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Vision Guard-Smart Eyewear for Driver Alertness

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Abstract

Driver fatigue and loss of alertness remain major contributors to traffic accidents and fatalities across the world. Although several advanced driver monitoring systems have been proposed, many of them rely on complex camera-based approaches or expensive vehicle-integrated solutions that are difficult to deploy in all types of vehicles. This paper presents Vision Guard, a low-cost, wearable and real-time driver alertness monitoring system designed as a smart eyewear platform. The proposed system continuously observes eye blink activity using a dedicated eye blink sensor and determines the alertness level of the driver through an Arduino UNO microcontroller. When prolonged eye closure is detected for more than three seconds, an audible warning is issued using a buzzer. If the eye closure exceeds five seconds, indicating severe drowsiness or unresponsiveness, a servo motor is activated to simulate a vehicle stopping mechanism. An LCD module displays real-time system status to improve user interaction. The prototype also integrates auxiliary sensors, including a Hall effect sensor and an ultrasonic sensor, as well as a relay module to demonstrate scalability and functional expansion. Experimental evaluation under simulated driving conditions confirms that the system can effectively detect drowsiness and trigger appropriate responses. The proposed platform provides an affordable and adaptable solution for enhancing road safety and offers a foundation for future developments such as Internet of Things (IoT) connectivity and intelligent fatigue prediction.

Introduction

Rapid growth in road transportation and increasing dependence on motor vehicles have significantly intensified road safety challenges across the world. While technological progress has improved vehicle performance and infrastructure, human-related factors continue to dominate the causes of traffic accidents. Among these factors, driver fatigue and drowsiness represent a critical risk, as they directly affect perception, reaction time, and decision-making capability. A fatigued driver may fail to respond promptly to traffic situations, which can lead to severe collisions and, in extreme cases, loss of life.

Drowsy driving has been reported to be comparable to impaired driving in terms of accident risk. Extended working hours, night driving, monotonous road environments, and physical exhaustion commonly contribute to reduced alertness. Despite growing awareness of this issue, many vehicles in daily use still lack dedicated systems capable of detecting early signs of driver fatigue.

Several approaches have been introduced to address this problem, including vision-based facial monitoring systems, steering behavior analysis, and wearable health monitoring devices. Camera-based solutions can track eye closure, head movement, and facial expressions; however, they usually require high-quality imaging hardware, controlled lighting conditions, and powerful processing units. Similarly, vehicle-behavior-based systems are strongly influenced by road conditions, driving style, and vehicle type, which can reduce their reliability. Wearable physiological monitoring devices may provide accurate results, but their cost and intrusiveness often limit widespread adoption.

In order to overcome these limitations, this project proposes *Vision Guard*, a wearable and low-cost driver alertness monitoring system designed in the form of smart eyewear. The proposed system integrates an infrared eye blink sensor into a wearable frame and continuously monitors the driver's eye activity in real time. The eye blink data are processed by an Arduino UNO microcontroller to determine whether the driver shows signs of abnormal eye closure behavior.

When the driver's eyes remain closed for more than three seconds, the system generates an audible warning using a buzzer to draw the driver's attention. If eye closure continues beyond five seconds, indicating a critical level of drowsiness or non-responsiveness, a servo motor is activated to simulate a vehicle stopping action. This layered response strategy ensures that the driver is first alerted and then subjected to a stronger intervention when the risk becomes severe.

By emphasizing simplicity, affordability, and real-time operation, Vision Guard is intended to provide an accessible alternative to expensive driver assistance systems. The proposed wearable solution is particularly suitable for older vehicles, motorcycles, commercial transport services, and users in developing regions where advanced in-vehicle monitoring systems are not commonly available. The project therefore contributes toward improving road safety by reducing the likelihood of fatigue-related accidents and promoting safer driving behavior.

The primary aim of this project is to design and implement a wearable smart eyewear system, named *Vision Guard*, that enhances driver safety by detecting drowsiness through real-time eye blink monitoring.

