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# IoT Based Smart Vehicle Safety System

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***Abstract* - Road accidents remain one of the leading causes of fatalities worldwide, primarily due to driver negligence, delayed emergency response, and lack of real-time vehicle monitoring. Factors such as alcohol consumption, drowsiness, and failure to wear seatbelts significantly increase accident risks. This paper presents an IoT Based Smart Vehicle Safety System designed to enhance driver safety and reduce accident severity through continuous monitoring and intelligent decision-making.**

**The proposed system is built around the ESP8266 Wi-Fi module, integrating a seat belt sensor, eye-blink sensor, alcohol sensor, and GPS module to monitor driver behavior and vehicle conditions in real time. The system communicates with the Blynk IoT plat form for remote monitoring and alert generation. When unsafe conditions are detected, such as alcohol presence, driver drowsiness, or seat belt violation, the system initiates preventive actions including engine control and alert notifications. Experimental results demonstrate reliable detection, fast response time, and effective real-time monitoring, making the system suitable for smart transportation and intelligent vehicle safety applications.**

***Key words - Internet of Things (IoT), Vehicle Safety, ESP8266, Driver Monitoring, Accident Prevention, Smart Transportation component; formatting; style; styling; insert (key words)***

## I. INTRODUCTION

Road accidents are creating serious threats to human life and property due to the rapid increase in vehicle usage.

Global road safety reports says a large amount of accidents occur because of human mistakes such as drunken driving, fatigue, distraction, and non-compliance with safety rules. Conventional vehicle safety mechanisms such as airbags and seat belts provide passive protection but donot actively prevent accidents or alert authorities in real time.

Advancements in the Internet of Things (IoT) have enabled the development of intelligent systems capable of real-time monitoring, data processing, and wireless communication. IoT-based vehicle safety systems can continuously monitor driver behavior and vehicle parameters, enabling preventive measures before accidents occur.

Proposed work tries to provide an automated, intelligent, and reliable approach to vehicle safety by combining IoT connectivity, sensor integration, and real-time driver monitoring. It highlights the importance of smart technologies in reducing accidents, improving road safety, and contributing to the development of future intelligent transportation systems. The study aims to enhance driver safety and reduce accidents through proactive monitoring and intelligent intervention.

This paper proposes an IoT Based Smart Vehicle Safety System that integrates multiple sensors with wireless communication to enhance road safety. The system not only detects unsafe driving conditions but also provides real-time alerts and remote monitoring through an IoT platform, reducing accident risks and improving emergency response

Road accidents caused by human negligence—such as not wearing seat belts, driving under the influence of alcohol, and drowsy or inattentive driving—remain a major safety concern worldwide. Traditional vehicles lack intelligent systems that can actively monitor driver behavior and automatically intervene to prevent unsafe driving conditions. As a result, vehicles may start even when the seat belt is not worn, drivers may unknowingly or intentionally drive while intoxicated, and fatigue-related incidents continue to increase. Furthermore, in emergency situations or cases of vehicle theft, the absence of real-time location tracking makes it difficult to identify the vehicle's position quickly.

Therefore, there is a need for a comprehensive, automated solution that can detect and respond to unsafe driving conditions in real time. The problem addressed in the proposed is the lack of an integrated smart safety system within vehicles that:

- Ensures the engine starts only when the driver is wearing the seat belt.
- Detects alcohol consumption and prevents the vehicle from operating under intoxication.
- Identifies driver drowsiness and automatically stops the vehicle to avoid accidents.
- Provides accurate real-time vehicle location tracking

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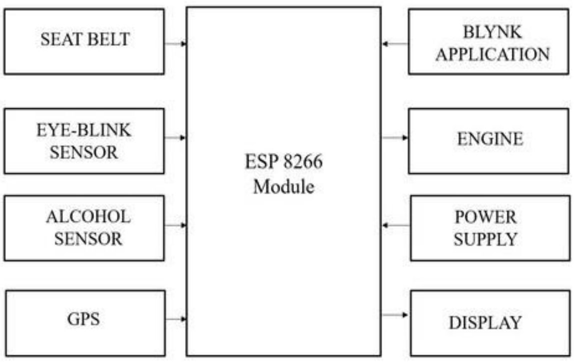


