INTEGRATED ACCIDENT PREVENTION SYSTEM

Names

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Abstract

In today's fast-paced world, road safety remains a critical concern, our project "Integrated Accident Prevention System" aims to enhance driver safety by employing advanced technologies to detect and mitigate potential risks on the road. This comprehensive system incorporates four key components: sleep detection, alcohol detection, automatic dipping of headlights. All these are integrated on Arduino UNO. The sleep detection feature utilizes sensors to monitor driver fatigue levels, issuing alerts when signs of drowsiness are detected, thereby prompting the driver to take necessary breaks or corrective actions. The alcohol detection mechanism employs sensors to analyse the driver's breath or touch, preventing the vehicle from starting if alcohol levels exceed safety thresholds, thus reducing the risk of impaired driving. Automatic dipping of headlights ensures optimal visibility for both the driver and oncoming vehicles by adjusting the intensity and direction of the headlights based on surrounding conditions, thereby minimizing glare and improving overall safety. By integrating these features into a cohesive system, our project endeavours to proactively mitigate the potential for accidents, thereby safeguarding the lives of drivers, passengers, and pedestrians alike, while promoting safer roadways for all.

***Keywords**: Road Safety, Sleep Detection, Alcohol Detection, Automatic Headlight Adjustment, Arduino UNO*

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1. INTRODUCTION

In today's world, staying safe on the road is a big concern. We face a few main problems when we're driving: feeling tired, drinking alcohol, and struggling with bright headlights. These issues can lead to accidents and put lives at risk. Firstly, feeling tired while driving is dangerous. Our busy lives can leave us exhausted, and when we're tired, our reaction times slow down. This means we might not be able to respond quickly if something unexpected happens on the road. Tiredness can sneak up on us, causing accidents without warning. Secondly, drinking alcohol and driving don't mix. Even though we know it's dangerous, some people still choose to drink before getting behind the wheel. Alcohol affects our ability to think clearly and slows down our reflexes, making accidents more likely. Despite efforts to stop it, drunk driving remains a serious problem. Lastly, bright headlights can be a problem, especially at night. When headlights shine directly into our eyes, it can be hard to see properly, making driving tricky and sometimes dangerous. This is called the Troxler effect, and it can cause distractions and make it harder to focus on the road ahead. Our project aims to tackle these issues by using smart technology to keep drivers safe. We're using sensors and clever systems to detect when drivers are tired or have been drinking. We're also working on ways to adjust headlights automatically, so they're not too bright for other drivers. By addressing these problems head-on, we hope to make the roads safer for everyone.

2. CURRENT PROBLEMS FACED BY DRIVERS

Drivers face risks from fatigue, impaired driving due to alcohol, and headlight glare. Fatigue lowers alertness, alcohol impairs judgment, and glare reduces visibility. Solutions are needed to detect fatigue, prevent impaired driving, and reduce headlight glare for safer roads.

2.1 Accidents due to Sleep Deprivation

Driver fatigue is a significant factor in road safety, often leading to severe accidents due to decreased alertness and slower reaction times. Long hours on the road, insufficient sleep, and monotonous driving conditions contribute to drowsiness, which can be as dangerous as driving under the influence. Proactive measures, such as fatigue detection systems, are essential to alert drivers before they reach critical levels of tiredness, thereby preventing potential accidents and saving lives.

The National Highway Traffic Safety Administration (NHTSA) estimates that around **100,000** police-reported crashes each year are the direct result of driver fatigue [1]. These accidents result in an estimated **1,550 deaths** and **71,000 injuries** annually in the United States.

2.2 Accidents Due to Alcohol Impairment

Impaired driving due to alcohol remains a pervasive problem, leading to a significant number of traffic accidents and fatalities each year. Alcohol affects cognitive and motor functions, making it difficult for drivers to react appropriately to road conditions and hazards. Despite strict laws and public awareness campaigns, the danger persists, underscoring the need for effective alcohol detection mechanisms in vehicles to prevent intoxicated individuals from driving.

According to the Centers for Disease Control and Prevention (CDC), alcohol-impaired driving accounts for about 28% of all traffic-related deaths in the United States [2]. In 2019, there were 10,142 deaths from alcohol-impaired driving crashes.