The system employs an infrared eye blink sensor mounted on a wearable frame to continuously observe the driver's eye condition. An Arduino UNO microcontroller processes the sensor output and measures the duration of eye closure. When the eyes remain closed for more than three seconds, the system activates an audible buzzer to alert the driver. If the eye closure exceeds five seconds, a servo motor is triggered to simulate a vehicle stopping mechanism, representing a critical safety response.

The overall objective is to develop a simple, low-cost, and reliable wearable solution capable of reducing fatigue-related road accidents. By offering a non-intrusive and easily deployable system, Vision Guard seeks to extend the availability of driver-assistance technology to a broader user population, including drivers operating older vehicles and those working in cost-constrained environments.

The specific objectives of the Vision Guard project are listed as follows:

1. To design and develop a wearable smart eyewear platform integrated with an infrared eye blink sensor for monitoring driver alertness.
2. To implement real-time data acquisition and processing using an Arduino UNO microcontroller for measuring eye closure duration and blink behavior.
3. To generate an audible warning through a buzzer when continuous eye closure exceeds three seconds.
4. To simulate a vehicle stopping or halting mechanism using a servo motor and relay-based DC motor control when eye closure exceeds five seconds.
5. To provide real-time user feedback by displaying system status and alerts on an LCD module.
6. To ensure a compact, energy-efficient, and user-friendly design suitable for practical on-road usage.

Literature Survey And Problem Statement

Research on driver alertness monitoring and accident prevention has expanded significantly over the past decade, driven by the increasing demand for safer transportation systems and intelligent driver assistance technologies. Early systems mainly focused on basic sensor-based monitoring and warning mechanisms. More recent studies have introduced biometric sensing, real-time automation, and intelligent decision logic to improve reliability and effectiveness. A detailed review of selected works relevant to the Vision Guard system is presented in this section.

Aravinda B., Chaithralakshmi C., Deeksha and Ashutha K. (2016) presented a low-cost accident prevention platform based on multiple sensors, including infrared, ultrasonic, and alcohol sensors. Their system was designed to monitor both driver condition and surrounding traffic conditions using a microcontroller-based architecture. Audible alarms and visual indicators were employed to notify the driver whenever unsafe conditions were detected. The primary contribution of this work lies in demonstrating how multiple low-cost sensors can be integrated into a single embedded platform for real-time safety monitoring. This concept directly influenced the design philosophy of Vision Guard, particularly in combining eye blink sensing with auxiliary sensors such as ultrasonic modules to enhance preventive safety actions.

Kartik Venkata Mutya and Sandeep Rudra (2015) proposed a road safety mechanism aimed at minimizing accidents during vehicle overtaking. Their approach relied on proximity sensing and intelligent warning strategies to alert drivers when overtaking maneuvers became dangerous. The system emphasized real-time hazard recognition and timely intervention. This work is relevant to the Vision Guard project because it demonstrated how immediate detection of unsafe situations can be coupled with automated response strategies. The concept of linking detection events with vehicle control actions inspired the implementation of a simulated vehicle stopping mechanism in the proposed wearable system.

Stephen Eduku, Mohammed Okoc Alhassan and Joseph Sekyi (2017) developed an automatic accident prevention and notification framework using wireless communication technology. Their system integrated a GSM module to transmit alerts when accidents or abnormal driver states were detected. Although the architecture relied heavily on external communication infrastructure, the study highlighted the importance of autonomous emergency response and notification without requiring driver input. This idea forms the basis for the future enhancement plans of Vision Guard, where wireless communication may be integrated to transmit drowsiness alerts to guardians or monitoring centers.

Dr. T. Kalaichelvi, Dr. V. Subedha and Mrs. A. Porselvi presented a real-time eye blink monitoring system for accident prevention using infrared sensors. Their work focused on analyzing eye state transitions and distinguishing normal blinking from prolonged eye closure associated with fatigue. A calibrated threshold-based approach was adopted to ensure accurate interpretation of blink durations. This research played a key role in shaping the signal processing and threshold logic used in Vision Guard, particularly in defining eye closure duration limits for generating alerts and initiating safety actions.