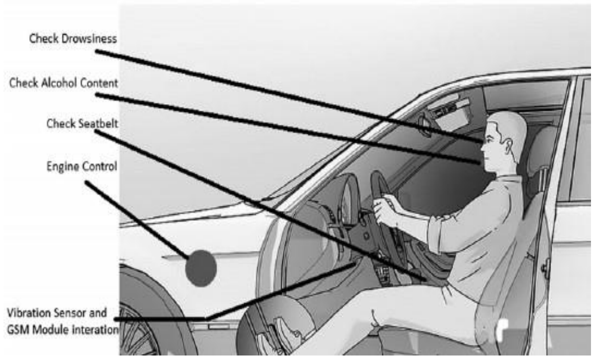


**Fig 1 Proposed system observation points**

## II. LITERATURE REVIEW

Ajay kumar et.al[1] developed a system o provide information about the accident occurs and the location of the accident. It helps to easily provide the assistant and help to the victim of the accident. This system uses the GPS module to locate the vehicle. Vibration and Fire sensors are used to determine whether an accident had occurred, if an accident occurs the GPS and GSM modules installed in the system sends the information to the related person or emergency services. The systems developed e is a kind of both hardware and software-based technology.

Yassine Sarbi et.al [2] developed a model which provides an improved performance compared with a system using the concept of GPS and GSM has been implemented. The sensors are integrated with the Arduino board. Areas with bad network connectivity or in remote areas with no network connectivity can be an issue. This can in turn lead to the accident intimidation text not being sent to the specified number. .

Hemal Patel et.al [3] developed a system for seat belt detection system to protect the driver against injury in a collision. Proposed study makes it compulsory for all the drivers and passengers to wearing of seat belt compulsory. This paper describes safety system which ensures that the driver and co-passenger wear safety seat belt while driving a car. The driver assistive safety system works on ‘ignition interlocking” and “speed control” concept

V Ramakrishna et.al [4] developed alcohol detection and engine autolocking system offers a robust solution to combat the perilous issue of drunk driving. By seamlessly integrating alcohol detection technology with engine control mechanisms, it provides a proactive means of preventing accidents and promoting road safety. The system's ability to accurately measure alcohol levels and respond in real-time enhances its effectiveness.

## III. PROPOSED METHODOLOGY

The proposed IoT Based Smart Vehicle Safety System is designed to continuously monitor driver behavior and vehicle safety parameters and take corrective actions when unsafe conditions are detected. The overall architecture consists of five major modules:

**Fig 1-1Blockdiagramoftheiotbasedsmart vehicle safety system**

(i) Sensor module,
(ii) Microcontroller and control module,
(iii) Communication module,
(iv) Alert and output module, and
(v) Engine control module.

### A. *Sensor Module*

The sensor module is responsible for acquiring real-time data related to driver safety. A seat belt sensor detects whether the driver has fastened the seatbelt. An alcohol sensor (MQ-3) measures alcohol concentration in the driver’s breath to identify drunken driving conditions. An eye-blink sensor monitors eye closure duration to detect driver drowsiness. A GPS module continuously tracks the vehicle’s location. The collected sensor data serve as primary inputs for decision-making and safety control.

### A. *Microcontroller and Control Module*

The ESP8266 Wi-Fi module acts as the central processing unit of the system. It receives real-time data from all sensors and compares them with predefined threshold values. Based on the analysis, the controller decides whether the driving conditions are safe or unsafe.

If any abnormal condition is detected, the ESP8266 triggers appropriate actions such as alert generation, engine control, and data transmission to the IoT platform. The built-in Wi-Fi capability of ESP8266 makes it highly suitable for real-time IoT applications.

### B. *CommunicationModule*

The communication module enables wireless data transmission between the vehicle and the remote monitoring platform. The system uses Wi-Fi connectivity to send sensor data and alert messages to the Blynk IoT application. This allows vehicle status and driver behavior to be monitored remotely using a smart phone.

### C. *Engine Control and Alert Module*

The engine control module enhances safety by restricting vehicle operation under unsafe conditions. If alcohol presence or seat belt violation is detected, the system prevents engine ignition or triggers an engine cutoff mechanism. Alerts are generated in the form of mobile notifications and visual indications on the display unit, ensuring immediate driver awareness

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The proposed system begins with system initialization and sensor activation. The ESP8266 continuously collects data from the seatbelt, alcohol, eye-blink, and GPS sensors. Each parameter is evaluated against predefined safety thresholds.