2.3 Troxler effect

The Troxler effect is a perceptual phenomenon where stationary objects in the peripheral vision fade or disappear when one focuses intently on a central point for an extended period. This occurs because the brain stops responding to unchanging stimuli in the peripheral visual field, leading to the disappearance of these objects from conscious perception.[3]

The effect is named after Swiss physician Ignaz Paul Vital Troxler, who first described it in 1804. It demonstrates the brain's tendency to filter out constant, unchanging sensory information to prioritize new or changing stimuli, which are more likely to be relevant or important.

In the context of driving, the Troxler effect can exacerbate the dangers posed by headlight glare. When drivers focus on the bright headlights of oncoming vehicles, their peripheral vision might fade, making it harder to notice obstacles or changes in the road environment. This combination of glare and the Troxler effect can significantly impair a driver's ability to maintain awareness and react promptly to potential hazards, increasing the risk of accidents.

2.4 Accidents Due to the Troxler Effect

The Troxler effect, combined with the intense glare from headlights, poses a subtle yet serious risk to drivers, particularly at night. This visual phenomenon can cause drivers to lose focus on important visual cues, leading to accidents. Glare from oncoming headlights can temporarily blind drivers, increasing the risk of collisions. Implementing adaptive headlight systems that automatically adjust brightness and direction can significantly reduce this risk, improving safety for all road users. According to Forbes, the statistics shown in Figure.1 gives the details of the accidents that had occurred in the year 2013 in Asia due to over-bright light. It shows clearly that India tops the list [4]. Hence, this becomes the major concern to think of a new innovative solution that is useful and also cost effective.

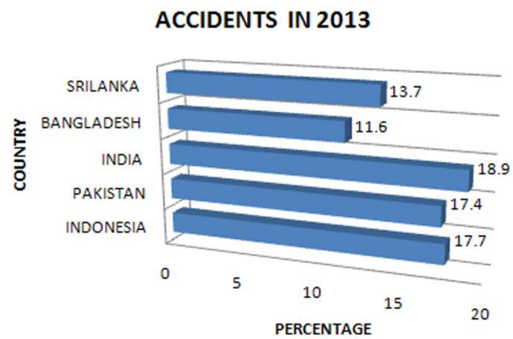

Figure-1:Accident report of Asia due to Troxler effect

3.HEAD LIGHT BEAMS

The headlight of vehicles in India typically consists of two bulbs, one for high beam and the other for low beam. From 6:00 pm to 5:00 am, especially during late-night travels, headlights are crucial for visibility. Drivers can switch between bright and dip modes using a switch. Bright mode is used in areas with no other sources of light, such as long highways or dark streets, providing maximum illumination [5]. On the other hand, dip or low beam is less intense and aimed lower, suitable for normal night driving conditions. Dip beam emits 700 lumens, while high beam emits 1200 lumens when tested at a standard distance of 50 feet from the vehicle [6]. Figure 2 shows the range of the low beam and the high beam. However, the high beam's longer range and higher brightness index can directly impact drivers approaching from the opposite direction. With a spread angle of 135 degrees for dip beam and 15 degrees for high beam [5], their respective ranges and coverage are evident. Human eyes can withstand around 1000 lumens when the source is at 20 feet. Therefore, it's crucial to switch to the dip beam when approaching oncoming traffic to ensure safe and courteous driving at night.

