Design and Implementation of a Driving Assistance System: Guardian Eye

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Abstract- Road traffic accidents caused by driver fatigue pose a significant threat to public safety, often resulting in severe injuries and fatalities. The Guardian Eye Driver Assistance System (DAS) is designed to mitigate this risk by continuously monitoring driver alertness and implementing real-time corrective actions. The system employs an Arduino UNO, based on ATmega328P microcontroller, an infrared (IR) sensor, and a relay mechanism to detect excessive blinking, a key indicator of drowsiness. Upon detection, a sound alarm is triggered to alert the driver, while a signal is transmitted to the Arduino controller to gradually decelerate the vehicle, ultimately bringing it to a safe stop if necessary. Additionally, an automated emergency notification is sent to a designated contact in case of driver incapacitation. The Guardian Eye system is designed to be cost-effective, scalable, and easily integrable into existing vehicle architectures. By providing a proactive response to driver fatigue, this technology has the potential to significantly reduce road traffic fatalities and enhance overall transportation safety.
Keywords – Driver Drowsiness, Guardian Eye, Driver Assistance System

I. INTRODUCTION

Ensuring safety across varied activities and situations is crucial in today's fast-moving society. Driver weariness has been identified as a direct or contributory factor in vehicle crashes, and it presents a risk to transportation networks. A driver's decision-making skills, awareness, and reaction times can all be seriously hampered by fatigue. Research suggests that operating a car when tired is equivalent to operating a vehicle while impaired by alcohol or drugs. According to estimates, sleepiness is a factor in between 2% and 23% of all traffic accidents in affluent countries [1]. The construction of a driver monitoring system that may provide alerts upon detecting tiredness may help prevent accidents and save lives. A. Javadtalab et al. [2] introduced an innovative technique for detecting driver drowsiness by combining methods for eye closure and yawning detection. A camera installed inside the vehicle records the driver's facial features, monitoring the eyes, face, and mouth. This detection process analyzes the eye and mouth regions to identify signs of fatigue. A fusion stage integrates the results to determine the driver's state, issuing a warning when drowsiness is observed. Jose Alguindigue et al. [3], developed a drowsiness detection system employing neural networks and focusing on physiological metrics such as heart rate variability (HRV), electrodermal activity (EDA), and eye-tracking data. This research included thirty participants in simulated driving settings and applied three different deep learning techniques: a sequential neural network (SNN) for EDA, a 1D-convolutional neural network (1D-CNN) for HRV, and eye tracking utilizing a convolutional recurrent neural network (CRNN).

In [4], a Drowsy Driver Identification System has been developed using eye blink detection via machine vision. A webcam monitors head movements and facial expressions to assess drowsiness. MATLAB's cascade object identifier detects facial features, analyzing blink frequency. Upon detecting fatigue, the system alerts the driver. The method achieves over 90% efficiency, enhancing road safety. Chao Zhang et al. [5] proposed a driver drowsiness detection approach utilizing multi-channel second-order blind identification (SOBI). It captures yawning, blinking, and blood volume pulse (BVP) via smart phone cameras as non-contact sensors. H. T. Choi et al. [6] introduces a multimodal deep learning approach that integrates both visual features (like eye and mouth movements) and physiological signals (such as heart rate) to enhance drowsiness detection accuracy. Experimental results demonstrate an accuracy of 90.5%. In [7], authors developed a driver drowsiness detection algorithm based on eyelid movement. The system adapts to various conditions, including low-resolution images. Experimental results show over 98% accuracy. This method enhances fatigue detection and road safety. In [8], the system utilizes real-time monitoring of the driver's eye state using image processing techniques, employing a