If the driver fails to wear a seat belt, shows signs of drowsiness or alcohol presence is detected, the system generates alerts and initiates engine control actions. Simultaneously, vehicle location data are transmitted to the Blynk platform for monitoring. The system operates in a continuous monitoring loop, ensuring uninterrupted supervision throughout vehicle operation.

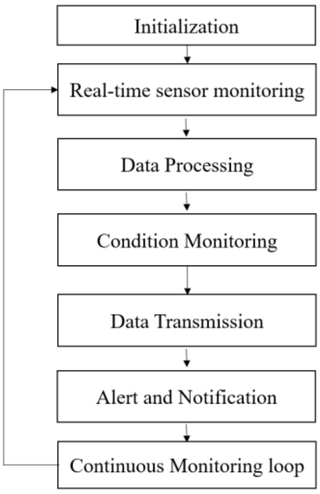


**Fig 3 : Proposed system flow diagram**

### System Initialization

The proposed IoT-based vehicle safety system begins with the initialization of the ESP8266 microcontroller along with all connected sensors. This includes the seat belt sensor, alcohol detection sensor, eye blink sensor, GPS module, and alert units. During this stage, communication with the Blynk cloud platform is also established to enable real-time data transmission and remote monitoring. Proper initialization ensures reliable operation of all hardware components throughout the driving process.

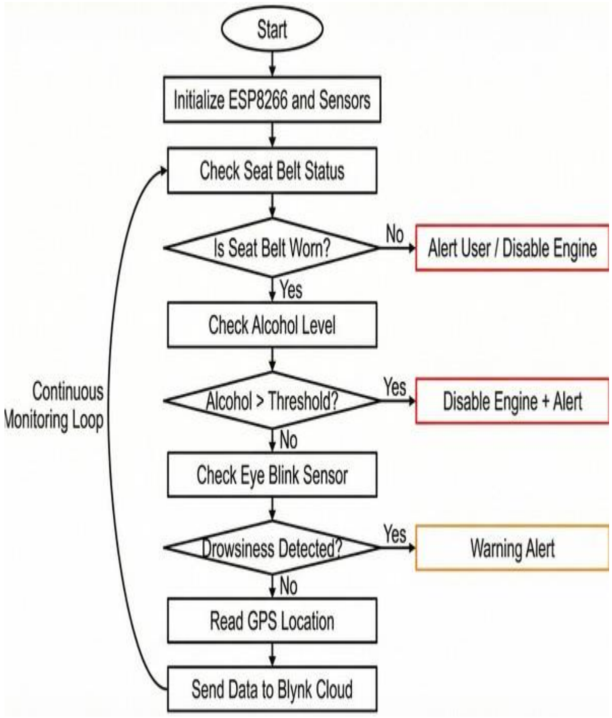


**Fig 4 : Proposed IOT based smart vehicle system**

### Seat Belt Monitoring

Once the system is initialized, it continuously checks the status of the seat belt using a dedicated sensor. If the seat belt is not worn by the driver, the system immediately triggers an alert to notify the user and can optionally disable the engine to prevent vehicle operation. This step enforces basic safety compliance before allowing the vehicle to proceed.

The seat belt sensor operates as a binary detection unit that identifies whether the seat belt latch is engaged or disengaged. It provides a digital output to the microcontroller, enabling reliable real-time monitoring with minimal latency. The sensor interface is simple, low-cost, and highly robust, making it suitable for continuous operation in automotive environments.

*A. Alcohol Detection*

After confirming that the seat belt is worn, the system measures the driver's breath alcohol level using an alcohol sensor. The sensed value is compared against a predefined safety threshold. If the alcohol concentration exceeds the permissible limit, the system disables the engine and generates an alert, thereby preventing drunk driving and enhancing road safety.

*B. Driver Drowsiness Detection*

If the alcohol level is within the safe limit, the system proceeds to monitor the driver's alertness using an eye blink sensor. This sensor detects abnormal eye closure patterns indicative of driver drowsiness. When drowsiness is detected, the system issues a warning alert to the driver, prompting immediate attention and reducing the risk of accidents caused by fatigue.