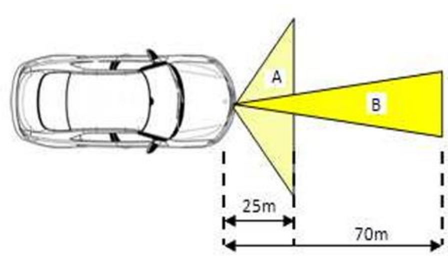

Figure-2: Range of low beam bulb (A) and high beam bulb (B) of a car

4.THE PROTOTYPE MODEL

4.1 Block Diagram & Circuit Diagram

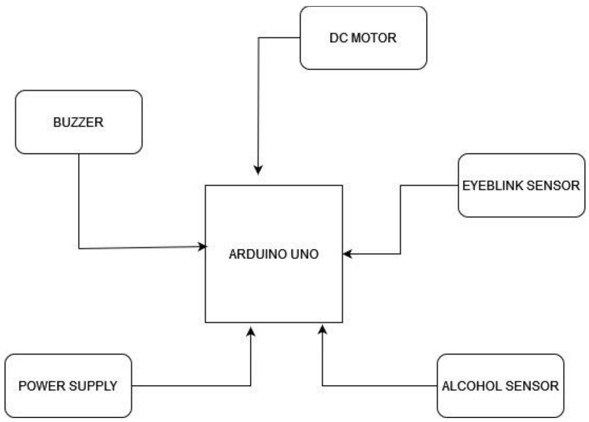

Figure-3: Block diagram of Alcohol and Sleep detection

Using an Arduino Uno, IR sensor, and MQ3 gas sensor, our system detects sleep and alcohol presence. The IR sensor senses the user's presence, activating alcohol detection via the MQ3 sensor when necessary. Upon detecting alcohol, a buzzer alerts, and a DC motor may deploy physical deterrents. The Arduino coordinates sensor data and actuator control. With user interface, power supply, enclosure, and safety measures, it's a comprehensive solution

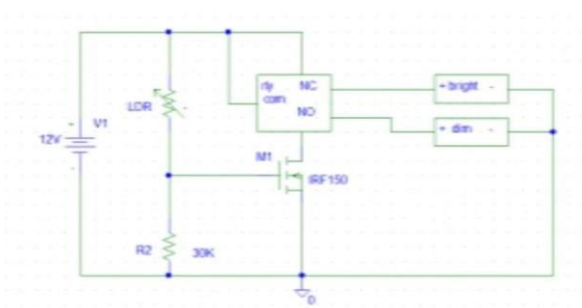

Figure-4: Circuit diagram of Automatic light dipping

The circuit is a simple assembly of commonly used circuit components. The layout is shown in Figure-4. The components have been chosen with utmost care and accuracy so as to keep the design simple and easy to implement.

4.2 Components Used

The various components used in the circuit are

Arduino UNO: The main control unit of the system, responsible for processing data from sensors and controlling other components. However, it's not directly involved in the automatic headlight dipping function.

Eye Blink Sensor (IR sensor): Monitors the driver's eye movements and detects instances of drowsiness or fatigue. When signs of drowsiness are detected, the system triggers alerts to prompt the driver to take breaks.

Buzzer: Produces audible alerts or alarms when the system detects signs of driver fatigue or alcohol impairment.

DC Motor: Simulates the vehicle engine in the prototype model. It can be controlled by the Arduino to demonstrate the system's response to different driving conditions.

Relay: Controls the switching between low beam and high beam headlights. The Arduino activates the relay to switch the headlights based on the surrounding conditions or driver inputs. However, it's not directly related to the automatic headlight dipping function.

MQ3 Alcohol Sensor: Detects the presence of alcohol in the driver's breath or touch. If alcohol levels exceed safety thresholds, the system prevents the vehicle from starting or alerts the driver.

LDR Sensor: Measures ambient light levels. This data is used to automatically adjust the intensity of the headlights based on surrounding conditions to minimize glare and improve visibility. This sensor is directly related to the automatic headlight dipping function.

LEDs: Represents the low beam and high beam headlights in the prototype. The LEDs illuminate to demonstrate the switching between low and high beams controlled by the LDR sensor.

BC547 Transistor: Acts as a switch to control the current flow to the LEDs representing the headlights. The LDR sensor controls the transistor to switch between low beam and high beam modes based on ambient light levels.

30k Ohm Resistor: Used in conjunction with the LDR sensor to form a voltage divider circuit. This circuit helps in converting changes in light intensity detected by the LDR sensor into a measurable voltage signal.

Lithium-Ion Battery: Powers the prototype system, providing energy for the components involved in the automatic headlight dipping function.

Power Supply for Arduino: Supplies power to the Arduino board to ensure its continuous operation. It's not directly related to the automatic headlight dipping function.

Breadboard and Jumper Wires: Used for prototyping and connecting the various electronic components together on a temporary basis. Jumper wires provide the necessary connections between components on the breadboard. They are used for the automatic headlight dipping function's circuitry.

4.3 Principle of operation

Sleep Detection:

The sleep detection system utilizes an eye blink sensor to monitor the driver's blink patterns. By continuously monitoring the frequency of eye blinks, the sensor can detect prolonged periods without blinking, indicating potential driver drowsiness. If such a scenario is detected, the system triggers an alert, activating the buzzer and stopping the motor to prompt the driver to take corrective action. This proactive approach helps prevent accidents caused by driver fatigue.