Raspberry Pi and camera to track eye movements and calculate the Eye Aspect Ratio (EAR). When the EAR indicates drowsiness, an alarm is triggered to alert the driver. The results indicate that the system can achieve an accuracy of around 80%, although performance may vary based on environmental factors. P. Bajaj et al. [9] developed a driver drowsiness detection system based on vision technology for road safety. A small in-vehicle camera monitors the driver's face and eyes. The algorithm for face recognition uses skin color detection, whereas the eye detection utilizes Circular Hough Transform. It tracks eye states, identifying open or closed conditions. If eyes remain closed for eight frames, a drowsiness alert is triggered. This approach enhances driver safety by providing timely warnings. Albadawi et al. [10] reviewed various visual, physiological, and vehicle-based methods, emphasizing that multi-sensor fusion and deep learning improve detection accuracy and system reliability. In 2023, Kim et al. [11] introduced a real-time IR-based monitoring system using facial landmarks to detect eye closure and head pose, offering efficient performance even under low-light conditions—ideal for embedded applications. Flórez et al. [12] advanced this work by implementing a CNN-based embedded system that analyzed eye and mouth movements to achieve accurate real-time drowsiness detection on edge devices. Most recently, Hassan et al. [13] employed transformer architectures to capture temporal eye-state patterns, enhancing robustness across datasets though at a higher computational cost. Collectively, these studies highlight a clear shift toward intelligent, real-time, and hardware-efficient driver assistance systems integrating visual and behavioral cues for improved road safety.

This article presents the Guardian Eye Driver Assistance System (DAS), an intelligent safety solution designed to monitor driver alertness by tracking eye movements. The system employs an embedded setup comprising an Arduino Uno microcontroller, infrared (IR) sensors, and a relay mechanism to detect signs of drowsiness or inattention. Upon detection, it promptly alerts the driver and gradually decelerates the vehicle to prevent potential accidents.
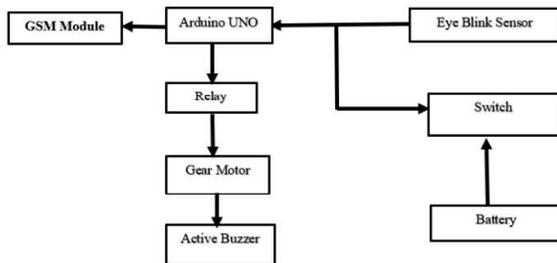

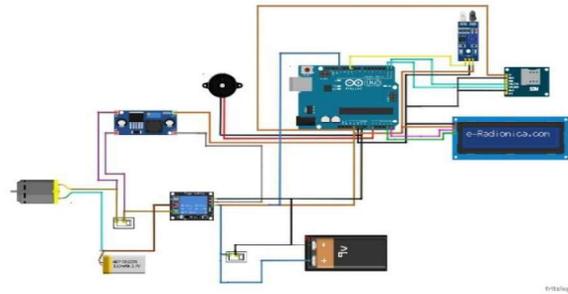**Figure 1:** Block Diagram of Driving Assistance System

Figure 2: Circuit configurations of Driving Assistance System

2. COMPONENT DESCRIPTION

2.1 Arduino UNO
The Arduino UNO is a development board built around the ATmega328P microcontroller. It is powered using a battery, an AC-to-DC converter, or a USB cable to link it to a computer.

Microcontroller: The UNO micro-controller, which is built on the Advanced Virtual RISC (AVR) architecture, is the brains behind the Arduino ATmega328P. It consists 14 digital pins and 6 analog input pins.

Clock Speed: 16 MHz.

Memory: 1 KB of EEPROM, 2 KB of SRAM, and 32 KB of Flash memory.

Figure 3: Arduino UNO

2.2 IR (Infrared) Sensor
An IR sensor interprets the surrounding area by emitting light and is able to detect an object. An IR sensor is capable of measuring the heat of an object as well as detect motion. The emitter is an infrared LED and the detector is an infrared photodiode. A photo-diode is sensitive to emitted IR light from the infrared LED. If a photodiode is exposed to infrared light, its output voltage and resistance will vary based on the intensity of the infrared light it receives.
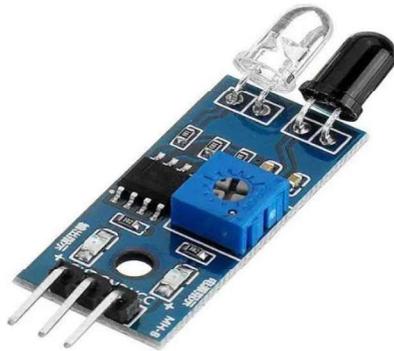
Figure 4: IR sensor

Specifications:
Operating Voltage: 3 to 5 VDC.
Detection Range: 2 to 10 cm.

