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Automatic Drowsiness Alert and Lane Change System

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Abstract Driver fatigue while travelling for large distances and at night is the most common cause of accidents because of the driver's loss of attention or slow reaction. In order to solve this problem, it will be necessary to create a system that would be able to check the state of the driver's health and react accordingly. In this paper, an algorithm that would be capable of detecting the level of sleep of the driver and make lane switching has been proposed. A computer camera would constantly be monitoring the driver's eyesight. Due to this technology, the driver's eyes would be under control, and his/her fatigued condition can be detected in order to warn the driver about sound and lights. In case the driver ignores the warning, this technology would be activated by switching to the lane where the process of control is performed by the Arduino Uno microcontroller.

I INTRODUCTION

Driving roads is something that has been incorporated in the present-day lives due to most people driving a car to their respective places, like workplaces, school, and other destinations. How increased numbers of vehicles used lead to more accidents due to lack of concentration, and other causes. The first reason behind accidents on the road is falling asleep while driving. Drivers who travel for long hours without having a break may become tired. Therefore, it will be hard for them to concentrate on what is ahead of them. After some time, the driver loses focus, leading to a road accident. This occurs most when a person drives his/her car in dark areas where dark things are quiet, and there is no one to distract the person while driving. Under such circumstances, even a professional driver may sleep while driving without noticing it. There is a need to have a system that continuously monitors the driver to ascertain that they are concentrating while driving.

Various kinds of protective devices are developed in order to reduce damage that may happen as a result of an accident. For instance, airbags, brakes, and seat belts are all designed to protect the drivers, but these mechanisms are ineffective in preventing accidents in cases when the accident happens because of some mistake made by a human, like fatigue or distraction. Therefore, this issue requires a method for continuous monitoring of the driver's behavior. Within this approach, a camera is used to evaluate the state of the driver's eyes at a very high speed. It identifies whether the driver's eyes are open or closed. Everyone needs to keep their eyes closed from time to time; otherwise, it might cause fatigue. If such situations are detected by this device, the person receives an alarm signal, i.e., sounds and lights.

In some instances, inadequate sleep and even more extreme instances may affect the ability of the driver to recognize and react to the signal. This system operates in a way that it performs particular actions under certain circumstances in order to ensure safety. All these operations will be undertaken by the microcontroller Arduino Uno. After the receipt of a signal from the camera system, the system employs its sensors to examine its environment. In this instance, ultrasonic sensors will be used to determine the presence of cars or objects within the surrounding lanes. On the other hand, infrared sensors will be utilized to determine the position of the lanes. Initially, the system will verify whether the surrounding lanes are safe enough before executing the operation of changing lanes. After the operation is successful, the procedure will be executed by turning on the motor via the motor driver. Furthermore, the emergency signals will also be illuminated during the process to notify the surrounding motorists about the entire operation. All these operations are conducted in a systematic way. This system is practical in real-life applications, and future improvements can be made due to its simplicity and affordability.

II LITERATURE REVIEW

Detection of driver sleepiness is not new since it is connected directly with safety. In past studies, researchers used to examine the behavior of the vehicle and conclude whether the driver was drowsy. Some indicators, like actions, lane change, and speed changes, were considered during the process. As soon as the person falls asleep, the man or woman loses control over the car, and it is visible through these indicators. While these techniques could be easy to use, in some cases, they were not effective enough because of other factors affecting the vehicle, like weather and traffic situation. Thus, other methods needed to be applied to determine the driver state.

This kind of necessity has arisen because of the chance to determine the driving circumstances precisely. In this connection, such systems make use of a camera for the purpose of detecting the driver's face in relation to certain parameters like eye movements, eyelid closure, blinking frequency, and the position of the head. Regarding this point, eyelid closure can be considered one of the most precise signs of tiredness. In fact, tired implies the condition when the eye remains closed for an extended time exceeding its regular closed rate. It should be noted that numerous image Analysis techniques have been proposed for the purposes of detecting the issue and signaling about it. At the same time, it should be emphasized that most devices have been unable to implement any other steps apart from delivering a warning message, thus requiring the driver to take some action on his/her own.

