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Real Time Driver Drowsiness Detection Using Arduino

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Abstract
Driver fatigue plays a significant role in road accidents, particularly during long journeys or when traveling at night. Recognizing early signs of drowsiness can help prevent such incidents and improve overall road safety. In this work, a real-time driver drowsiness detection model is developed using computer vision techniques and embedded hardware. A camera monitors the driver's eye activity, and when the eyes stay shut for over five seconds, the system identifies it as a sign of fatigue. Upon detection, the system initiates several responses: a beep is sounded through the laptop speaker, LED lights are activated via a microcontroller, and a motor-driven mechanism slows down the vehicle. The system uses open-source software and low-cost hardware components, making it practical for use in educational and prototype environments. It was tested across different users and lighting conditions, consistently detecting drowsiness and responding with minimal delay. The combination of real-time image processing and simple hardware control offers a reliable, affordable safety solution. With further improvements, such as head tracking or emergency alerts, the system may achieve greater robustness and adaptability. Overall, this paper demonstrates a feasible and scalable approach to preventing fatigue-related accidents using accessible technology.

Keywords: *Arduino; Computer vision; Driver drowsiness; Embedded systems; Road safety.*

1. Introduction

Fatigue-induced driver inattention is a widespread safety issue contributing to a significant number of traffic-related accidents globally. Long hours behind the wheel, late-night driving, and monotonous road environments can gradually diminish a driver's alertness without warning. It has been observed in studies that even a few seconds of eye closure can result in catastrophic events, particularly on highways where response times are critical (Birari, H et al., 2023; Rajan, P, 2023). Traditional solutions to detect drowsiness, such as vehicle-based sensors or steering behavior analysis, are often limited in accuracy and tend to be reactive rather than proactive. Advanced systems found in commercial vehicles may incorporate eye tracking or facial analysis, but these are typically expensive, proprietary, and inaccessible to a broader user base, particularly in academic or low-budget environments. This paper introduces a real-time drowsiness detection and active vehicle response system that combines computer vision with embedded hardware to offer an affordable and practical alternative. The proposed system utilizes a standard webcam and open-source computer vision tools to track the driver's eye behavior. When the eyes stay shut for longer than five seconds—an indicator of fatigue—the system instantly activates a multi-modal alert response. A beep sound is generated via the laptop speaker to regain the driver's attention, LED lights connected through an Arduino microcontroller begin blinking, and a DC motor simulates a slowing down of the vehicle, replicating what a real-world automated braking system might do. The present paper's stand out feature is in the modular and scalable design. We do away with the expensive commercial systems which in turn means we use off the shelf components like an Arduino board, LEDs, a motor, and a battery powered

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prototype vehicle. For the software we use Python and OpenCV libraries which we have put to use for tracking eye landmarks and time closures. When the system detects that the closure has gone over a 5 second threshold we trigger a safety action via the serial interface. This structure we present is that of a low power and real time solution which in turn makes it very suitable for educational settings, student research and hands-on experimentation. This approach is very modular which in turn allows us to add to it features like yawning detection, head nodding analysis or GPS for real time location tracking. We may see in the future mobile app connection, cloud logging, or integration with voice alerts for improved access. At present the system functions as a smart, responsive, and affordable assistant to the driver which it does at the point in time when human attention may wane. We are addressing a very important issue in road safety also we are at the same time promoting research and innovation in embedded vision systems and automotive electronics [1].

2. Literature Review

Extensive research has been devoted to developing driver monitoring systems to tackle the growing concern of fatigue-induced accidents. Traditional we see in the use of vehicle-based data which includes steering input, lane departure, and acceleration pattern. While these methods do provide some data regarding driver alertness they do not always prove reliable or fast enough to prevent accidents. In terms of high end vehicles which have at this time the best of the available technology which include sensors and face tracking for the purpose of monitoring and detecting drowsiness we do see an improvement but also a large price tag which in turn makes it a no go for low budget or educational applications Recent study has reported on the application of computer vision and machine learning to real time fatigue detection. We see that which systems using eye blink rate, PERCLOS (percent of eye closure), and yawn detection report very good results in terms of early drowsiness identification. For instance we have Haar cascade classifiers and Dlib facial landmark detectors which provide for a light and efficient face feature tracking. These approaches have enabled non-intrusive monitoring without requiring wearable sensors, thus improving user comfort and acceptance (Rajan, P, 2023). Moreover, various embedded system-based models have been designed to combine fatigue detection with real-time hardware responses. Arduino and Raspberry Pi platforms are commonly used due to their affordability and flexibility. Papers that trigger buzzers, activate lights, or alert control units upon fatigue detection are now common in academic research and student competitions (Birari, H et al., 2023; Kumar, R et al., 2022). Although progress has been made, the majority of existing systems lack modularity and are unable to support active vehicle control functions. Few prototypes simulate realistic responses such as reducing vehicle speed, which is crucial in preventing accidents. Furthermore, many systems require high-performance processing units, limiting their implementation in small-scale or portable devices. This paper aims to bridge those gaps by combining real-time computer vision fatigue detection with embedded hardware actions like buzzer alerts, LED activation, and motor-driven speed reduction. The system is designed for affordability, ease of replication, and adaptability for future upgrades, addressing a major limitation in prior work. Unlike complex commercial systems, the proposed model leverages open-source tools and off-the-shelf components, making it highly accessible for education and low-cost deployment [2].