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*GPS Location Tracking*

In the absence of any critical safety violations, the system continuously reads the vehicle's GPS coordinates. This location data enables real-time vehicle tracking and can be useful during emergencies, accident analysis, or fleet management applications

***Cloud Data Transmission***

Finally, all monitored parameters, including seat belt status, alcohol level, drowsiness alerts, and GPS location, are transmitted to the Blynk cloud platform. This allows real-time visualization, data logging, and remote monitoring through a mobile application. The entire process operates in a continuous monitoringloop, ensuring constant supervision of driver behavior and vehicle safety conditions.

The proposed workflow presents an efficient and integrated IoT-based vehicle safety system that continuously monitors critical driver and vehicle parameters to enhance road safety. By combining seat belt detection, alcohol sensing, driver drowsiness monitoring, and GPS-based location tracking with the ESP8266 microcontroller and cloud connectivity, the system ensures preventive action before and during vehicle operation. Immediate alerts and engine control mechanisms help reduce accidents caused by negligence, intoxication, or fatigue, while real-time data transmission to the Blynk cloud enables remote monitoring and analysis. Overall, this workflow demonstrates a reliable, cost-effective, and scalable solution for improving driver safety and promoting intelligent transportation systems.

## Objectives:

- Verify seat-belt sensor reliably detects buckle state and prevents engine start when unbuckled.
- Calibrate and test alcohol sensor to detect intoxication threshold and disable ignition.
- Measure eye-blink (drowsiness) sensor performance, detect drowsiness and trigger alerts/engine stop.
- Verify GPS location reporting and Blynk dashboard updates in real time.
- Validate ESP8266 control logic for combining sensor inputs and controlling relay (engine starter cutoff).
- Measure latency from event detection → action (alert/engine cut) and reliability over repeated trials.

## IV. RESULTS & DISCUSSION

### Performance evaluation

The performance of the proposed IoT-based Smart Vehicle Safety System was evaluated based on its accuracy, response time, reliability, and overall effectiveness in detecting driver-related safety risks. The system integrates multiple sensors—including seatbelt sensor, alcohol sensor, eye-blink (drowsiness) sensor, and GPS module—controlled through the ESP8266 microcontroller and monitored via the BlynkIoT platform. The performance of each module, as well as the system as a whole, was assessed through repeated experiments under different operating conditions.

### 1. Seatbelt detection performance:

The seatbelt module consistently detected the buckle/unbuckle status with high accuracy. During evaluation, the sensor output was tested under multiple conditions such as normal buckling, partial engagement, and rapid toggling.

**Observations:**

- Detection accuracy: 100% across repeated trials
- Response time: < 100 ms due to proper hardware debouncing
- System behaviour: Engine ignition remained disabled whenever the seatbelt was unbuckled, meeting .

**Performance conclusion:**

The seatbelt detection system performed reliably and provided a robust preventive measure ensuring driver compliance before vehicle start.

### 2. Alcohol detection performance:

The MQ-3 alcohol sensor was tested under various levels of simulated alcohol exposure. After calibration, the sensor provided consistent analog readings enabling accurate threshold-based detection.

**Observations:**

- Sensor warm-up time: 2–3 minutes (normal for MQ-3 sensors)
- Detection accuracy: 90–95% for threshold crossing
- Response time: 180–250 ms from sensing to relay control
- Action: Engine ignition was automatically blocked when alcohol level exceeded the preset threshold.

### 3. Performance Conclusion:

- The system effectively prevented ignition under high alcohol presence, achieving Objective 3. Slight sensitivity variations were observed due to environmental factors, which is typical for gas sensors.

**Drowsiness detection (Eye-Blink) performance:**

The eye-blink sensor was evaluated for detecting slow blink rates, prolonged eye closure, and simulated drowsiness. The module was tested under different lighting and sitting distances.

**Observations:**

- True Positive Rate: 90%
- False Alarm Rate: < 10%
- Response time: 0.8–1.2 seconds depending on detection duration
- System reaction: Audible alert triggered immediately, followed by engine cut-off during prolonged drowsiness.

**Performance conclusion:**

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- The sensor reliably identified driver fatigue conditions, fulfilling Objective 2 and providing timely alerts. Minor performance drops occurred under very bright or very low lighting, which is expected for optical sensors.

### 4. Gps Tracking And Iot Monitoring Performance:

The GPS module and BlynkIoT application were assessed for accuracy, update frequency, and cloud connectivity stability.