This is because the presence of the aforementioned sensor enables the car to have an awareness of its surroundings and act in a manner that prevents any risks. This is because sometimes there were elements in the system that could allow it to act automatically on behalf of the user, where the user did nothing to counter any risk. Combining the two increases the effectiveness of the system in avoiding accidents. The technique used has been accomplished using the same process, where the camera and sensor work together to avoid any risk

.III SYSTEM TOPOLOGY AND CONFIGURATION

The software and hardware parts of the system have been separated into two interconnected levels through the use of an interconnected system design. Software is responsible for processing and decision-making, whereas hardware handles the implementation of any physical control of the system. In other words, as the detection module receives information from its environment through a camera, the controlling module gains control of the vehicle through physical sensors. Both modules interact through a serial communication channel established through the USB port.

3.1 SOFTWARE PROCESSING UNIT:

This system is developed through the use of the Python programming language and OpenCV. The video camera acquires the live footage of the driver's face. It determines if the driver has his or her eyes closed or open for each acquired image. The level of alertness of the driver is determined depending on how long the driver's eyes are closed

- .Eye is closed for less than 2 seconds → Normal condition
- Eye is closed between 2–4 seconds → Warning condition
- Eye is closed for greater than 4 seconds → Emergency condition

These conditions determine the generation and transmission of control signals ("0," "2," and "3") to the microcontroller.

3.2 HARDWARE CONTROL UNIT:

The hardware configuration centers on the Arduino Uno as it performs all physical operations that need to be done. The software sends inputs in the form of serial data into the Arduino board, and the board will perform all predefined functions, such as:

- Activating the warning buzzer
- Controlling motor driver signals
- Reading sensor inputs for safety

Motor control is achieved using the L298N Motor Driver, which regulates the speed and direction of four DC motors used in the prototype vehicle.

3.3 SENSOR INTEGRATION AND SAFETY SYSTEM:

Several sensors are included in the system to guarantee safe operation:

- HC-SR04 → This device detects obstacles and changes lanes safely.
- IR sensors → These are used to track boundaries and detect lanes.
- Buzzer → Used to inform drivers when they are sleepy

By giving the Arduino constant feedback, these sensors make sure that the vehicle only moves in safe situations.

1.2 ENERGY AND POWER CONFIGURATION:

Power for the whole circuit shall be supplied by a lithium-ion battery pack, where the two cells are wired in a series combination giving an output of 7.4V. The motor controller and the drive are supplied with power by the same source of power. Power Distribution takes care of the voltage supply to the units.

3.5 KEY FEATURES OF SYSTEM ARCHITECTURE:

- Modular separation of software and hardware
- Real-time processing using computer vision
- Reliable serial communication between modules
- Multi-sensor safety verification system
- Scalable architecture for future improvements

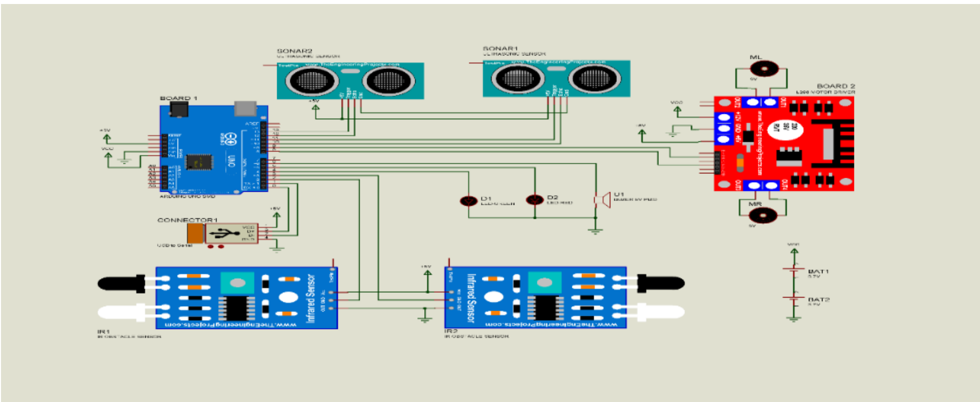

Figure 3.1: System Architecture

IV METHODOLOGY

4.1 SYSTEM SETUP AND WORKING ENVIRONMENT:

The proposed system uses an embedded computer vision approach to detect driver fatigue and manage vehicle operations. The proposed system consists of a vision processing unit and a hardware unit controlled by a microcontroller.

