Driver Alertness Detection with Dual Alert System

Authors:

Mohammed Azeem A

Ashfaq Ur Rahman H N

Sagar H N

Under guidance of

Associate Professor Dr. Mohammed Mujeer Ulla

Affiliation:

School of Computer Science and Engineering,

Presidency University, Bangalore

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ABSTRACT: Driver drowsiness is a major cause of road accidents, leading to severe injuries and fatalities worldwide. This research focuses on developing a cost-effective and efficient Driver Alertness Detection system suitable for four-wheelers that lack integrated safety features. The system utilizes an Arduino Uno, an eye blink sensor, and an ADXL345 accelerometer to monitor the driver's eye blinks and head movements. Prolonged eye closure or head tilts beyond a threshold triggers dual alerts through a piezo buzzer and vibration motors installed on the steering wheel. Powered by a 9V battery with a 5V regulator, the system is compact, easy to install, and operates on Embedded C. The proposed solution aims to enhance road safety by minimizing drowsiness-induced accidents, especially in cost-sensitive markets.

1. INTRODUCTION

Road accidents caused by driver drowsiness remain a pressing issue, accounting for a significant number of fatalities and injuries worldwide. Fatigue reduces a driver's reaction time and awareness, making it a critical factor in traffic safety. Advanced driver assistance systems (ADAS) in high-end vehicles address this issue, but their high costs render them inaccessible for most budget-friendly vehicles. This creates a need for an affordable and effective alternative that can be retrofitted to existing vehicles.

This study presents the development of a low-cost Driver Alertness Detection system aimed at improving safety for drivers of four-wheelers. The system leverages an Arduino Uno, an eye blink sensor to monitor eyelid activity, and an ADXL345 accelerometer to detect excessive head movements. By identifying prolonged eye closure or head tilts beyond a defined threshold, the system triggers immediate alerts through a piezo buzzer and vibration motors embedded in the steering wheel.

With its straightforward design and use of widely available components, this solution offers a practical approach to reducing drowsiness-induced accidents, especially in regions where cost-effective safety solutions are needed the most.

2. EXISTING METHODS

Several advanced driver alertness detection systems are currently available, primarily integrated into high-end vehicles. These systems leverage technologies such as camera-based facial recognition, infrared sensors, and physiological monitoring to detect signs of drowsiness. Camera-based systems monitor the driver's facial features, such as eye closure, blinking patterns, and head movements, to assess alertness. Some solutions also use sensors to track heart rate, skin conductivity, or other physiological indicators associated with fatigue.

In addition, machine learning algorithms are employed to analyze the collected data and provide accurate predictions of drowsiness. These systems offer high precision and are capable of functioning in real-time, providing timely alerts to drivers to prevent accidents.

DRAWBACKS: Despite their effectiveness, existing driver alertness detection systems have notable drawbacks that limit their widespread adoption. Camera-based systems are highly dependent on environmental conditions, such as lighting and visibility, which can significantly affect their accuracy. For instance, poor lighting at night, glare, or obstructions like sunglasses can interfere with facial recognition.

Additionally, these systems require sophisticated and expensive hardware, such as high-resolution cameras, infrared sensors, and powerful processors, making them cost-prohibitive for many consumers. The complexity of their design and integration further adds to the overall cost, making them impractical for budget-conscious markets.

Moreover, systems that rely on physiological monitoring often involve invasive or uncomfortable wearables, such as heart rate monitors, which may not be practical for long-term use. Maintenance requirements and the need for constant calibration further hinder the feasibility of these solutions, particularly in resource-constrained environments.

3. LITERATURE REVIEW

No.	Paper Title	Method	Advantages	Limitations
1.	Driver Drowsiness Detection by Applying Deep Learning Techniques to Sequences of Images	Deep learning with CNN and RNN; fuzzy logic system for drowsiness estimation.	High specificity in avoiding false alarms.	Moderate accuracy on test data (60%).
2.	Real-time Driver Drowsiness Detection using Computer Vision	EAR (Eye Aspect Ratio) and Yawn detection with OpenCV and Raspberry Pi.	Low-cost implementation with real-time alert system.	Ineffective in low-light conditions due to Raspberry Pi camera limitations.
3.	Driver Drowsiness Detection Using Machine Learning	Eye and yawn detection using OpenCV and machine learning with Python.	Simple and efficient method using real-time video feed.	Limited testing and optimization scope for varying driving environments.

Fig 1. Literature Review Table

4. PROPOSED METHOD

This study presents a cost-effective and reliable Driver Alertness Detection system using readily available hardware components and Embedded C programming. The proposed system integrates an Arduino Uno with sensors and actuators to detect and respond to signs of driver drowsiness.

Key features of the system include:

1. **Eye Blink Sensor**: Detects prolonged eye closures (≥3 seconds) to identify drowsiness.
2. **ADXL345 Accelerometer**: Monitors head movements; alerts if movements exceed 100 degrees for more than 3 seconds.
3. **Alert Mechanism**: Provides dual alerts—a piezo buzzer for sound and vibration motors on the steering wheel—for immediate feedback to the driver.
4. **Power Supply**: Operates on a 9V battery regulated to 5V, ensuring compatibility with all components.
5. **Switch Control**: Enables manual activation or deactivation of the system.

The system architecture emphasizes simplicity, affordability, and ease of implementation, making it suitable for retrofitting in vehicles lacking advanced safety systems. By continuously monitoring driver behavior and delivering timely alerts, the proposed method aims to significantly reduce drowsiness-related accidents, particularly in cost-sensitive markets.

