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Driver Stability Detection Before Vehicle Starts

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Abstract: *Road accidents caused by driver drowsiness, alcohol consumption, fatigue, and unsafe driving behavior continue to be a major concern worldwide. Most existing driver monitoring systems operate only after the vehicle has started, limiting their ability to prevent accidents at an early stage. This paper presents the development and performance evaluation of an IoT-based Driver Stability Detection System Before Vehicle Start. The proposed system integrates computer vision, IoT technologies, and multiple sensors to assess the driver's physical and mental condition before vehicle ignition.*

The system utilizes a camera module for monitoring driver alertness, an MQ-3 alcohol sensor for detecting alcohol concentration, a seat belt verification module, and physiological monitoring sensors. Data collected from these modules is processed through a microcontroller-based architecture to determine the driver's fitness for operating the vehicle. Based on the evaluation, the system either permits or restricts vehicle ignition. Additionally, GSM and GPS modules are employed to generate emergency alerts and transmit real-time location information when unsafe conditions are detected.

The developed prototype was tested under various driving scenarios including alcohol detection, drowsiness detection, seat belt verification, and normal driving conditions. Experimental results demonstrate reliable system performance in identifying unsafe driver states and preventing vehicle operation under risky conditions. The proposed system offers a proactive approach to road safety by ensuring that only stable and alert drivers are allowed to operate vehicles, thereby reducing the likelihood of road accidents.

Keywords: Driver Stability Detection, Internet of Things (IoT), Driver Monitoring System, Drowsiness Detection, Alcohol Detection, Computer Vision, Vehicle Safety, Pre-Ignition Safety System

I. INTRODUCTION

Road accidents are a major public safety concern worldwide, resulting in significant loss of life and property every year. Driver-related factors such as drowsiness, fatigue, alcohol consumption, health issues, and negligence are among the primary causes of these accidents. Impaired driving conditions reduce concentration, reaction time, decision-making ability, and overall driving performance, thereby increasing the risk of collisions and road fatalities.

However, these systems primarily focus on protecting passengers after an accident occurs rather than preventing the accident itself. Existing Driver Monitoring Systems (DMS) use cameras and sensors to monitor driver behavior during vehicle operation, but most of these systems become active only after the vehicle has started. As a result, an unstable or impaired driver may still begin driving before any preventive action is taken.

To address this limitation, an intelligent pre-ignition safety mechanism is required that evaluates the driver's condition before allowing vehicle operation. The proposed IoT-Based Driver Stability Detection System Before Vehicle Start assesses the driver's physical and mental fitness using computer vision and sensor-based technologies. The system integrates a camera module for drowsiness detection, an MQ-3 alcohol sensor for alcohol level monitoring, seat belt verification, and health monitoring modules. The collected data is processed through a microcontroller-based platform to determine whether the driver is fit to operate the vehicle safely.

If unsafe conditions such as alcohol consumption, fatigue, or seat belt non-compliance are detected, the system restricts vehicle ignition and generates alerts. Additionally, GPS and GSM modules provide location tracking and emergency

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notifications when required. By ensuring that only stable and alert drivers are allowed to start the vehicle, the proposed system contributes to accident prevention and enhances overall road safety.

II. PROPOSED SYSTEM

The proposed IoT-Based Driver Stability Detection System Before Vehicle Start is designed to evaluate the driver's physical and mental condition before allowing vehicle ignition. The system aims to reduce road accidents caused by driver drowsiness, alcohol consumption, health abnormalities, and negligence by preventing vehicle operation under unsafe conditions.

The system integrates multiple sensors and computer vision techniques to monitor critical driver parameters. A camera module is used to capture real-time facial images for detecting drowsiness and fatigue through eye movement analysis. An MQ-3 alcohol sensor measures the driver's breath alcohol concentration, while a seat belt sensor verifies proper seat belt usage before vehicle start. Additionally, a heart rate sensor monitors the driver's physiological condition to identify abnormal health situations.

All sensor data is collected and processed by a Raspberry Pi/ESP32-based controller, which acts as the central processing unit of the system. The collected information is analyzed to determine the driver's fitness for operating the vehicle. Based on predefined threshold values, the system generates a Driver Fitness Decision.

If all safety parameters are within acceptable limits, the system allows vehicle ignition through a relay-controlled mechanism. However, if alcohol is detected, drowsiness is identified, abnormal health conditions are observed, or the seat belt is not fastened, the system automatically blocks vehicle ignition and activates warning alerts.

To enhance safety, the system also incorporates IoT functionality using GSM and GPS modules. In emergency situations, alert messages along with real-time location information can be transmitted to predefined contacts. This integrated approach provides a proactive safety mechanism that prevents unsafe driving before vehicle operation begins.