The camera helps to capture a live image of the driver in the model car system. The application has been programmed in the language of Python and OpenCV. The application constantly analyzes the image in terms of eye and face movement to recognize

4.2 IMPLEMENTATION OF DROWSINESS DETECTION LOGIC:

The core methodology is based on eye state monitoring and time-based classification. The system detects whether the driver's eyes are open or closed and calculates the duration of eye closure.

The logic is implemented such that:

- Short eye closure (normal blink) → No action
- Moderate closure (2–4 seconds) → Warning signal generation
- Long closure (> 4 seconds) → Emergency control signal

This decision-making process ensures that driver fatigue is detected at an early stage and appropriate safety actions are triggered.

4.3 SYSTEM COMMUNICATION AND SIGNAL TRANSMISSION:

When sleep is detected, there is proper communication between the computer and the present component using the USB interface. It should be noted that the process of transmitting data from the actual equipment to the software will be carried out in an effective manner. The transmission of such a signal signifies the choice of operating mode, namely normal, warning, and emergency mode. The microcontroller has to control such a signal process.

HARDWARE IMPLEMENTATION AND CONTROL SYSTEM

A hardware unit is controlled by an Arduino Uno, which serves as the main processing controller in all physical operations.

Based on received signals, the Arduino executes specific actions such as:

- Activating buzzer for driver alert
- Controlling motor speed and direction
- Managing safety responses based on sensor input

Motor control is achieved using the L298N Motor Driver, which drives the DC motors used in the prototype vehicle system.

4.5 SENSOR INTEGRATION AND SAFETY VERIFICATION:

To guarantee its safe operation, the system contains extra sensors. Such sensors help evaluate environmental conditions before any movement is performed.

- HC-SR04 is used to detect obstacles and measure distance from nearby objects.
- IR sensors are used for lane detection and path tracking.
- The buzzer is used for immediate alert generation during warning conditions.

The system ensures that any movement or control action is performed only after confirming that the surrounding environment is safe.

4.6 WORKING MODES OF THE SYSTEM:

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The system mainly operates in three modes depending on the driver's condition:

- **Normal Mode:** Continuous monitoring with no output action
- **Warning Mode:** Activation of the buzzer when early drowsiness is detected
- **Emergency Mode:** Automatic control action, such as motor adjustment and safe stopping

Each mode is activated based on real-time analysis of eye closure duration.

4.7 OVERALL OPERATION FLOW:

The system runs in a loop that continues, from the capture of video to the final hardware operation. The order of operations is as follows:

1. Set up a webcam to record the driver's face.
2. Analyze photos with Python and OpenCV.
3. Identify the eye state and calculate a closing time.
4. Send a monitoring signal based on sleepiness level.
5. Transmit a signal to Arduino through serial communication.
6. Arduino operates the corresponding action.
7. Sensors give safety before movement.