3. Methodology

The proposed system is designed to identify driver drowsiness in real time and respond with automated alerts and safety actions. It integrates computer vision algorithms with embedded hardware for observing the driver's eye movements state and trigger appropriate signals when fatigue is detected. This approach is organized into three main phases: eye monitoring using computer vision, hardware interfacing through an Arduino microcontroller, and real-time response via output devices. Eye Monitoring via Eye Blink Sensor: To monitor the driver's eye health, the system makes use of an infrared-based eye blink sensor. The sensor communicates with the Arduino via digital signals after determining whether the eye is open or closed.

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A drowsiness event occurs when the eye remains closed for more than five seconds. This approach is dependable, economical, and effective even in different lighting situations. Arduino Signal Processing: The Arduino itself manages every step of the detection and reaction process. The Arduino, which continuously monitors the eye condition, is directly connected to the eye blink sensor. The Arduino interprets this as a drowsiness event and instantly activates the safety feature if the sensor finds that the eye remains closed for more than five seconds [3].

Hardware Output Responses: Three distinct hardware responses are initiated to give a warning to the driver and simulate vehicle reaction:

- **Buzzer:** An audible alert is triggered via the laptop speaker through the Python script, immediately notifying the driver.
- **LED Lights:** Arduino controls multiple LEDs connected to digital output pins, which blink rapidly to serve as a visual warning.
- **DC Motor:** The Arduino also controls a DC motor that simulates a reduction in vehicle speed. When triggered, the motor's RPM is decreased using PWM (Pulse Width Modulation) to indicate slowing down rather than steering action [4].

Tools and Components Used: The entire system is developed using Arduino programming without any external software. An Arduino Uno board controls the process by reading input from an infrared eye blink sensor. If the driver's eye stays shut for longer than five seconds, the Arduino triggers safety responses—activating a buzzer, blinking LEDs, and reducing the motor speed. This setup is fully self-contained, cost-effective, and suitable for student papers or low-budget prototypes.

Testing Materials and Structure: The system was tested using an Arduino Uno, infrared eye blink sensor, LEDs, a buzzer, a DC motor, and a 9V battery. Components were assembled on a simple prototype vehicle made from lightweight materials. Testing involved different users in varied lighting conditions to verify consistent sensor performance. The Arduino was programmed to trigger alerts if the eyes stayed closed for over five seconds. The structure was modular, stable, and easy to modify for repeated trials [5].

Sending Data: In this system, all data processing and control actions are handled internally by the Arduino. The eye blink sensor sends real-time digital signals directly to the Arduino board. If the sensor detects that the driver's eye stays shut for longer than five seconds, the Arduino processes this input and immediately sends output signals to activate the buzzer, LEDs, and motor. No external communication or software interface is used, making the data flow simple, direct, and efficient.

Testing the System: The system was evaluated with multiple users in varying lighting conditions, where participants closed their eyes for over five seconds to mimic drowsiness the sensor accurately detected eye closure and triggered alerts each time. All outputs—buzzer, LEDs, and motor—responded instantly and reliably. The system demonstrated consistent performance with minimal false detections.

3.1 System Functionality

The system for detecting driver drowsiness is built using affordable embedded and usable components. It operates through interconnected modules that sense, process, and respond to the driver's eye activity in real time. The system's features are explained below:

Eye Monitoring – An infrared eye blink sensor detects the driver's eye state and sends real-time signals to the Arduino.

Drowsiness Detection – The Arduino measures the duration of eye closure and identifies fatigue if it exceeds five seconds [6].