Main Modules of the Proposed System

1. Driver Face Detection and Monitoring Module
2. Drowsiness Detection Module
3. Alcohol Detection Module
4. Heart Rate Monitoring Module
5. Seat Belt Verification Module
6. Driver Fitness Evaluation Module
7. Vehicle Ignition Control Module
8. GPS and GSM Alert Module
9. IoT Monitoring and Notification Module

III. SYSTEM ARCHITECTURE

The proposed Driver Stability Detection System Before Vehicle Start consists of multiple hardware and software modules that work together to evaluate the driver's condition before vehicle ignition. The architecture integrates computer vision, IoT sensors, communication modules, and an ignition control mechanism to ensure safe vehicle operation.

The system begins with data acquisition through various sensors and monitoring devices. A camera module captures real-time facial images of the driver for drowsiness and fatigue detection. The MQ-3 alcohol sensor measures breath alcohol concentration, while the heart rate sensor monitors the driver's physiological condition. A seat belt sensor verifies whether the seat belt is properly fastened before vehicle startup.

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All collected data is transmitted to the Raspberry Pi/ESP32 controller, which acts as the central processing unit of the system. The controller processes the sensor readings and image data using predefined threshold values and decision-making algorithms. Based on the analysis, the system determines whether the driver is fit to operate the vehicle safely.
If all safety conditions are satisfied, the controller activates the relay module and permits vehicle ignition. If any unsafe condition is detected, such as alcohol consumption, drowsiness, abnormal heart rate, or seat belt non-compliance, the system blocks vehicle ignition and activates warning alerts through a buzzer and display unit.
For emergency situations, the GPS module provides real-time location information while the GSM module sends alert messages to predefined emergency contacts. The IoT platform stores monitoring data and allows remote access for analysis and tracking.

Components of System Architecture

1. Camera Module
Captures driver's facial images.
Used for drowsiness and fatigue detection.
2. MQ-3 Alcohol Sensor
Detects alcohol concentration in breath.
Prevents vehicle ignition if alcohol exceeds threshold.
3. Heart Rate Sensor
Monitors driver's physiological condition.
Detects abnormal health conditions.
4. Seat Belt Sensor
Verifies seat belt usage.
Ensures compliance before ignition.
5. Raspberry Pi / ESP32 Controller
Central processing unit.
Processes sensor data and controls system operations.
6. Relay Module
Controls vehicle ignition.
Enables or disables vehicle startup.
7. GPS Module
Provides real-time location tracking.
8. GSM Module
Sends emergency notifications and alerts.
9. Buzzer and Display Unit
Generates audio and visual warning messages.
10. IoT Cloud Platform
Stores monitoring data.
Enables remote monitoring and analysis.

IV. WORKING METHODOLOGY

The proposed IoT-Based Driver Stability Detection System Before Vehicle Start operates by continuously monitoring the driver's physical and mental condition before allowing vehicle ignition. The system integrates computer vision, sensors, and communication modules to ensure that only a stable and alert driver can operate the vehicle.

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Step 1: Driver Identification and Monitoring
When the driver enters the vehicle, the system is activated automatically. The camera module captures real-time facial images and verifies the presence of the driver. Facial features and eye movements are analyzed to detect signs of drowsiness and fatigue.

Step 2: Alcohol Detection
The MQ-3 alcohol sensor measures the alcohol concentration in the driver's breath. The sensor output is compared with predefined threshold values. If the alcohol level exceeds the permissible limit, the system identifies the driver as unfit for driving.

Step 3: Heart Rate Monitoring
The heart rate sensor continuously monitors the driver's physiological condition. Abnormal heart rate values may indicate stress, fatigue, or potential health issues that can affect driving performance.

Step 4: Seat Belt Verification
The seat belt sensor checks whether the driver has properly fastened the seat belt. If the seat belt is not worn, the system generates a warning and prevents vehicle ignition until compliance is achieved.

Step 5: Data Processing and Driver Fitness Evaluation
All sensor readings and image-processing results are transmitted to the Raspberry Pi/ESP32 controller. The controller analyzes the collected information and evaluates the driver's overall fitness using predefined decision rules.

Step 6: Ignition Control Decision
Based on the evaluation results, the system makes one of the following decisions:
If all safety parameters are within acceptable limits, vehicle ignition is allowed.
If alcohol is detected, drowsiness is identified, abnormal heart rate is observed, or the seat belt is not fastened, vehicle ignition is blocked.

Step 7: Alert Generation and Emergency Response
In unsafe conditions, the system activates a buzzer and displays warning messages. The GSM module sends alert notifications, while the GPS module provides real-time location information to predefined emergency contacts if required.

Step 8: IoT Data Monitoring
The collected sensor data and system status are uploaded to the IoT platform for real-time monitoring, analysis, and future reference.