5. OBJECTIVES

The primary objectives of this research are:

1. **Develop a Cost-Effective Solution**: Create a low-cost driver alertness detection system that can be easily implemented in vehicles lacking advanced safety features.
2. **Detect Drowsiness Accurately**: Utilize an eye blink sensor and accelerometer to monitor signs of driver fatigue, such as prolonged eye closure and abnormal head movements.
3. **Provide Immediate Alerts**: Implement dual alert mechanisms, including a piezo buzzer and vibration motors, to ensure the driver is promptly notified of drowsiness.
4. **Enhance Road Safety**: Reduce the risk of accidents caused by drowsy driving by delivering timely warnings to drivers.
5. **Ensure Simplicity and Reliability**: Design a system that is straightforward to install, operate, and maintain, while ensuring reliable performance across various driving conditions.

6. METHODOLOGY

Driver Alertness Detection system is designed to identify drowsiness in drivers based on eye closure and head movement patterns. The methodology is structured as follows:

1. **System Hardware**:
   - **Eye Blink Sensor**: Installed to monitor the duration of eye closures. If the eyes remain closed for 3 seconds or more, it is flagged as a sign of drowsiness.
   - **ADXL345 Accelerometer**: Mounted to detect head movements. A tilt beyond 100 degrees lasting 3 seconds indicates potential drowsiness or distraction.
   - **Piezo Buzzer and Vibration Motors**: Provide dual alerts—sound and vibration on the steering wheel—to immediately notify the driver.
   - **Power Supply**: A 9V battery regulated to 5V powers the system, ensuring compatibility and stable operation of all components.
   - **Switch**: Allows the system to be manually activated or deactivated as needed.
2. **Software Implementation**:
   - **Programming Language**: The system is programmed using Embedded C, optimized for real-time performance and minimal resource usage.
   - **Sensor Data Processing**: The Arduino Uno collects and processes data from the sensors, comparing inputs against predefined thresholds for eye closure duration and head tilt angle.
   - **Alert Generation**: Upon detecting drowsiness, the microcontroller activates the buzzer and vibration motors simultaneously to alert the driver.
3. **Workflow**:
   - The system begins monitoring once powered on and activated using the switch.
   - The eye blink sensor continuously measures eye closure duration, while the accelerometer tracks head movements.
   - Sensor data is processed in real-time by the Arduino Uno.
   - If thresholds are exceeded, alerts are triggered to ensure immediate driver attention.
4. **Testing and Calibration**:
   - The system is tested in simulated driving environments to calibrate the sensor thresholds for eye closure and head tilt.
   - Various scenarios, such as different lighting conditions and driving postures, are simulated to ensure reliability.

This methodology ensures a robust, low-cost solution that enhances driver safety and reduces the risk of accidents caused by drowsiness.

7. ARCHITECTURE

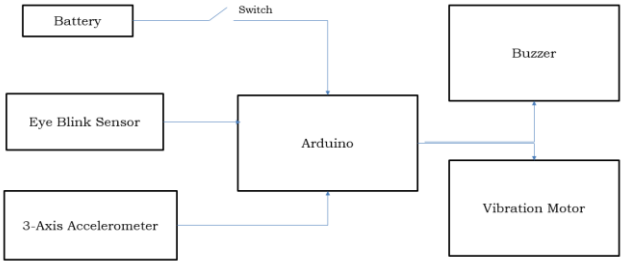

Fig 2. Basic Architecture

8. BUILT CIRCUIT

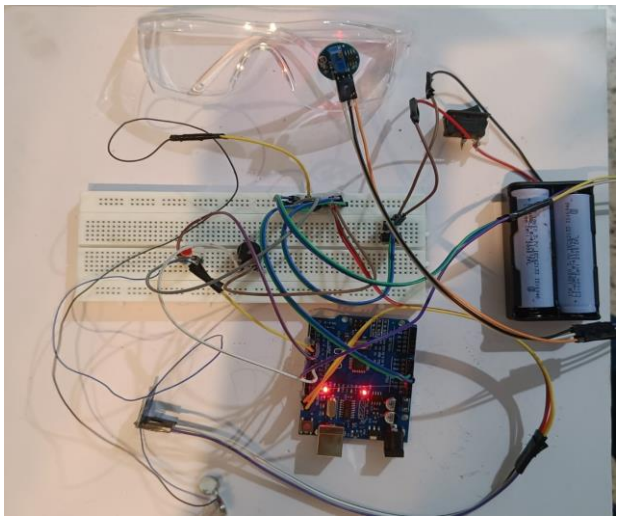

Fig 3. Implemented circuit in ON mode

9. OUTCOMES

1. **Drowsiness Detection:**
   - Detects driver drowsiness based on prolonged eye blinks (>3 seconds) and head movement (head tilt >100 degrees for 3+ seconds).

2. **Alert System:**
   - Dual alerts are triggered: a piezo buzzer sound and a vibration motor on the steering wheel.
3. **Cost-Effective Solution:**
   - Affordable add-on for vehicles without integrated alertness features, using simple components like Arduino Uno and sensors.
4. **Improved Road Safety:**
   - Enhances safety by preventing accidents due to driver fatigue.
5. **Scalability:**
   - Can be adapted for different vehicles and further improved with advanced techniques.

10. REFERENCES

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