2.3 Relay

This is a 5V single-channel relay module, commonly used for controlling high-voltage devices with low-power microcontrollers like Arduino and Raspberry Pi. It features an SRD-05VDC-SL-C relay, capable of handling 10A at 250V AC or 30V DC. The module includes an optocoupler for isolation, indicator LEDs for status monitoring, and terminals for easy wiring. It operates with a low-level trigger, making it ideal for automation and IoT applications.

Figure 5: Relay

Specifications:
Voltage: 5V.
Maximum Current: 20mA.
Relay Current Capacity for DC: 5V, 10A.

2.4 DC-DC Buck Converter

The LM2596 series regulators are single-chip integrated circuits which incorporate all the building blocks of a buck (step-down) switching regulator designed to handle 3 A load with reasonable load regulation. It offers fixed output voltages of 3.3V, 5V, and 12V, along with a version that allows adjustable output.
Specifications:
Input Voltage: 12V.
Output Voltage: 5V.

Figure 6: LM2596 DC-DC Buck Converter

2.5 I2C LCD

This is an I2C connected 16x2 character LCD screen, meaning that it has two rows of text, each capable of displaying 16 characters. The screen's specs indicate that the characters shown on the blue background will be white which will further enhance their clarity and presentation. There are also other limitations that need to be tackled, especially in Arduino LCD projects where the I2C interface is not available. For instance, the available number of pins gets limited, most notably when using the Arduino Uno. The same rotary controls do not have a standard wiring scheme, so the multitude of connections becomes a problem. To solve those problems, we can propose this special I2C 16x2 Arduino LCD that uses I2C communication which needs only 4 connections to be made - VCC, GND, SDA, SCL.

Figure 7: I2C LCD

Using the I2C interface also allows for saving a minimum of 4 digital or analog pins on Arduino, therefore simplifying the project's wiring terminals and making it more straightforward.

2.6 DC Motor

The 12V DC motor is a compact, reliable component ideal for rotating small wheels in lightweight projects such as robotics or small vehicles. Powered by a 12V direct current source like a battery, it provides moderate torque and adjustable speed, making it versatile for various applications.

Specifications:
Operating Voltage: 12V.
Current: 0.14A.
RPM: 12500.

Figure 8: DC Motor

2.7 Buzzer
A piezo buzzer is an electronic gadget that sounds an alarm or produces a tone. It typically has a simple design, is lightweight, and is affordable. The applications of piezoelectric vibration plates in small, high-density assemblies are numerous because of their dependability and versatility in producing audible signals, which can range from multi-tones and melodies to monotone buzzes and alarms. Furthermore, they are perfect for many battery-operated devices due to their low power consumption.

Figure 9: Buzzer

III. SYSTEM IMPLEMENTATION

3.1 Implementation
Setting up hardware components: First, all the required components, such as the Arduino UNO,IR Sensor, Relay, DC Motor, Buzzer and I2C LCD screen, are gathered and then connected together as per the circuit diagram.Writing the code: After setting up the hardware,the code for the Arduino UNO board is written. The code consists of giving the signal to relay, and then from relay it goes to the motor. Then a code is written for GSM module to send SMS to a particular phone number and "SMS sent" is displayed on LCD. Uploading the code to Arduino UNO: Once the code is written, it is uploaded to the Arduino UNO board through a USB cable, connected to the computer.
Displaying the message: The message "Warning! The driver might have fallen asleep" is sent to the phone number entered in the code.
3.2 Connections
IR Sensor → Arduino
VCC: 5V
GND: GND
Output: Digital Pin 10
Relay Module → Arduino
VCC: 5V

GND: GND
IN: Digital Pin 7
Motor & Battery
Motor connected to Relay NC (Normally Closed) through switch
Relay NO (Normally Open) left unconnected
Positive of 4V Battery to Motor
Negative of 4V Battery to Relay COM
Buzzer Connection
Positive: Digital Pin 13
Negative: GND
 Switches
Connected to 9V Battery for manual control.