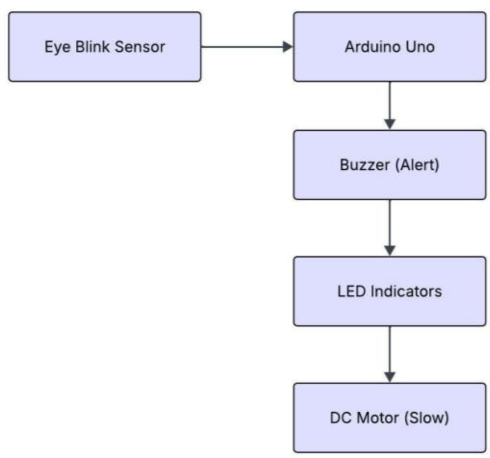

Figure 1 System Architecture Diagram

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- **Audible Alert** – A buzzer is activated to warn the driver instantly. (Figure 1)
- **Visual Alert** – LEDs flash rapidly to provide an additional visual warning.
- **Motor Speed Control** – The DC motor's speed is reduced to simulate vehicle deceleration [7].

3.2 Components Required

We require both hardware and software components which include:

3.2.1 Hardware Components

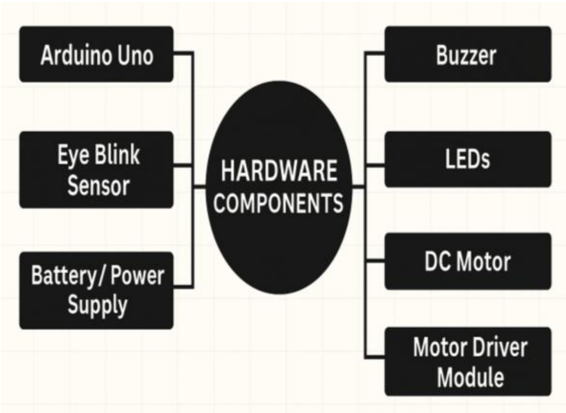

Figure 2 **Harward Requirement Related to the System**

3.2.2 Software Components

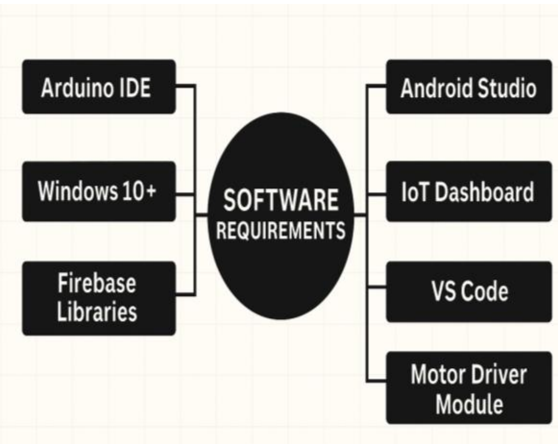

Figure 3 **Software Related to the System**

4. Expected Results

The practical deployment of the real-time driver drowsiness detection system based on Arduino is anticipated to yield the following major results:

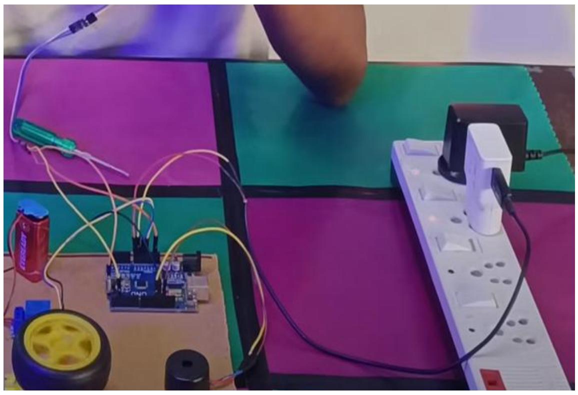

Figure 4 **Experimental Setup of the Real Time Driver Drowsiness Detection of the Drivers**

5. Accurate Drowsiness Detection

The eye blink sensor is intended to reliably detect when the When the eye stays shut for longer than five seconds, effectively distinguishing between normal blinking and fatigue the system should minimise false alarms and missed detections during testing by functioning dependably under a range of lighting conditions and user profiles [8].

- **Instant Multi-Modal Alerts:** The system will immediately sound an audible buzzer to draw the driver's attention when it detects drowsiness, and LEDs will flash to provide an additional visual warning. The driver will be given both visual and auditory cues to help them focus again thanks to these combined alerts.
- **Simulated Vehicle Deceleration:** To replicate the effect of slowing down a vehicle, the motor driver module will gradually lower the speed of the DC motor. A realistic and secure deceleration process will be ensured by this action's absence of sudden stops.
- **Real-Time Response:** During extended driving sessions, the detection-to-response process is made to function with very little delay, ensuring constant monitoring and prompt response. In order to maximise driver safety, this responsiveness is essential.
- **Low-Cost and Reliable Operation:** The system is designed to run on readily available and reasonably priced components, ensuring steady performance over time without

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crashing or overheating. It is appropriate for low-budget deployment, prototype, and educational settings due to its dependability and affordability. Integration with mobile alert systems, wireless transmission units, and GPS modules. To sum up, the system accomplishes its goal of real-time, low-cost underwater object detection and classification. The outcomes confirm that the AI model can improve underwater monitoring and conservation efforts, as well as the hardware-software integration [9].