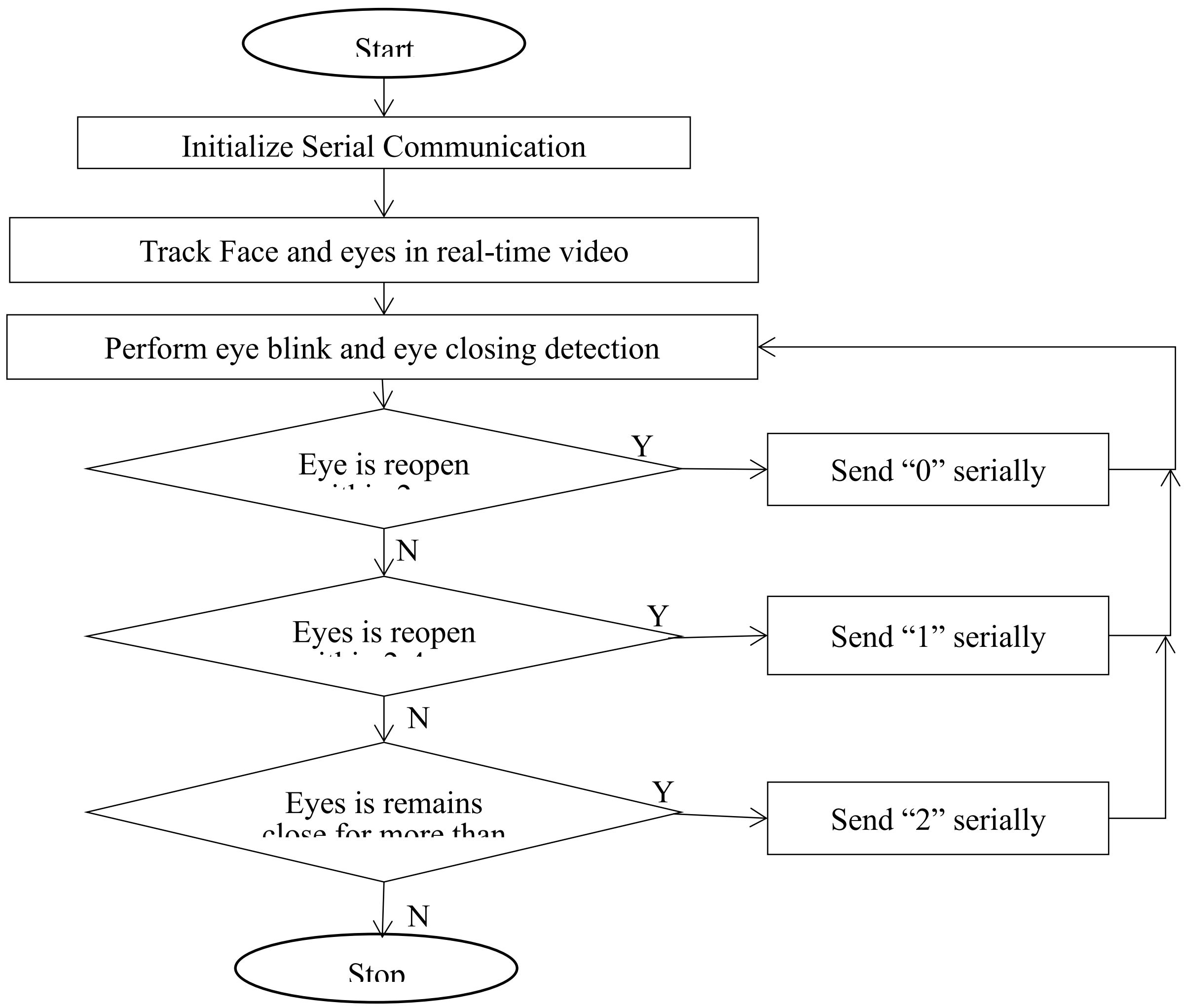

Figure 4.1: Flow chart of Python code

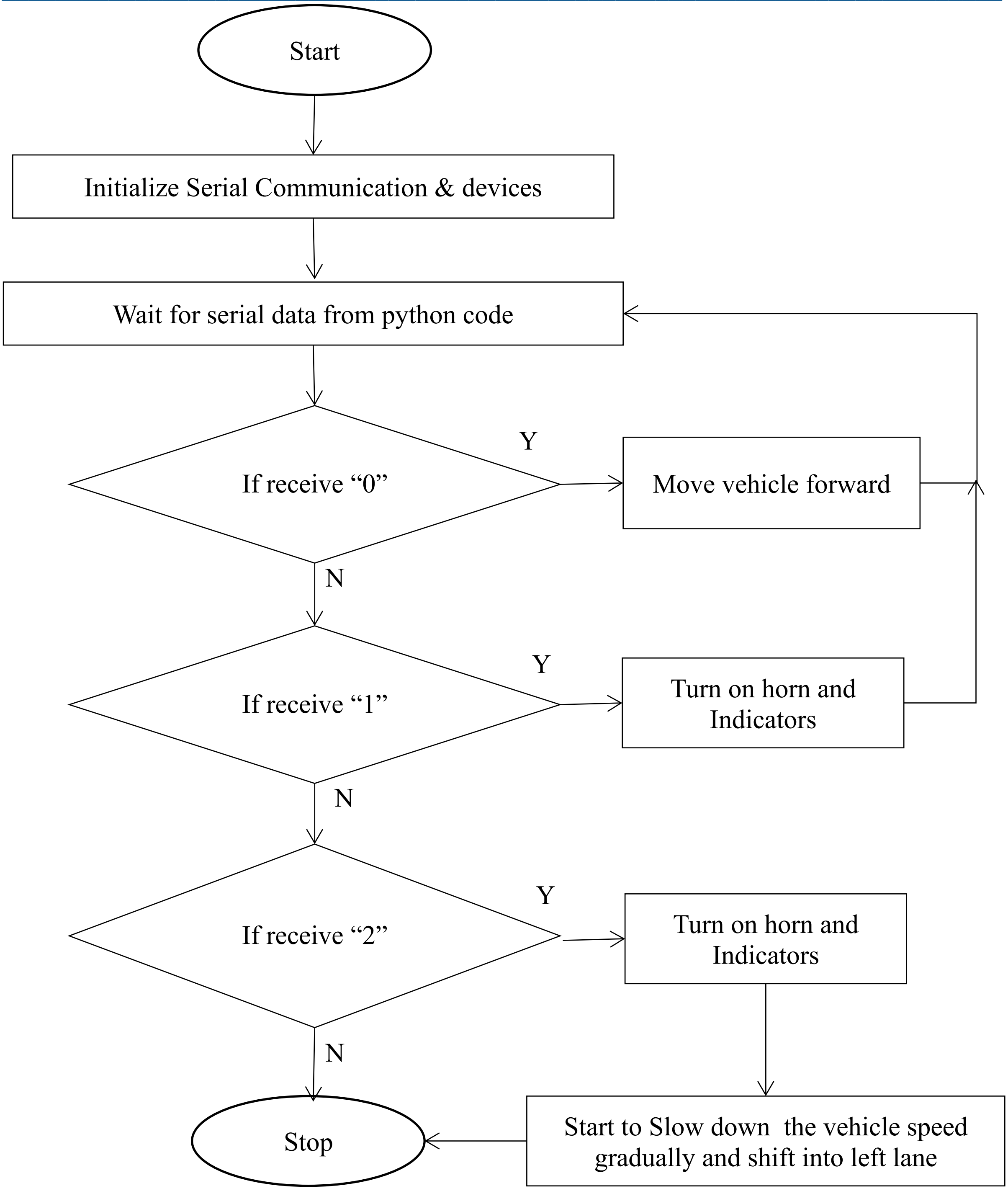

Figure 4.2**:** Flow chart of Arduino code

V PERFORMANCE ANALYSIS

The proposed sleep tracking system for drivers, together with vehicle control, can be analyzed according to the efficiency of sleepiness detection, current -period response, and safety in vehicle handling by the component -based approach. It utilizes computer-based techniques incorporated with control systems, and system effectiveness is estimated based on detection efficiency, real-time response, and operational stability.

5.1 SYSTEM DETECTION PERFORMANCE:

Eye-tracking software is designed using Python and OpenCV that continuously monitors the driver's eye movement of the driver. Accordingly, in laboratory conditions, the technique can differentiate normal blinks or those involving prolonged eye closures. The eye-closure period is the parameter used in identification to identify driving scenarios.

- Normal blinking (< 2 seconds): No action required
- Drowsy condition (2–4 seconds): Warning signal generated
- Critical condition (> 4 seconds): Emergency control signal generated

The system's identification is constant during operation, making it suitable for real-time tracking systems.

5.2 RESPONSE TIME PERFORMANCE:

The system gives a much quicker reaction time to actual action taken. Through the serial communication interface, the software is able to interact and give instructions in a very quick manner. Whenever a signal is received, the hardware reacts instantly and starts working on the output component. For instance, it can make use of the buzzer or the motor control system.

5.3 HARDWARE OPERATION PERFORMANCE:

The hardware section uses the L298N Motor Driver to successfully perform controller commands.

