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IoT Vehicle Safety System Ensuring Helmet and Seat Belt Usage for Ignition

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Abstract

The IoT Vehicle Safety System is an innovative solution designed to improve road safety by making sure that helmets and seat belts are used before a vehicle can start. This system uses smart technology like sensors, cameras, and real-time processing to monitor the driver's and passenger's safety measures. It includes a helmet detection feature that uses image recognition to confirm whether helmets are worn, while seat belt sensors check if seat belts are properly fastened. All the data from these devices is managed by a central control unit, such as a microcontroller, which decides whether the vehicle can be started. If it detects that safety rules aren't being followed like not wearing a helmet or an unfastened seat belt it blocks the ignition and sends real-time alerts to the user. This not only encourages safer habits but also aims to reduce accidents and improve overall vehicle safety.

Keywords: *Helmet Detection, Ignition Control, Image Recognition, IoT Safety System, Vehicle Safety*

1. Introduction

The Vehicle Safety System based on IoT is intended to check whether important safety practices, such as the use of helmets and seat belt buckling, are observed before a vehicle is driven. Such minor but important safety precautions are usually not observed, leading to enhanced possibilities of accidents. Our system employs intelligent sensors that ensure these practices are checked automatically and that the driver and passengers are safe before the vehicle is put into motion. The system operates through sensors that check whether the helmet is being worn and whether the seat belts are correctly fastened. If either of these safety features is absent, the system will not allow the vehicle to start. This is an automated process that ensures that safety comes first and that drivers and passengers are completely secure before the trip starts. The IoT controller is the core of the system. It processes information from the helmet and seat belt sensors in real time. It quickly makes decisions, permitting or denying the ignition of the vehicle depending on what it receives. The system assists in enforcing safety without the need for reminders or manual checks.

In addition to the safety inspection, the system has an alert system that notifies users when the safety requirements are not fulfilled. It is capable of providing a visual or sound warning to alert the driver or passengers to remedy any safety issue. The reminders prompt users to adopt safer driving practices, thus resulting in reduced accidents and more secure road conditions. Through the integration of IoT technology, this system is an important factor in enhancing road safety, decreasing accidents, and making driving safer for all. It makes sure that fundamental but crucial safety procedures are adhered to prior to the vehicle's movement, encouraging responsible driving practices. As the system gains more ground, it has the potential to be a primary driver in making people aware of road safety. By nudging users to follow safety protocols on a regular basis, it makes them adopt good habits, ultimately decreasing the incidence of accidents that are caused by human mistakes. This technology, with its capacity to monitor, enforce, and remind users, becomes an invaluable asset in making roads safer for all. In summary, the IoT-based Vehicle Safety

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System is a significant step towards enhancing vehicle safety. By combining basic but important safety checks with real-time monitoring and warning systems, this technology makes sure that all safety rules are followed before the vehicle starts. It helps prevent careless mistakes by reminding users to wear helmets and fasten seat belts. This kind of system has the power to greatly improve road safety and reduce accidents, making it an important part of modern transportation in the coming years. In the future, this system can be enhanced further by incorporating additional features such as GPS tracking, crash detection, or automatic emergency notification to authorities in the event of a collision. These additional features would not only enhance safety but also enhance the overall driving experience. The versatility of IoT makes it possible for this system to be upgraded and modified to suit various vehicle types and user requirements. As more individuals are made aware of road safety, such intelligent systems will soon become the norm for all vehicles. Over time, the widespread adoption of this technology can lead to a significant decrease in accident rates and bring about a safer traffic environment for all.

2. System Architecture

The IoT-based vehicle safety system includes sensors, a microcontroller, and an ignition control unit to enforce helmet and seat belt usage. Sensors detect compliance, while the microcontroller processes data and either enables ignition or activates alerts if safety measures are not met.

2.1. Workflow

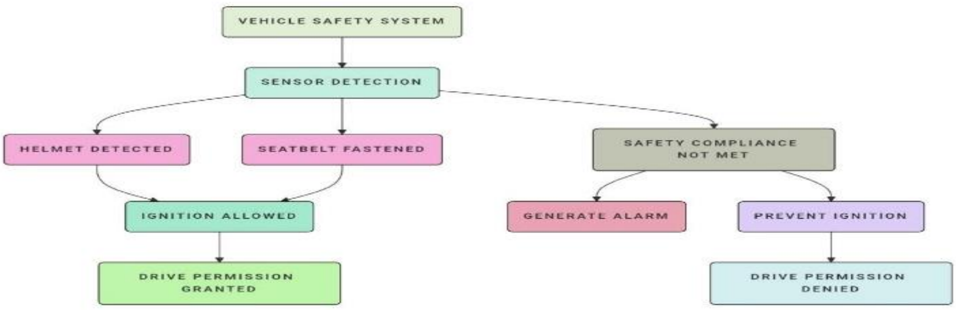

Figure 1 Workflow

3. Methodology

The IoT Vehicle Safety System is designed with different sensors, a microcontroller, and real-time monitoring methods for proper helmet and seat belt wear prior to vehicle start. The system is programmed to automatically check if the rider is using a helmet and if all the seat belts are securely fastened. The vehicle will not start if any of the safety requirements are not in place. The whole process is managed by a microcontroller, which receives inputs from the sensors and manages the ignition system, shown in Figure 1 [1-4].