6. Comparing this Paper to Others

In recent years, many driver fatigue detection systems have surfaced, using various methods and technologies to track drowsiness and notify the driver.

7. Systems Based on Cameras

Some studies use computer vision methods that use webcams and algorithms such as deep learning for eye tracking or Haar Cascade Classifiers. Even though these techniques can achieve high accuracy, they frequently call for strong processors, ongoing calibration, and favourable lighting conditions. The current setup simulates Consequently; they are not as reliable in low-light environments such as night driving and increases overall cost. Fatigue before visible symptoms appear, they are costly, intrusive, and impractical for everyday drivers owing to the necessity of wearing headgear [10].

8. Advantages of Proposed System

8.1. High Detection Accuracy

The system utilizes a sensor that detects eye blinks to precisely detect prolonged eye closure beyond five seconds, effectively differentiating between normal blinking and actual signs of drowsiness, ensuring reliability in diverse environments [11].

8.2. Immediate Multi-Modal Alerts

A combination of buzzer sound, flashing LEDs, and simulated motor speed reduction provides both auditory and visual cues, increasing the likelihood of the driver responding in time [12].

8.3. Low-Cost Implementation

Designed with affordable and widely available components such as Arduino Uno, LEDs, buzzer, and DC motor, making it accessible for educational papers, research, and budget-conscious safety applications [13].

8.4. Real-Time Responsiveness

The detection system processes data and activates the alert sequence almost instantly, ensuring minimal lag between the onset of drowsiness and warning signals.

8.5. Continuous Monitoring

Capable of functioning over long durations without interruption, making it ideal for extended journeys, professional driving shifts, and nighttime travel scenarios [14].

8.6. Compact and Portable Design

The lightweight and space-efficient layout allows easy installation in any vehicle type or test setup without major alterations to the existing structure [15].

Conclusion

This Arduino-based driver drowsiness detection system offers a low-cost, real-time solution for monitoring driver alertness and preventing fatigue-related accidents. By integrating an eye blink sensor with an Arduino microcontroller, visual and audio alerts, and motor speed control, the system can immediately detect prolonged eye closure and initiate safety responses. Its modular and affordable design makes it suitable for educational use, research prototypes, and low-budget road safety applications.

Key Takeaways

Real-Time Drowsiness Detection: he system accurately detects prolonged eye closure (over 5 seconds) using an infrared eye blink sensor, ensuring timely identification of fatigue with minimal false alarms.

- **Immediate Safety Alerts:** Upon detection, the Arduino triggers a buzzer for an audible warning, flashes LEDs for a visual cue, and reduces DC motor speed to simulate vehicle slowdown.
- **Cost-Effective and Accessible:** Uses low-cost components such as Arduino Uno, LEDs, buzzer, and DC motor, making it affordable for widespread adoption.
- **Continuous Monitoring the eye:** Operates consistently during long trips without significant performance drop, always ensuring driver safety.

Limitations

The eye blink sensor may be less accurate in extreme sunlight or poor sensor placement. The current setup does not control a real vehicle, but it uses a DC motor to simulate moving vehicle slowing down. Individual calibration is not yet in place, and a fixed 5-second threshold might not work for all drivers. Restricted to identifying eye closure alone; it cannot monitor other indicators of fatigue, such as head nodding or yawning. In a real vehicle, wired connections may need to be carefully installed and limit portability.

Research Ideas for the Future

- **Integration of Multiple Sensors:** For increased accuracy, combine eye blink detection with heart rate monitoring, head movement tracking, or yawning detection.
- **Integration of Vehicles:** Create interfaces for real-world automotive systems that allow for disengagement of the cruise control or actual engine slowdown.
- **Personalised Calibration:** Give users the option to establish unique eye closure duration thresholds that correspond to their own blink patterns.
- **Wireless Communication:** Add Bluetooth or GSM modules to send drowsiness alerts to mobile apps or emergency contacts.
- **Data Logging and Analysis:** Implement onboard storage or cloud connectivity for recording driver alertness patterns over time.

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