Alcohol Detection:

In parallel, the alcohol detection system employs an alcohol sensor to analyze the driver's breath or touch for alcohol presence. If the sensor detects alcohol levels exceeding safety thresholds, it immediately triggers an alert, preventing the vehicle from starting. This preventive measure aims to mitigate the risk of impaired driving and potential accidents due to alcohol consumption.

Automatic headlight dipping:

The automatic headlight dipping system enhances night driving safety by dynamically adjusting between high and low beams based on ambient light. It uses a Light Dependent Resistor (LDR) to sense incoming light intensity. As light intensity increases, such as from oncoming headlights, the LDR's resistance decreases, causing an imbalance in the potential divider network, which triggers a transistor. The transistor activates a relay that switches from the normally closed (NC) terminal (high beam) to the normally open (NO) terminal (low beam), reducing glare for oncoming drivers. When the light intensity decreases, the LDR's resistance increases, restoring balance, switching off the transistor, and deactivating the relay to revert to high beams. This system ensures optimal visibility and minimizes glare, enhancing nighttime driving safety and reducing accident risks.

4.4 Flow Chart

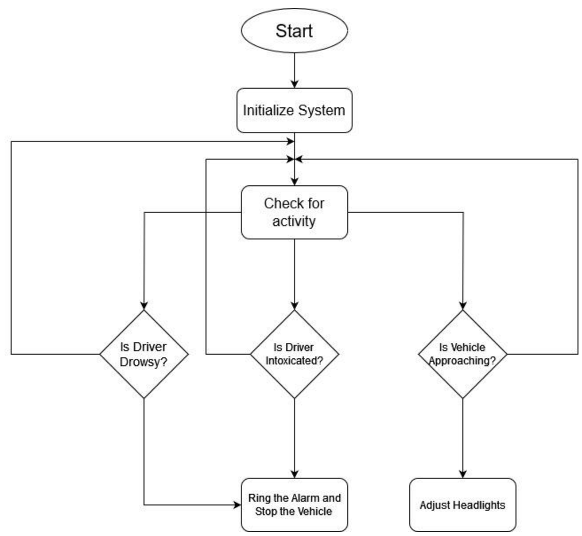

Figure-5:Flowchart of our project

In this flowchart as shown in figure-5 , the motor or the vehicle is initialised, then the system checks for the following activities: if the driver is drowsy, then the alarm rings and the vehicle is stopped if not then again, the system goes for a check. Also, if the driver is intoxicated, again the alarm rings and if not system checks for the activity. Similarly, if any vehicle is approaching, the headlights will be adjusted to low beam automatically if not again it shifts to the higher beam. This is how the flowchart works.

5.THE ACTUAL MODEL

5.1 Real-Time Operation of the Integrated Accident Prevention System

Based on the prototype, an actual working model of the same circuit has been constructed as shown in the figure-6.

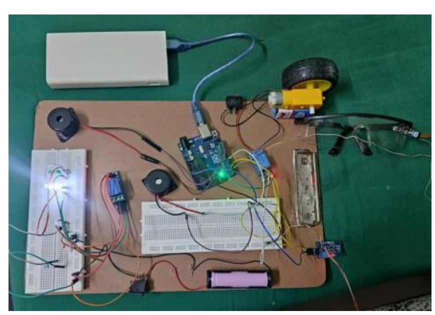

Figure-6: The Actual Model

The exact same components have been used in its construction.

Sleep Detection with IR Sensor

In Real time the sleep detection system employs an IR sensor embedded in transparent glasses worn by the driver to monitor eye blink patterns in real-time as shown in figure-7.

Figure-7:Driver awake

The IR sensor detects the driver's blinks by sensing interruptions in the infrared beam caused by eyelid movement. The Arduino UNO processes this data, tracking the duration between blinks. If it detects prolonged periods without blinking, indicating potential drowsiness, It activates a buzzer and stops the motor as shown in the figure-8, prompting the driver to take a break.

Figure-8:Driver drowsy

For the prototype, the Arduino UNO is powered by an adapter, ensuring a stable power supply for continuous monitoring. In a real-time application, the system would be integrated with the car's battery, providing a constant and reliable power source for the sensors and Arduino.