Madhumanti Maiti, Tanaya Banerjee and Kalyan Chatterjee (2015) introduced a dual-sensor accident prevention prototype that combined an eye blink sensor with an accelerometer module. The accelerometer was used to detect head movements such as nodding, which often accompany fatigue. By combining multiple physiological indicators, the system significantly reduced false detections caused by random blinking or temporary eye closure. This multi-parameter sensing strategy directly influenced the Vision Guard prototype by encouraging the inclusion of additional sensing components to support the primary blink-based detection mechanism and improve system robustness in real driving environments.

Milan Pandey, Kushal Chaudhar, Rajnish Kumar and co-authors (2018) developed an assistive system for paralyzed individuals using eye motion detection. Although the application domain was different, the study demonstrated the effectiveness of infrared eye tracking sensors in a non-intrusive and lightweight configuration. Their results validated the practicality of wearable eye-based interaction systems and confirmed that accurate eye motion detection can be achieved without complex imaging hardware. This work reinforced the decision to adopt a compact IR-based sensing approach for Vision Guard instead of camera-based solutions.

Taner Danisman, Ioan Marius Bilasco, Christophe Djeraba and Rachid Ihaddadene (2010) presented a video-based drowsiness detection method that analyzed blink frequency, duration, and temporal patterns to determine driver alertness. Statistical models were used to correlate eye blink behavior with cognitive fatigue levels. Although Vision Guard does not employ camera-based processing due to cost and computational limitations, this research provided strong scientific validation that eye blink patterns represent reliable indicators of drowsiness. The findings guided the formulation of blink duration thresholds and pattern interpretation used in the proposed wearable system.

Sabu George, Manohara Pai M. M., Radhika M. Pai and Samir Kumar Praharaj (2017) investigated the use of eye blink count and blink duration for behavioral and attention analysis. Their study demonstrated that prolonged eye closure and abnormal blink timing are strongly correlated with reduced attention levels. The conclusions of this research supported the design of time-based decision rules in Vision Guard, particularly in establishing prolonged eye closure as the primary trigger for audible warnings and automated intervention.

Overall, the reviewed literature highlights several important directions that influenced the development of the Vision Guard system. These include the integration of multiple low-cost sensors for real-time monitoring, the use of blink-based physiological indicators for fatigue detection, the benefit of combining multiple parameters to improve reliability, the growing importance of automated safety actions beyond simple warning mechanisms, and the adoption of compact and non-intrusive hardware architectures suitable for everyday use.

Problem Statement

Driver fatigue and drowsiness significantly degrade perception, reaction speed, and decision-making ability, thereby increasing the likelihood of serious traffic accidents. These conditions are particularly common during prolonged driving sessions and night-time travel. Although a variety of driver monitoring systems have been proposed to address this issue, most existing solutions primarily focus on providing visual or auditory warnings to the driver.

Such warning-only approaches depend entirely on the driver's capacity to respond in time. In situations involving extreme fatigue or short-duration sleep episodes, commonly known as microsleep, the driver may be unable to react even when alerts are generated. Consequently, the effectiveness of purely alert-based systems becomes limited under critical conditions.

In addition, many currently available driver monitoring technologies rely on externally mounted cameras or dashboard-based sensors. These systems are often costly, sensitive to illumination variations, head movement, and seating posture, and may be inconvenient for daily use. Their installation and calibration requirements further restrict widespread adoption, especially in older vehicles and low-resource environments.

Therefore, there exists a clear need for a compact, wearable, and low-cost solution that can continuously and reliably monitor a driver's eye activity, with particular emphasis on detecting prolonged eye closure, which is a strong indicator of drowsiness. Beyond issuing real-time audible alerts, the system must also be capable of initiating an automated safety response when the driver fails to regain alertness within a critical time window. This response should be implemented through an integrated control mechanism capable of simulating or enabling vehicle stopping functions.

