. The video stream was converted into individual frames for processing. Each frame was resized and converted to grayscale to reduce the computational complexity and improve the processing speed.

3.3 Face and Facial Feature Detection

Face detection was performed using a pre-trained Haar Cascade or a similar face detection model. Once the face is detected, facial landmarks are identified to locate important regions, such as the eyes and mouth. These landmarks are used to continuously monitor eye and mouth movements.

3.4 Drowsiness Feature Extraction

Two main indicators of drowsiness were analyzed.

3.4.1 Eye Aspect Ratio (EAR)



The Eye Aspect Ratio was calculated to measure the openness of the eyes. When the eyes remained closed for a certain duration, the EAR value fell below a predefined threshold, indicating drowsiness.

3.4.2 Yawning Detection

Yawning was detected by analyzing mouth opening using mouth landmarks. A high mouth-opening ratio for a continuous period indicates that the driver is yawning frequently, which is a sign of fatigue.

3.5 Drowsiness Decision Logic

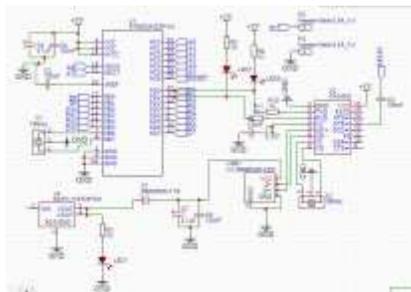
The system uses a threshold-based logic to classify the driver's state. If the eye closure duration exceeds a set time limit or the yawning frequency crosses a predefined threshold, the system classifies the driver as drowsy. Otherwise, the driver was considered to be alert.

3.6 Alert Mechanism

When drowsiness was detected, the system activated an alert mechanism. This can be an audible alarm, vibration, or visual warning displayed on the screen. The alert continues until the driver becomes alert.

4. IMPLEMENTATION

Schematic & Reference Design



The proposed driver drowsiness detection system was implemented using real-time video processing to monitor the facial features and identify fatigue-related behaviors. A camera mounted on the vehicle dashboard continuously

captured the driver's face, and the video frames were processed to detect drowsiness signs.

Initially, the captured frames were pre-processed by resizing and converting them to grayscale to reduce the computational complexity. Face detection was then performed to locate the driver's face region, followed by facial landmark detection to identify key points around the eyes and the mouth. These landmarks were used to analyze the eye and mouth movements.

Eye closure was evaluated using the Eye Aspect Ratio (EAR). When the EAR value dropped below a predefined threshold for a specific duration, the system identified the driver as being drowsy. Similarly, yawning was detected by measuring the distance between the upper and lower lip. Frequent or prolonged mouth opening was considered an additional indicator of the fatigue.

A decision module combined the eye and mouth analysis results to determine the driver's state of alertness. When drowsiness was detected, an alert system was activated to warn the driver through an audible alarm and an on-screen notification. The system was tested under different lighting conditions to verify its reliability and real-time performance.

5. CONCLUSION

Road accidents caused by driver fatigue remain a major global safety concern, and effective monitoring systems are essential for reducing the associated risks. In this study, a vision-based driver drowsiness detection system was designed and implemented to identify early signs of fatigue by using facial feature analysis. The system continuously monitors the driver's eye and mouth movements to determine alertness levels and generate timely warnings when drowsiness is detected.

The proposed approach focuses on non-intrusive monitoring, eliminating the need for physical sensors attached to the driver. This makes the system comfortable for long-duration driving and suitable for deployment in real-world scenarios. Using facial landmark detection, the system accurately tracked eye closure and yawning behavior, which are widely recognized indicators of fatigue. The Eye Aspect Ratio (EAR) and mouth opening measurements were used as primary parameters to evaluate the driver's state, enabling reliable detection of prolonged eye closure and frequent yawning.

Experimental evaluation showed that the system performed effectively in real time under varying lighting conditions and driving scenarios. The preprocessing techniques helped reduce the computational complexity, making the system efficient for implementation on standard computing platforms. The threshold-based decision logic provides a simple yet effective method for classifying the driver's alertness state with minimal false alarms. The alert mechanism ensured

immediate feedback to the driver, which is critical for preventing fatigue-related accidents from occurring.

Overall, the results demonstrate that vision-based driver monitoring systems can serve as practical and cost-effective solutions for enhancing road safety. The proposed system has the potential to be integrated into modern vehicles, driver-assistance systems, and intelligent transportation frameworks. By providing Through continuous monitoring and timely alerts, such systems can significantly reduce the number of accidents caused by drowsy driving and contribute to safer driving environments.

6. FUTURE WORK

Although the proposed system shows promising performance, several improvements can be explored in future studies. The system can be enhanced by integrating infrared cameras to support nighttime driving in low-light environments. Machine or deep learning models can be employed to improve detection accuracy and reduce false alarms. Additional physiological parameters, such as head pose estimation and gaze tracking, can be included to provide a more reliable fatigue assessment. Furthermore, the system can be implemented on embedded platforms, such as Raspberry Pi or automotive-grade hardware, for real-world deployment. Integration with vehicle control systems for automatic braking or lane assistance can further increase safety and reduce the risk of accidents in the future.

7. REFERENCE

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RESEARCH HIGHLIGHTS

1. Developed a real-time driver drowsiness detection system using facial feature analysis for improved road safety.
2. Implemented eye and mouth behavior metrics to accurately identify fatigue indicators such as eye closure and yawning.
3. Designed an alert mechanism to warn drivers instantly and reduce the risk of accidents.
4. Proposed a low-cost, non-intrusive system suitable for integration into modern vehicles and smart transportation systems.