Alcohol Detection

The alcohol detection component uses an MQ3 alcohol sensor placed near the driver's seat to continuously sample the driver's breath. The sensor detects the presence and concentration of alcohol in the breath. If the concentration exceeds the safety threshold, the Arduino UNO triggers an alert, activating the buzzer and preventing the vehicle from starting by stopping the motor as shown in the figure-9.

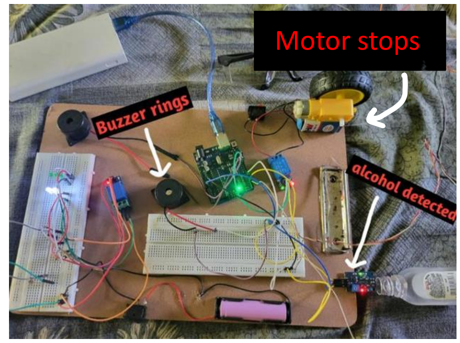

Figure-9:Acohol Detection

For demonstration purposes, a 9-watt battery powers the DC motor used to simulate the engine operation. In a real vehicle, the alcohol detection system would draw power directly from the car's battery, ensuring the sensor and alert mechanisms are always operational.

Automatic Headlight Dipping

The Automatic Headlight Dipping System enhances night driving safety by using an LDR to detect the intensity of incoming light, particularly from oncoming vehicles. This system operates in real-time by simulating conditions where the LDR is exposed to bright light, such as the headlights of an approaching vehicle, causing a change in the LDR's resistance. The system is powered by a 12V DC supply, which, in practical applications, can be sourced from the car's battery pack. The headlights, LDR, and transistor are all connected to this DC supply.

Under normal conditions, the vehicle operates using a high beam bulb, represented by a white LED in Figure-10. In this scenario, the relay is in the Normally Closed (NC) position.

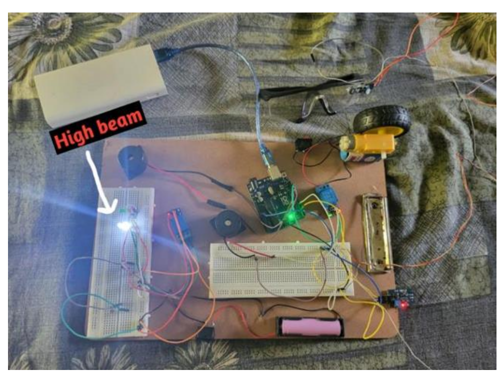

Figure-10: Normal condition

To observe the real-time operation of this circuit, a high-intensity flashlight is employed to mimic the scenario of an approaching vehicle. When the LDR detects light, the circuit should automatically transition from high beam to low beam mode. Thus, as long as the LDR senses the bright light (representing an approaching vehicle), the high beam bulb (WHITE LED) remains illuminated. However, once the incident light intensity surpasses a certain threshold, indicating the close proximity of another vehicle, the LDR registers this increase and experiences a drop in resistance.This drop triggers conduction in the transistor, causing the relay to switch its contacts. Consequently, the Normally Open (NO) contact, connected to the low beam bulb, is activated. Simultaneously, the Normally Closed (NC) terminal is deactivated. Consequently, the low beam light automatically switches on (indicated by the GREEN LED in Figure-11). The left side of Figure-11 is illuminated by the flashlight to simulate the presence of an approaching vehicle.

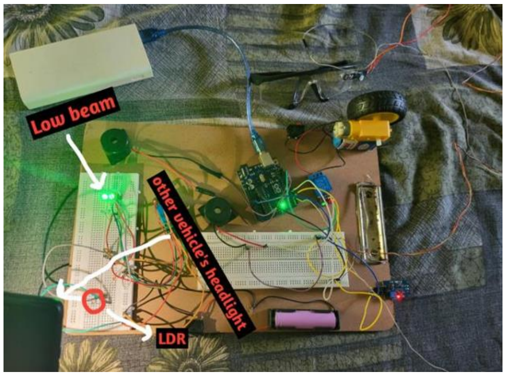

Figure-11: Automatic change to low beam

5.2 The Implementation

The model had been constructed and proved to be working model. There are a few criteria which need to be addressed while placing this device in a real vehicle. Implementing the Integrated Accident Prevention System (IAPS) in real-time necessitates meticulous placement and installation of its components within the vehicle to ensure optimal functionality and user interaction. Here's a detailed breakdown:

Sleep Detection with IR Sensor
Placement: The IR sensor, embedded in transparent glasses, should be comfortably worn by the driver. It should be positioned to effectively monitor the driver's eye blink patterns without causing discomfort or obstruction to vision.
Installation: The Arduino UNO, along with the buzzer and motor control, can be installed within the vehicle's dashboard or console area for easy access and monitoring. Wiring should be neatly routed to avoid interference with other components.