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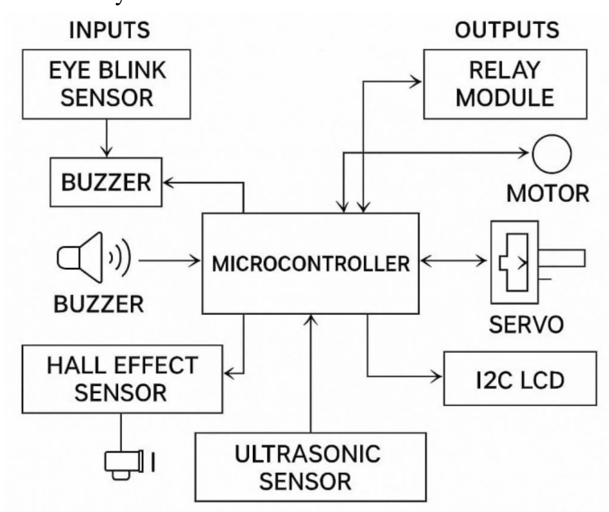
VISION GUARD – SMART EYEWEAR FOR DRIVER ALERTNESS

The Vision Guard system is designed as a compact wearable driver-assistance platform that combines embedded processing with real-time physiological sensing to enhance road safety. The overall architecture prioritizes simplicity, reliability, and rapid response while maintaining a low hardware and computational footprint. The primary objective of the system is to continuously monitor the driver's eye activity and initiate timely warning and intervention mechanisms when signs of fatigue are detected.

At the core of the wearable design is an infrared-based eye blink sensor mounted on the eyewear frame. The placement of the sensor is carefully selected to ensure consistent alignment with the eye while preserving user comfort and minimizing visual obstruction. Unlike conventional camera-based driver monitoring systems, which depend on image acquisition, lighting conditions, and complex vision algorithms, the infrared sensing approach enables direct and fast detection of eyelid movement. This makes the system less sensitive to variations in ambient light, head orientation, and seating posture, thereby improving robustness in real driving environments.

The digital output from the eye blink sensor is continuously sampled by an Arduino UNO microcontroller, which serves as the main processing unit of the system. The microcontroller evaluates the duration of eye closure in real time and compares the measured values with predefined safety thresholds. Under normal driving conditions, natural blinking occurs for very short intervals, typically well below one second. However, extended eye closure is widely recognized as a strong indicator of reduced alertness and potential microsleep episodes.



In the proposed design, when the detected eye closure exceeds three seconds, the system immediately activates an audible warning using a buzzer. This first-level response is intended to prompt the driver to regain attention and restore safe driving behavior. If the eye closure persists beyond five seconds, indicating a more critical state of fatigue or temporary loss of responsiveness, the system escalates its response by

activating a servo motor through the motor control circuitry. This action demonstrates a physical intervention mechanism, representing how the system could be integrated in future implementations with braking, ignition cut-off, or speed control modules.

The Vision Guard platform also incorporates a liquid crystal display that continuously presents the operational state of the system. Typical messages include normal monitoring status, warning notifications during prolonged eye closure, and intervention indicators during critical events. The display improves system transparency and assists both users and developers in verifying system behavior during operation and testing.

Block Diagram & Explanation

The block diagram of the Vision Guard system illustrates the hardware configuration of a real- time driver alertness monitoring system. It is designed to detect drowsiness, warn the driver, and automatically halt the vehicle to prevent accidents. The central controller in this system is the Arduino Uno, which serves as the main processing and control unit. It collects sensor data from various input modules and triggers specific outputs such as buzzers, displays, and motors based on predefined safety logic.