4. RESULTS

4.1 Testing
The system was tested by simulating eye blinks and verifying that the sensor detects the changes accurately. Then, keeping the eyes closed for an extended period (2s or 3s)to see whether the relay functions properly and beeps the buzzer. The relay module effectively switched the circuit to control the alarm and motor system.
4.2 Result
The Driving Assistant system demonstrated reliable performance in detecting drowsiness through blinking of eyes. When the driver's eye remained closed for a particular amount of time (2 sec), the buzzer activated promptly, providing an alert. The relay then cut off the supply and made motor to stop, proving the feasibility of integrating an automatic vehicle control mechanism. The response time of the system was fast. Overall, the system is proved effective in enhancing driver safety, offering a responsive and automated solution for drowsiness detection. The integration of GSM module for emergency alerts further enhances its functionality in real-world applications.

Figure 10: Result on LCD

5. CONCLUSION

The Guardian Eye Driving Assistant System presents a highly effective and automated solution to the pressing issue of driver drowsiness. By integrating an Arduino-based microcontroller, IR sensor, relay module, and buzzer, this system successfully detects excessive eye blinking a key indicator of driver fatigue and triggers an alert. Furthermore, the inclusion of a relay mechanism ensures gradual vehicle deceleration and a controlled stop, helps reducing the danger of crashes resulting from fatigued driving. Compared to existing drowsiness detection methods such as electrooculogram (EOG) monitoring, facial recognition, and physiological signal

tracking the Guardian Eye system offers a cost-effective and easily deployable alternative that does not rely on computationally heavy techniques like deep learning or complex image processing. In conclusion, the Guardian Eye system represents a significant step towards enhancing road safety, offering a practical, low-cost, and scalable approach to preventing drowsiness-related accidents. One limitation of this project is its reliance on infrared (IR) sensor-based eye blink detection, which may be affected by environmental factors such as low light conditions, reflections, or obstructions (e.g., sunglasses). With further research and refinement, this system has the potential to become a standard safety feature in modern vehicles, ultimately saving lives and fostering safer driving environments worldwide.
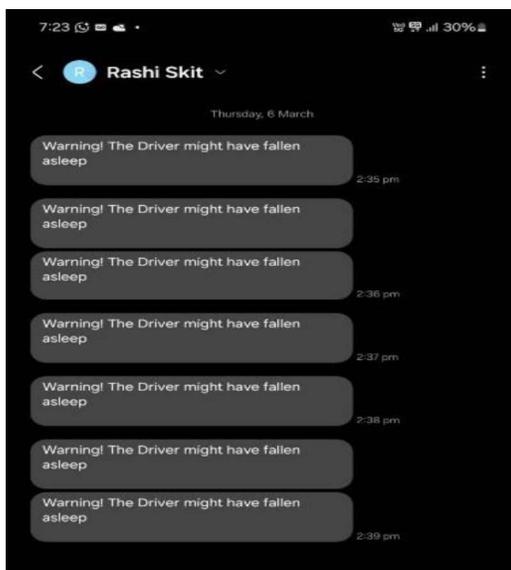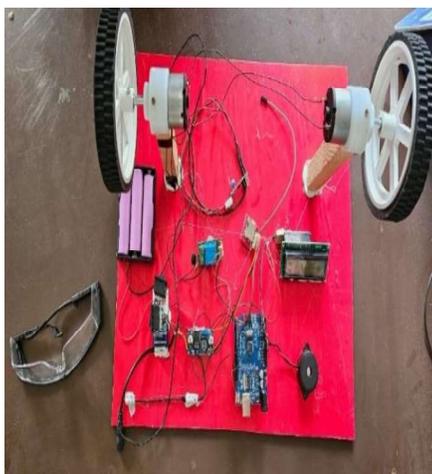

Figure 11: Snapshot of message

Figure 11: Snapshot of Hardware Mode

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