Workflow of the System
Driver enters vehicle.
Camera captures driver's face.
Alcohol sensor measures alcohol level.
Heart rate sensor monitors health condition.
Seat belt status is verified.
Controller processes all inputs.
Driver fitness is evaluated.
Ignition decision is generated.

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Vehicle starts if driver is fit.
Alerts are generated if unsafe conditions are detected.

V. IMPLEMENTATION

The proposed Driver Stability Detection System was implemented using Raspberry Pi/ESP32, MQ-3 alcohol sensor, heart rate sensor, seat belt sensor, camera module, GSM, GPS, and relay module. The camera continuously monitors the driver's facial features for drowsiness detection, while the sensors collect real-time information related to alcohol level, health condition, and seat belt status.

All sensor data is processed by the controller, which evaluates the driver's fitness before vehicle ignition. If the driver satisfies all safety conditions, the relay module enables vehicle ignition. Otherwise, the system blocks ignition and generates warning alerts. GPS and GSM modules are used to provide location tracking and emergency notifications during unsafe situations.

The developed prototype integrates hardware and software components into a unified IoT-based safety system capable of preventing vehicle operation under unstable driving conditions.

DIAGRAMS – CIRCUIT, HARDWARE, OUTPUT

VI. TESTING AND VALIDATION

The developed prototype was tested under various driving conditions to evaluate its functionality, reliability, and safety performance. Individual sensors and the integrated system were validated to ensure accurate detection of unsafe driving conditions before vehicle ignition.

6.1 Unit Testing

Individual components such as the MQ-3 alcohol sensor, heart rate sensor, seat belt sensor, camera module, GPS module, and GSM module were tested separately. The obtained results confirmed proper sensor operation and reliable data acquisition.

6.2 Integration Testing

The complete system was tested by integrating all hardware and software modules. Sensor data was processed by the controller to evaluate the driver's fitness and generate ignition control decisions.

Test Scenario	Expected Result	Actual Result
Normal Driver	Ignition ON	Pass
Alcohol Detected	Ignition OFF	Pass
Drowsy Driver	Ignition OFF	Pass
Seat Belt Not Worn	Ignition OFF	Pass
Abnormal Heart Rate	Alert Generated	Pass

6.3 System Validation

Experimental testing demonstrated that the proposed system successfully detected unsafe driver conditions and prevented vehicle ignition when necessary. The integrated safety mechanism effectively improved pre-driving monitoring and ensured reliable system performance under different operating conditions.

VII. RESULTS AND DISCUSSION

The proposed IoT-Based Driver Stability Detection System was successfully implemented and tested under different driving conditions. The system effectively monitored driver alertness, alcohol level, heart rate, and seat belt status

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before vehicle ignition. Based on the collected sensor data, the controller accurately determined the driver's fitness and generated appropriate ignition control decisions.

7.1 Experimental Results

The system was evaluated using multiple test scenarios to verify its functionality and reliability.

Test Scenario	System Response
Normal Driver Condition	Vehicle Ignition Enabled
Alcohol Detected	Vehicle Ignition Disabled
Drowsiness Detected	Vehicle Ignition Disabled
Seat Belt Not Fastened	Vehicle Ignition Disabled
Abnormal Heart Rate	Warning Alert Generated

7.2 Discussion

The experimental results demonstrate that the proposed system successfully prevented vehicle startup when unsafe driving conditions were detected. The MQ-3 sensor accurately identified alcohol presence, while the camera module effectively detected driver drowsiness through facial monitoring. The seat belt and heart rate monitoring modules further enhanced the overall safety mechanism.

The integration of GPS and GSM modules enabled emergency alert generation and location tracking, improving the system's response during critical situations. The IoT platform provided real-time monitoring and data accessibility, making the system suitable for intelligent transportation and vehicle safety applications.

Overall, the developed prototype achieved reliable performance and demonstrated the feasibility of implementing a pre-ignition driver safety system for accident prevention and improved road safety.

VIII. CONCLUSION

The proposed IoT-Based Driver Stability Detection System Before Vehicle Start provides an effective solution for improving road safety by evaluating the driver's condition prior to vehicle ignition. The system integrates computer vision, alcohol detection, heart rate monitoring, seat belt verification, and IoT technologies to assess the driver's fitness for operating a vehicle.

The developed prototype was successfully implemented and tested under various driving conditions. Experimental results demonstrated that the system accurately detected unsafe situations such as alcohol consumption, drowsiness, abnormal health conditions, and seat belt non-compliance. Based on the detected conditions, the system effectively controlled vehicle ignition and generated appropriate alerts.

The integration of GPS and GSM modules further enhanced the system by enabling emergency notifications and location tracking. Overall, the proposed system offers a proactive approach to accident prevention by ensuring that only physically and mentally fit drivers are allowed to operate vehicles. This contributes to safer transportation systems and supports the development of intelligent vehicle safety solutions.