Alcohol Detection:
Placement: The MQ3 alcohol sensor should be strategically placed near the driver's seat to facilitate easy breath sampling. It should be positioned in a location where it can accurately detect the driver's breath without obstructing movement or comfort.
Installation: Similar to the sleep detection system, the Arduino UNO and alert mechanisms can be installed within the dashboard or console area. Proper ventilation should be ensured to prevent any buildup of gases from the alcohol sensor.

Automatic Headlight Dipping:
Placement: The LDR sensor should be mounted on the exterior of the vehicle, preferably near the front windshield or on the roof, to effectively sense incoming light intensity from oncoming vehicles as shown in the figure-12.

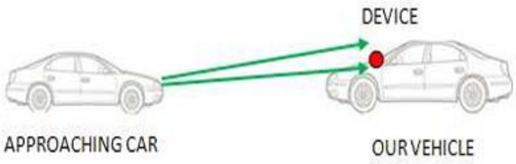

Figure-12:Positioning of the device

Installation: The circuitry for automatic headlight dipping, including the transistor-relay circuit, should be installed within the vehicle's engine compartment or near the headlights. Proper insulation and waterproofing should be applied to protect the components from environmental elements.
Concerns may arise regarding potential interference from other sources of light on the road, such as signboards, street lights, and buildings. However, since an LDR is utilized as the light sensor and its placement is highly directional, it remains unaffected by these additional light sources that may be present in the vicinity. Furthermore, the nature of light emitted by a vehicle's headlamp is distinct. The maximum spread angle of the headlight is limited to 135 degrees [5]. In contrast, other light sources, such as signboards and streetlights, are typically located further away from the road, resulting in a significantly higher spread angle.
As a consequence, by the time light from these other sources reaches the sensor, its intensity is greatly reduced below the triggering threshold level. Therefore, the system's sensitivity remains focused primarily on the specific nature of light emitted by approaching vehicles, ensuring reliable detection and appropriate switching between high and low beam

modes without being affected by extraneous light sources.

Power Supply
Integration: All components of the IAPS should be integrated with the vehicle's electrical system. The Arduino UNO, sensors, and alert mechanisms should be powered by the car's battery, typically a 12V battery, to ensure consistent and reliable operation.
Wiring: Careful attention should be paid to wiring and connections to avoid interference with other vehicle systems and ensure safety. Wiring should be neatly routed and secured to prevent any hazards or malfunctions.

6. LMITATIONS

One Sided High-beam situation: Despite its advancements, the Integrated Accident Prevention System (IAPS) has some limitations:
A significant limitation of this prototype arises when one vehicle approaching from the opposite direction has its high beam engaged while the other vehicle has its low beam activated. In such scenarios, the space at which the automatic switching occurs may be reduced, potentially causing glare for the driver using the low beam. Additionally, this prototype does not address the issue of glare from the rear, which occurs when vehicles with high beam headlights closely follow another vehicle [6].Therefore, despite its effectiveness in detecting and responding to oncoming high beam headlights, this prototype falls short in situations where both high and low beams are present from opposing vehicles. Moreover, it does not mitigate glare from vehicles positioned behind, necessitating further improvements or complementary systems to address these challenges comprehensively.
Sunlight Sensitivity: The IR sensor used for sleep detection may be overly sensitive to sunlight, leading to potential inaccuracies during daytime driving.
Environmental Factors: Adverse weather conditions or poor road conditions may affect system performance, especially for the automatic headlight dipping feature.
Dependency on Power Supply: Reliability is contingent upon a stable power supply, which could be disrupted by battery issues or electrical faults.

CONCLUSIONS

The Integrated Accident Prevention System marks a significant leap forward in automotive safety technology. By seamlessly integrating advanced sensors and real-time monitoring mechanisms within vehicles, we've created a comprehensive solution to address the risks of driver fatigue, alcohol impairment, and poor visibility.

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