4.2 System Components and Functional Description

Input Components

1. Eye Blink Sensor

The eye blink sensor serves as the primary sensing element for evaluating the driver's level of alertness. It continuously determines whether the eyelids are open or closed and forwards this information to the Arduino UNO in real time. When continuous eye closure exceeds the predefined safe duration, the sensor output indicates a potential drowsiness condition. This mechanism forms the first and most critical layer of detection in the Vision Guard system, enabling early identification of fatigue and facilitating timely preventive action. Continuous monitoring through this sensor significantly contributes to minimizing accidents caused by reduced driver attention.

2. Hall Effect Sensor

The Hall effect sensor is incorporated to observe wheel or shaft rotation and thereby estimate vehicle movement. Each rotation of the wheel generates a magnetic pulse, which is captured and counted by the Arduino UNO. From the pulse count, the system determines whether the vehicle is in motion and estimates its speed. This information is displayed on the LCD module for real-time monitoring and verification. The availability of motion and speed data ensures that automated control actions, such as motor shutdown, are executed only when the vehicle is actively moving, thus avoiding unnecessary intervention.

3. Ultrasonic Sensor

The ultrasonic sensor is used to detect obstacles positioned in front of the vehicle. It operates by transmitting ultrasonic waves and calculating the time required for the reflected echo to return. The Arduino UNO converts this time-of-flight measurement into distance information. When an object is detected within a critical range, the system can initiate a warning or enforce a stopping action. This sensor provides an additional safety layer by supporting collision avoidance during emergency intervention triggered by driver drowsiness.

4. Processing Unit – Arduino UNO

The Arduino UNO functions as the central control and decision-making unit of the Vision Guard system. It collects and processes data from the eye blink sensor, Hall effect sensor, and ultrasonic sensor. Based on the programmed logic and timing thresholds, the microcontroller determines the appropriate system response. The Arduino UNO coordinates all output devices, including the buzzer, relay module, servo motor, and I2C LCD display. In addition, it manages time-based operations such as eye-closure duration measurement and driver response intervals, ensuring synchronized and safe system operation.

Output Components

1. Buzzer

The buzzer provides the first level of user feedback once drowsiness is detected. After the Arduino UNO confirms prolonged eye closure, the buzzer is activated to produce an audible alert. Simultaneously, a predefined response interval is initiated during which the driver is expected to restore attention by opening the eyes. If normal eye activity is detected within this period, the alert is terminated and the system returns to standard monitoring mode. This stage is intended to provide a non-intrusive corrective prompt before automated intervention is applied.

2. Relay Module

The relay module acts as an electronically controlled switch that enables the Arduino UNO to disconnect the power supplied to the drive motor. When the driver fails to respond to the warning stage, the microcontroller activates the relay to isolate the motor circuit. This action ensures immediate cessation of the simulated vehicle drive system, thereby preventing unsafe motion while the driver remains unresponsive.

3. Motor

The DC motor represents the vehicle propulsion unit in the experimental prototype. Its operation reflects the motion state of the vehicle. Upon activation of the relay module, the motor power is interrupted, and the motor stops. This behavior demonstrates how Vision Guard can enforce a controlled stop in the presence of critical drowsiness conditions.

4. Servo Motor

In addition to electronic motor cutoff, a servo motor is used to demonstrate a mechanical intervention mechanism. The servo is controlled directly by the Arduino UNO and is configured to simulate a braking or wheel-disengagement action. This secondary intervention layer enhances system reliability by providing an alternative physical response pathway, which may be required in real-world implementations where redundant safety mechanisms are desirable.

5. I2C LCD Display

The I2C-based LCD module presents continuous system feedback to the user. Displayed information includes driver alertness status, warning and intervention messages, as well as speed and obstacle distance data obtained from the Hall effect and ultrasonic sensors. The display improves transparency of system operation and assists both drivers and developers in understanding the real-time behavior of the Vision Guard platform.