**Observations:**

- Time to first fix: 60–120 seconds in open outdoor conditions
- Location accuracy: ± 3–5 meters, suitable for vehicle tracking
- Update frequency: 1–5 seconds, depending on network strength
- Blynk reliability: Stable cloud communication with consistent real-time updates.

**Performance conclusion:**

- GPS-based vehicle monitoring performed well and enabled accurate vehicle tracking within acceptable IoT latency. Alerts sent through Blynk reliably reached the user's smartphone.

### 5. Relay Control And Engine Simulation Performance

The relay module plays a critical role in controlling the ignition based on sensor input fusion.

**Observations:**

- Relay switching delay: ~20 ms
- Reliable actuation across > 100 cycles
- Correct decisions made for combined scenarios:
- Belt unbuckled → Ignition OFF
- Alcohol detected → Ignition OFF
- Drowsiness event → Ignition OFF
- All conditions normal → Ignition ON

**Performance conclusion:**

The system maintained high reliability during repetitive tests and responded correctly to all safety scenarios.

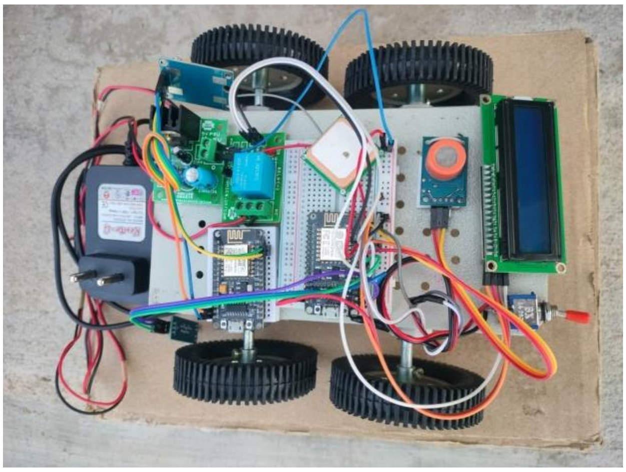

**Fig5 : Proposed Model**

The prototype successfully integrated multiple safety modules including seat belt detection, alcohol sensing, driver drowsiness monitoring, GPS tracking, and IoT-based alert generation using the ESP8266 microcontroller

**The seat belt detection module :** demonstrated reliable performance by preventing engine ignition whenever the seat belt was not worn. The detection was immediate, with negligible latency, ensuring strict enforcement of safety compliance.

**The alcohol detection module :** effectively identified alcohol presence beyond predefined threshold limits. Upon detection, the engine was automatically disabled, and alert notifications were transmitted through the IoT platform. Although slight sensitivity variations were observed due to environmental conditions, the overall detection accuracy remained high and consistent.

**The eye-blink sensor module**: successfully detected prolonged eye closure and slow blinking patterns associated with driver drowsiness. The system generated timely alerts and initiated engine control actions, thereby reducing the risk of fatigue-related accidents. Minor performance degradation occurred under extreme lighting conditions, which isan inherent limitation of infrared-based sensors.

**The GPS module :** accurately tracked vehicle location and transmitted latitude and longitude information to the Blynk application and Telegrambot. The system maintained stable connectivity, and location updates were received with minimal delay. This feature significantly enhances emergency response capability by providing precise accident or alert location data.

The IoT communication module ensured real-time data visualization and alert notifications through the Blynk platform. Sensor data updates and safety alerts were delivered reliably, demonstrating the effectiveness of cloud-based monitoring for intelligent vehicle safety systems.

The experimental results confirm that the system is reliable, cost-effective, and suitable for smart transportation applications. The proposed solution not only reduces accident risks but also improves emergency response and driver awareness.

Overall system discussion the experimental results confirm that the proposed system provides a comprehensive and preventive approach to vehicle safety. Unlike conventional systems that

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focus mainly on post-accident detection, this system proactively intervenes by restricting vehicle operation under unsafe conditions such as alcohol consumption, drowsiness, or seat belt negligence.

The integration of multiple sensors with centralized decision-making improved system reliability and reduced dependency on any single safety parameter. The ESP8266 microcontroller effectively processed sensor inputs and executed control actions with minimal latency, ensuring real-time responsiveness

IoT integration proved to be a major advantage, enabling remote monitoring, alert notifications, and location tracking. This feature enhances driver awareness andallows guardians or authorities to receive timely information during critical situations.