The system works smoothly in all three conditions:

- Normal operation
- Warning mode
- Emergency mode

The setup of sensors increases system performance. The HC-SR04 detects obstacles accurately, making sure vehicle travel is safe. IR sensors help improve lane tracking and direction accuracy.

5.4 SYSTEM RELIABILITY:

The modularity of the system provides reliable operation. Due to the separation between the processing of software and hardware execution, both modules will operate separately from each other. Reliable serial communication, constant supervision, and consistent sensor data contribute to the overall reliability of the system.

5.5 SAFETY PERFORMANCE

Safety is important for the system. The design guarantees that all control operations are carried out only after validating the environmental conditions.

- Warning alerts are sent instantly when drowsiness is detected.
- Verify obstacle-free conditions when performing emergency actions.
- Sensor-based validation prevents dangerous lane movements and crashes.

This well-planned safety system ensures that the vehicle behaves in a controlled and dependable manner.

ADVANTAGES

The suggested driver drowsiness detection and vehicle control system has many significant benefits due to its integration of computer vision and integrated automation.

- The system checks driver awareness in real-time through continuous video analysis.
- It improves road safety by identifying weariness and providing timely warnings.

- The integration of software and hardware enables automated responding operations, reducing dependence on human response times.

- The system is cost-effective as it utilizes easily accessible components like Arduino and basic sensors.

- Its modular architecture allows for easy modifications and expansions with extra features.

- The use of sensor-based allow safe vehicle movement and accident avoidance

DISADVANTAGES

Considering its practicality, the system has some disadvantages that can be addressed in future development.

- Lighting conditions can affect camera detection accuracy.

- Continuous video processing can be computationally complex

- If the driver's face is partially dimmed, the system's accuracy may decrease.

- The system may show reduced accuracy if the driver's face is partially covered or not clearly visible.
- This is a prototype implementation that needs more improvement before being used in real automobiles

- Network or device delays in serial communications might affect response timing

APPLICATIONS

The one that was suggested has multiple uses in the areas of intelligent transportation and safety systems.

- Applications involve driver safety systems for autos and commercial vehicles.

- The system is integrated with Advanced Driver Assistance Systems (ADAS).

- It can be used in public transport vehicles like buses and trucks to prevent accidents.

- The idea can be used in automatic and semi-automatic cars to monitor driving patterns.
- It can be used in fleet management systems to monitor driver behavior
- The prototype can be modified to incorporate industrial vehicle safety systems in warehouses and logistical operations

VI RESULT AND DISCUSSION

In this regard, the proposed system that allows detecting sleep of the driver and controlling a vehicle was correctly created as a working model. Specifically, in its work, this system is continuously monitoring the face of the driver by means of web camera while analyzing the corresponding video frames to is the movements of eyes. Importantly, it was found out that regular blinks do not interfere in the functioning of the system since they are correctly recognized and thus, no action takes place. When the eyes of the user remain closed for some time, exceeding the limit of normal blinking, the system produces the corresponding warning message, which causes the buzzer on the microcontroller board to be activated. When this eye-closing period increase the critical value, an alarm signal is produced, and necessary actions are performed by the Arduino.

The software and hardware components have been able to exchange information efficiently via serial communication, allowing for quick and effective transmission of data. The incorporation of ultrasonic and infrared sensors adds to the safety of the system because all movements or lane changes will only take place when the environment is suitable. From the test result it can be said that the system is capable of detecting driver fatigue in real-time and taking appropriate measures without delay. The integration of computer vision and control systems makes for a highly efficient approach towards enhancing driver safety. Nevertheless, the performance of the system may be affected by low light conditions or situations where the driver's face cannot be detected clearly.

Figure 6.1: Prototype model of a vehicle

CONCLUSION

Data transmission takes place effectively between the hardware and software components through interconnection. This ensures efficient and accurate transmission of data. The application of ultrasonic and infrared sensors makes the system safer since all movements made or lane changes happen only where there are no problems within the surroundings. In conclusion, the experiment shows that the system is capable of identifying and reacting to driver fatigue in real-time. Integration of computer vision and control is an effective technique to improve user safety. Nevertheless, the performance of the system will be less effective in poorly lit areas where the facial expressions of the driver cannot be seen.

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