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Flow chart & Explanation

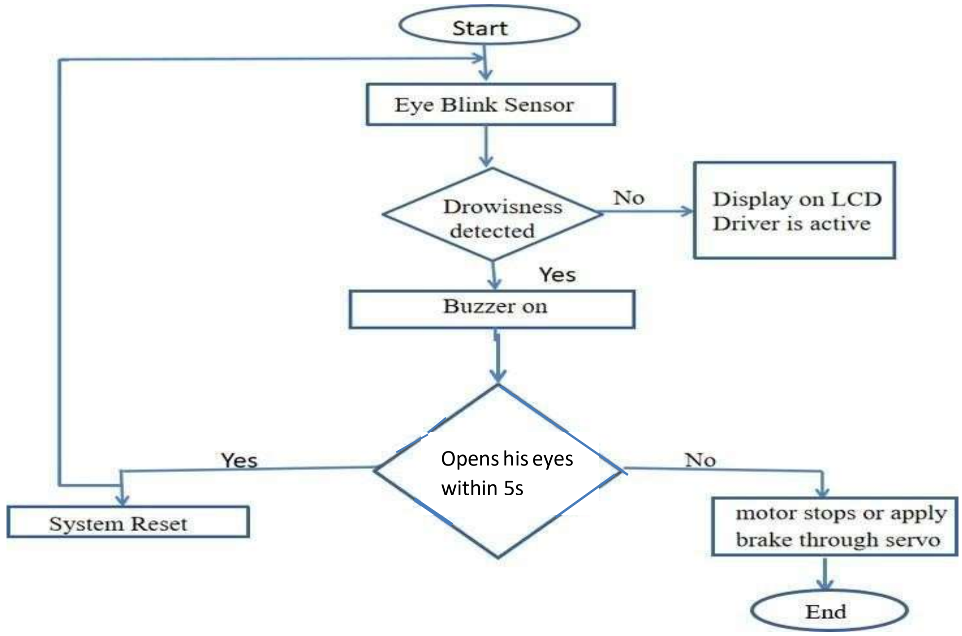

Figure 2 Flow chart

The above Flow Chart is described as follows

The flowchart represents a non-invasive approach, using an eye blink sensor to ensure that the driver's comfort and safety are not compromised by bulky equipment or intrusive methods. The system includes a built-in fail-safe: if the driver doesn't respond within 10 seconds, not only does the motor stop, but the servo motor also applies a physical disengagement, ensuring the vehicle halts safely. The logic shown in the flowchart illustrates how real-time decision making is performed automatically by the microcontroller, without the need for human intervention once drowsiness is detected. The flowchart ensures that the driver is kept informed throughout the process via the I2C LCD display—whether they are active, drowsy, or the vehicle has been stopped for safety

1. The Vision Guard: Smart Eyewear for Driver Alertness system initiates its operation by continuously monitoring the driver's eye state through an embedded eye blink sensor.
2. This sensor constantly feeds data to the system, which then evaluates whether "Drowsiness is detected." This detection occurs if the driver's eyes remain closed for a duration exceeding a pre-set threshold, such as more than 3 seconds. If no drowsiness is detected (i.e., the driver's eyes are open or blinking normally), the system confirms "Driver is active" on an LCD display and continues to loop back, maintaining constant vigilance.
3. However, should drowsiness be detected, Vision Guard immediately activates a "Buzzer on" to provide an audible alert, aiming to wake the driver. Following the buzzer activation, the system enters a critical secondary monitoring phase, checking if the driver "opens his eyes within 5 seconds."
4. If the driver responds and opens their eyes within this timeframe, the system performs a "System Reset," returning to continuous eye monitoring.
5. Conversely, if the driver remains unresponsive and does not open their eyes within the 10-second period, Vision Guard proceeds to its ultimate safety intervention: a "motor stops or apply brake through servo" mechanism is engaged to bring the vehicle to a halt, thereby preventing a potential accident.
6. This critical action marks the "End" of the immediate operational cycle for that specific drowsy driving incident.