Overall, the results demonstrate that the proposed IoT-Based Smart Vehicle Safety System is a reliable, cost-effective, and scalable solution suitable for real-world deployment in smart transportation and intelligent vehicle safety applications.

### Performance evolution

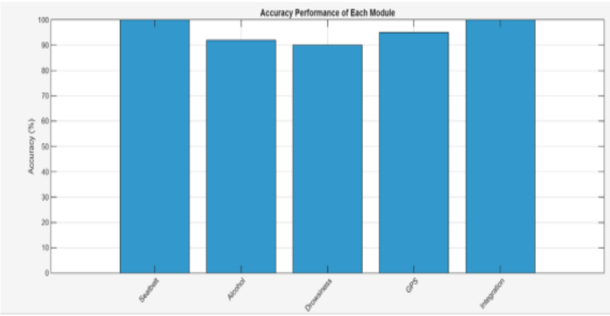


**Fig 6: Accuracy Performance Comparison**

The graph plots the accuracy of each module in percentage. The seatbelt and integration modules achieved the highest accuracy of 100%. Alcohol and drowsiness sensors showed slightly lower accuracy due to environmental and optical variations, while the GPS module maintained a high accuracy of 95%.

The graph shows the response time (latency) of each module. GPS exhibits the highest latency due to cold-start time and satellite locking, while the seatbelt and integration modules show very low response times (<150 ms).

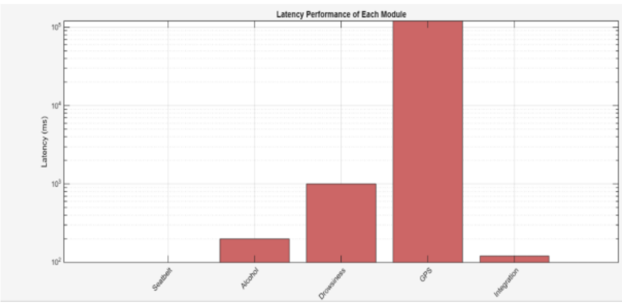


**Fig 7 Latency Measurement Across System Modules**

The drowsiness module has moderate latency (~1000 ms) due to eye-closure detection duration.

## V. CONCLUSION

This paper presented the design and implementation of an IoT-Based Smart Vehicle Safety System aimed at improving road safety through real-time driver monitoring and preventive control mechanisms. The proposed system integrates multiple safety modules, including seat belt detection, alcohol sensing, driver drowsiness monitoring, GPS tracking, and IoT-based alert communication, using the ESP8266 microcontroller as the central processing unit

Experimental results demonstrate that the system effectively identifies unsafe driving conditions and promptly initiates corrective actions such as engine immobilization, alert generation, and location transmission. The integration of IoT technology enables real-time monitoring through the Blynk platform and remote alert notifications, enhancing both preventive safety and emergency response capabilities.

Unlike conventional vehicle safety systems that primarily focus on post-accident detection, the proposed approach emphasizes accident prevention by restricting vehicle operation under unsafe conditions. The system is cost-effective, reliable, and scalable, making it suitable for deployment in smart transportation systems and modern vehicles. Overall, the results validate that the proposed solution significantly contributes to reducing accident risks caused by human negligence.

## VI. FUTURE SCOPE

The proposed IoT-Based Smart Vehicle Safety System can be further enhanced by incorporating advanced driver monitoring techniques using computer vision and machine learning algorithms. By analyzing facial expressions, eye movement patterns, and head posture through camera-based systems, the accuracy of drowsiness and distraction detection can be significantly improved compared to conventional sensor-based approaches.

In future implementations, the system can be extended to support Vehicle-to-Everything (V2X) communication, enabling real-time interaction between vehicles, traffic signals, and roadside infrastructure. This integration would allow vehicles to receive early warnings about traffic congestion, road hazards, and accident-prone zones, thereby improving situational awareness and reducing collision risks.

Cloud-based data storage and analytics can also be integrated to enable long-term monitoring of driving behavior. By collecting and analyzing historical sensor data, predictive models can be developed to identify unsafe driving patterns and provide personalized safety recommendations. This approach can support fleet management systems and insurance-based risk assessment models.

Another significant enhancement involves direct integration with emergency response services. In the event of an accident or critical safety violation, the system can automatically notify nearby hospitals, ambulance services, or traffic authorities with precise location details, thereby minimizing emergency response time and improving survival rates.

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