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Review Article

Development of a Low-Cost Wearable Anti-Sleep Alarm System Using Infrared Sensing

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A B S T R A C T

Driver fatigue remains one of the most significant causes of road accidents across the globe. According to recent surveys, nearly one in every four highway accidents can be traced back to drowsy driving. Fatigue slows human reflexes, reduces alertness, and can result in microsleep episodes, where drivers lose consciousness for a few seconds. Traditional fatigue detection systems, such as camera -based driver monitoring systems or advanced biometric wearables, are often too costly and inaccessible for everyday drivers. This research introduces a low -cost, wearable, and compact 'Anti -Sleep Glasses' that detect eye closure and alert the user through auditory and haptic signals. The device integrates an Arduino Pro Mini microcontroller, an infrared (IR) sensor, a buzzer, and a vibration motor mounted on a conventional eyeglass frame. The IR sensor works on the principle of reflection to monitor eye openness. When eyelids remain closed for more than two seconds, the system activates both a buzzer and a vibrator, en suring the driver is immediately alerted. By providing a cost -effective solution, this research highlights the potential of do -it-yourself (DIY) wearable electronics in reducing fatigue -related accidents. The abstract summarizes the project by emphasizing the growing concern of drowsy driving and how affordable electronics can offer life -saving innovations. This work has broad potential to be adapted not only by individuals but also by public transport and industrial operation.

Keywords: DIY, IR Sensor, Detection System, Biometric, Glasses

Introduction

Road safety has become an increasingly critical issue as the number of vehicles on highways continues to grow. Among the various causes of accidents, driver drowsiness is one of the most dangerous yet least recognized factors. Studies indicate that fatigue is responsible for approximately 20 –30% of road accidents, particularly during long -haul and night driving. Unlike mechanical failures, fatigue -related crashes are preventable if timely detection and warning systems are in place.[1,2]

Existing commercial solutions, such as st eering wheel monitoring systems, camera -based eye trackers, and high -end wearables, though effective, remain either intrusive, costly, or impractical for daily drivers. This project bridges the gap by providing a wearable, low -cost, and DIY alternative. Th e Anti -Sleep Glasses are designed to sense eyelid closure using an infrared reflection detection principle. If a driver's eyes remain shut beyond a critical threshold of two seconds, it indicates possible drowsiness. The system immediately triggers both auditory and haptic alerts to ensure driver awareness is restored.[3,4]

The aim of this project is not only to improve road safety but also to demonstrate how simple, low -cost electronic components can be used in innovative applications. It provides an excellent opportunity for students, researchers, and enthusiasts to explore embedded systems, sensor technology, and human –machine interaction. In addition, the project contributes to the field of Intelligent Transportation Systems (ITS). By integrating such devices in fleets of trucks, buses, and public transport systems, governments and organizations can significantly reduce accident rates, ensuring better public safety.[5]

Literature Review

Several studies have been conducted on driver fatigue detection. Many commercial cars today feature camera -based systems that analyze eyelid movement and head tilt. However, these solutions are expensive and often limited to luxury vehicles. Other wearable solutions, such as smart bands, track heart rate and alert drivers when anomalies are detected. While effective, these systems can be intrusive and may not directly track eye closure, which is one of the most reliable signs of drowsiness. In contrast, the Anti -Sleep Glasses focus specifically on monitoring eyelid closure using an infrared sensor, making them simpler and more cost -effective. Academic research also emphasizes that eye closure is a strong predictor of fatigue, and wearable glasses can act as an immediate and personal safety device. This literature review highlights the importance of low -cost, accessible alternatives to ensure road safety for a wider population.[6-8]

Flow of Operation

Working of Anti-Sleep Glasses

The Anti-Sleep Glasses operate in a step-by-step manner to ensure driver safety, as illustrated in Figure

- **Power Supply:** The device runs on a rechargeable 3.7V battery, which provides continuous energy for all the components. Once the power is switched on, the system becomes active.
- **Eye Movement Detection:** An infrared (IR) sensor is positioned to monitor the user's eyelid activity. It keeps scanning in real-time to check whether the eyes are open or closed.
- **Signal Processing by Arduino:** The signals from the IR sensor are sent to an Arduino microcontroller. The Arduino processes this information instantly and determines the status of the eyes.
- **Drowsiness Check (Threshold Setting):** If the eyelids remain closed beyond a set limit of about 2 seconds, the system identifies this as a sign of drowsiness or microsleep.
- **Warning System Activation:** As soon as drowsiness is detected, the device immediately activates a buzzer and a small vibration motor. These alerts are designed to wake up the driver and prevent accidents.
- **Automatic Reset:** When the eyes open again, the sensor detects normal activity. The Arduino resets the alerts, and the system continues monitoring without requiring any manual action.

The operation of the Anti-Sleep Alarm begins with the IR LED and photodiode detecting eyelid movement, as illustrated in Figure 1. The signal from the sensor is then processed through an amplifier and comparator circuit, and finally interpreted by a microcontroller or timer to trigger the buzzer when eyelids remain closed for a specified duration.

For data transmission and communication, the system uses the MQTT publish–subscribe model, which is shown in Figure 2. This ensures efficient, lightweight communication between the device and connected systems.