Results And Discussion

The performance of the Vision Guard smart eyewear system was experimentally evaluated under controlled conditions in order to assess its detection accuracy, response time, and operational reliability. The testing procedure focused on three representative driving situations that commonly occur in real-world environments, namely normal

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attentive driving, short-term drowsiness with driver recovery, and severe drowsiness without user response. These scenarios were selected to validate both the warning and the automated intervention capabilities of the proposed system.

Normal Driving Condition (Driver Alert State)

In the first experimental case, the system was activated while the driver remained fully attentive and exhibited normal blinking behavior. The eye blink sensor continuously monitored eyelid activity and reported regular blink patterns with no extended eye closure.

Since the measured eye closure duration did not exceed the predefined safety thresholds, the system maintained its monitoring state and did not activate any alert or control action. The LCD display indicated the normal operational status with the message:

"System Ready – Driver is Awake"

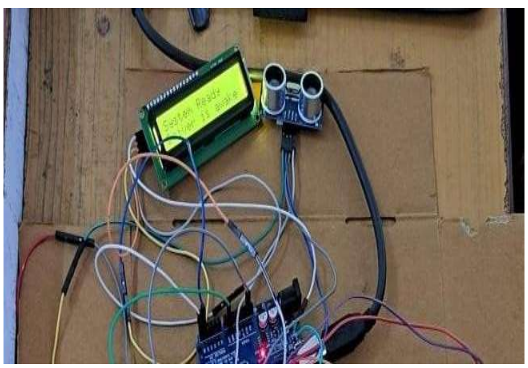

Figure 3 System Ready: Driver is Awake

The buzzer remained inactive and the simulated vehicle drive system continued operating without interruption. This result confirms that the proposed system is capable of distinguishing between natural blinking and fatigue-related eye closure. More importantly, it demonstrates that the system does not generate false alarms during routine driving, thereby ensuring that the wearable device remains non-intrusive and comfortable for continuous use.

Temporary Drowsiness with Driver Response

The second test scenario represented a situation in which the driver begins to experience mild drowsiness but remains responsive to warning signals. During this test, the driver intentionally closed the eyes for a period exceeding three seconds in order to trigger the first alert threshold.

The eye blink sensor successfully detected the prolonged closure and the Arduino UNO activated the audible warning device. At the same time, the LCD displayed the alert message:

"Alert – Drowsiness Detected"

Immediately after the warning was issued, the driver reopened the eyes and resumed normal blinking behavior. The system promptly identified the return to a normal eye state, deactivated the buzzer, and restored the display message to:

"Driver is Awake"

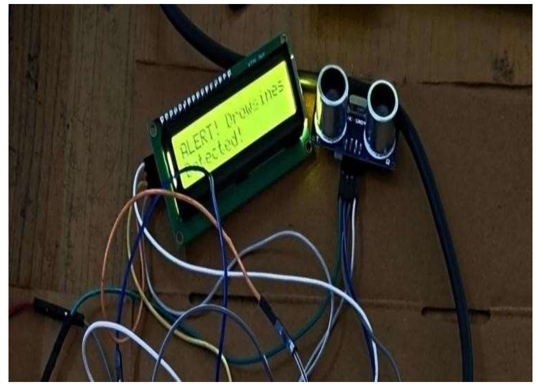

Figure 4 Drowsiness Detected

This experimental case verifies that the proposed system can detect early-stage drowsiness and deliver a timely auditory alert. The quick transition back to the normal monitoring mode after the driver's response indicates that the system operates with low latency and reliable state switching. The results demonstrate that Vision Guard effectively supports preventive safety by enabling drivers to correct their behavior before a hazardous condition develops.

Severe Drowsiness without Driver Response

The final test scenario simulated a critical condition in which the driver experiences extreme fatigue or microsleep and does not respond to warning signals. In this case, the driver maintained continuous eye closure for a duration exceeding five seconds.