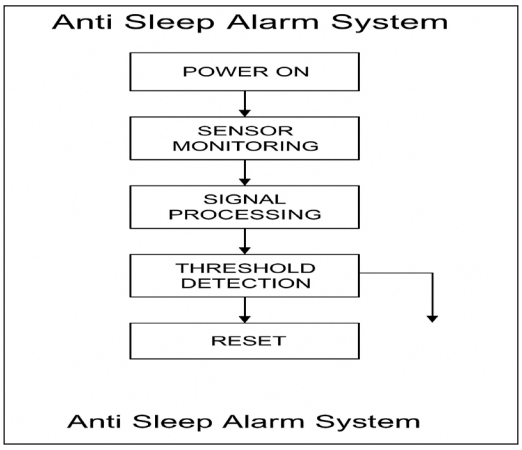

Figure 1.flowchart of Anti-sleep Alarm system

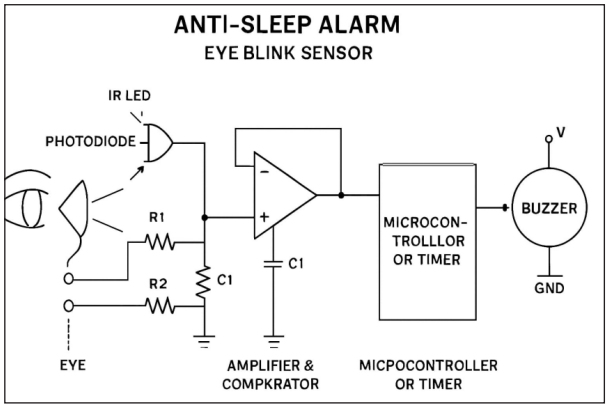

Figure 2.Structural flow of the proposed system

Components and Working Principle

The Anti-Sleep Glasses consist of several low-cost electronic components assembled onto an eyeglass frame. The following components are essential for its functioning:

- **Arduino Pro Mini:** Serves as the brain of the system, processing signals from the IR sensor and activating outputs.

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- **IR Sensor Module:** Consists of an IR LED, photodiode, op-amp, and potentiometer. It detects the reflection from the eyes to determine whether they are open or closed.
- **BC547 NPN Transistor:** Used to amplify the microcontroller output to drive the buzzer and vibration motor. - Resistor (4.7kΩ): Ensures safe current flow into the transistor's base. - Vibrator Motor: Provides tactile feedback when drowsiness is detected
- **5V Buzzer:** Produces an audible alarm to alert the driver.
- **3.7V Battery:** Acts as a portable power source for the system. - Eyeglass Frame: Provides the structure to mount all components in a comfortable, wearable manner.

Working Principle

The IR sensor continuously emits infrared light toward the driver's eyes. When the eyelids are open, a specific reflection pattern is detected by the photodiode. When the eyelids close, the reflection changes significantly, which is detected by the Arduino. If the eyes remain closed for approximately two seconds, the Arduino activates the buzzer and the vibration motor, providing both auditory and tactile alerts. This dual -mode feedback ensures that the driver is effectively reminded to stay alert (fig 3).

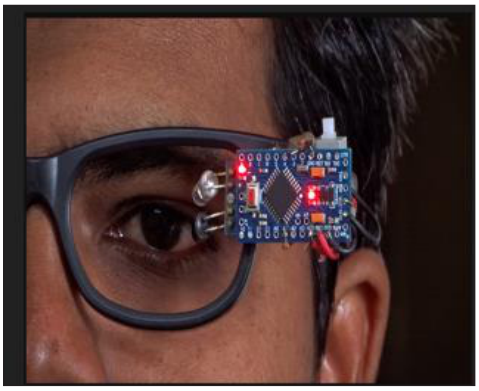

Fig.3 Module output

Applications

The Anti -Sleep Glasses have numerous real -world applications across different fields.

Some of the most notable are:

- **Driving Safety:** The primary application is preventing road accidents by alerting drivers during fatigue. It is especially valuable for truck drivers, long -distance commuters, and night -time drivers.
- **Aviation Safety:** Pilots on long -haul flights may us e the glasses as an additional alert mechanism.
- **Railway Operations:** Train drivers responsible for hundreds of passengers can benefit from such a continuous monitoring system.
- **Industrial Safety:** Workers operating cranes, forklifts, or other heavy mach inery can use it to remain alert.
- **Medical Field:** Doctors and nurses performing critical tasks during night shifts can benefit from drowsiness alerts.
- **Academic Support:** Students engaged in late -night study sessions can avoid drowsiness.
- **Office/IT Professionals :** Employees working extended hours in night shifts can maintain productivity.
- **Defense and Surveillance:** Soldiers or guards performing long hours of duty can use this as an additional safety measure.
- **Public Transport:** Bus and taxi drivers can use it to ensure the safety of passengers.

Conclusion

Driver fatigue is a major contributor to road accidents, and this project offers a practical solution to help reduce such risks. The 'Anti-Sleep Glasses' are a low-cost, wearable device designed to detect prolonged eye closure and immediately alert the driver using sound and vibrations. Using simple components like an IR sensor and an Arduino Pro Mini, the system provides a reliable and budget-friendly way to combat drowsiness behind the wheel. This innovation shows how accessible, DIY electronics can enhance road safety and could be beneficial not just for individual drivers, but also in commercial transport and industrial settings.

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