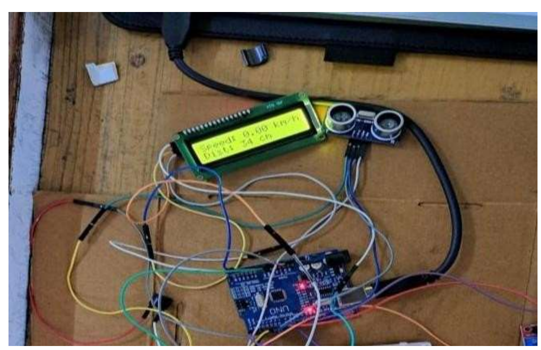

Figure 5 Distance and Speed

After the initial alert phase, and in the absence of any detected recovery in eye activity, the system automatically entered the emergency intervention state. The Arduino UNO triggered the relay module, which disconnected the power supply to the DC motor. As a result, the simulated vehicle drive mechanism was brought to a complete stop.

This automated response confirms the ability of the Vision Guard system to escalate from a warning-only strategy to a direct safety intervention when the driver fails to regain alertness. Such behavior is particularly important in scenarios where the driver may be temporarily unconscious or unable to respond to auditory prompts.

Figure 6 Vision Guard Project Setup

In addition to the intervention action, the LCD display presented contextual operating data to assist in system monitoring and post-event analysis. The displayed information included:

- **Vehicle speed (km/h)** obtained from the Hall effect sensor, and
- **Front obstacle distance (cm)** measured using the ultrasonic sensor.

The availability of this supplementary information demonstrates that the system not only performs driver monitoring and intervention but also maintains situational awareness during emergency events, thereby improving the overall safety intelligence of the platform.

Conclusion And Future Scope

This research presented *Vision Guard*, a smart eyewear-based driver alertness monitoring system developed to mitigate road accidents caused by fatigue and microsleep. The proposed solution adopts a lightweight wearable architecture that continuously observes the driver's eye activity using an infrared eye-blink sensing module mounted on eyeglasses. Unlike camera-centric approaches, the developed system offers fast response, low computational complexity, and stable performance under varying illumination conditions.

The core contribution of Vision Guard lies in its staged safety strategy. When abnormal eye closure exceeding three seconds is detected, the system immediately generates an audible warning to regain the driver's attention. If eye closure persists beyond five seconds, indicating a potentially dangerous level of drowsiness, a mechanical intervention is initiated through a servo-assisted control mechanism that simulates vehicle stopping. This progressive escalation ensures that early fatigue is addressed through non-intrusive alerts, while severe conditions are handled through automated safety actions.

The prototype integrates cost-effective and widely available components, including an Arduino UNO microcontroller, an infrared eye blink sensor, a buzzer, a servo motor, an ultrasonic distance sensor, a Hall-effect speed sensor, and an I²C-based LCD interface. Real-time messages such as system readiness, driver activity status, drowsiness alerts, speed readings, and front-object distance are continuously presented to enhance transparency and user awareness. Experimental validation under different user behaviors and lighting conditions demonstrated stable detection, timely responses, and reliable system transitions between monitoring, alert, and intervention modes.

Overall, the Vision Guard system successfully satisfies the design objectives of affordability, simplicity, and operational effectiveness. The results confirm the feasibility of using wearable sensing technology as a practical alternative to expensive in-vehicle driver monitoring systems. By combining real-time eye monitoring with intelligent alerting and simulated vehicle control, the proposed platform offers a promising and scalable approach for reducing fatigue-related road accidents, particularly in resource-constrained environments.

Future Scope

Although the developed Vision Guard prototype demonstrates reliable performance, several extensions can be introduced to further improve its functionality, adaptability, and deployment readiness.

Integration with vehicle control networks. Future versions can interface directly with in-vehicle electronic systems through Controller Area Network (CAN) communication. Such integration would enable controlled deceleration, braking assistance, or engine torque limitation when a driver remains unresponsive, thereby extending the current relay-based stopping mechanism into a real automotive environment.

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