3.1. Components and Modules

- **ESP32-CAM Module:** This module works as the brain of the system. It captures real-time images to check whether the rider is wearing a helmet, using a trained object detection model.
- **FTDI Module:** It is utilized for uploading code onto the ESP32-CAM because it does not support a USB port [5].

3.2. Output Indicator

- **LED:** Serves as a visual output for ignition status. If helmet and seatbelt are both detected properly, the LED is ON, which indicates that the vehicle is ready for starting. If either condition is not satisfied, the LED is OFF, displaying that the ignition is blocked.

3.3. Software Platform

- **Arduino IDE:** The primary development environment utilized to code, compile, and upload code to the ESP32-CAM. Safety checks, image recognition, and LED control logic is implemented here [6-12].

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4. Implementation

The IoT Vehicle Safety System ensuring helmet and seatbelt usage for ignition is developed using a microcontroller as the central control unit. The system integrates multiple sensors and actuators to enforce safety compliance before allowing vehicle ignition. The implementation process includes hardware setup, software configuration, and system testing.

4.1. Hardware Setup

- **ESP32-CAM Module:** The ESP32-CAM is the central part of the system. It takes real-time images of the rider and applies a trained object detection model to verify whether the helmet is worn. Apart from image processing, the ESP32-CAM also manages the system's logic and controls the ignition indicator. It takes the central role in decision-making based on safety inputs.
- **FTDI Module:** The FTDI module is used to program the ESP32-CAM. Since there is no built-in USB port in the ESP32-CAM, the FTDI comes to the rescue in bridging the microcontroller with the computer. It enables uploading code through the Arduino IDE and assists with serial communication for debugging purposes.
- **LED Indicator:** An LED is employed as an output device to indicate the ignition status. When all safety conditions are fulfilled the LED glows, indicating that the car can be started. When any condition is not fulfilled, the LED is off, indicating that ignition is blocked. This gives a simple and clear means of informing the user of the system status.
- **Power Supply and Connections:** Everything gets connected by using jumper wires. The hardware is powered during programming through the FTDI module. Efficient connections make operations stable and well-integrated in a vehicle [13-16].

4.2. Software Configuration

The Arduino IDE is used to program the microcontroller, allowing it to detect sensor inputs and manage the ignition system.

4.3. System Testing

- Each sensor is tested individually to ensure accurate detection of helmet usage and seatbelt fastening.
- The microcontroller logic is validated by simulating different compliance and non-compliance scenarios.
- The ignition control system is tested to ensure that the vehicle starts only when safety conditions are met, shown in Figure 2.

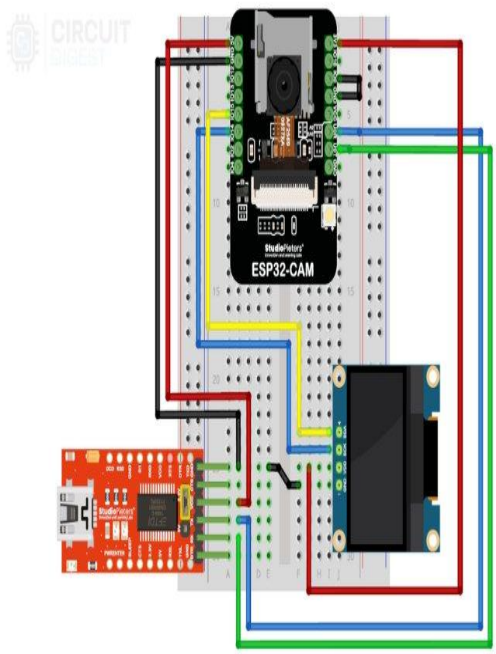

Figure 2 Circuit Diagram

5. Results and Discussion

The IoT Vehicle Safety System effectively ensures that both helmet and seatbelt usage are verified before the vehicle ignition is enabled. Sensors continuously monitor compliance, and the system processes data in real time, preventing unsafe driving practices. The system records and analyzes sensor data, providing insights into user compliance trends. If a helmet or seatbelt is not detected, the ignition remains disabled, and an alert is sent to the user. This system not only focuses on prevention but also helps in creating awareness among users by reinforcing safe driving habits every time the vehicle is used, shown in Figure 3.

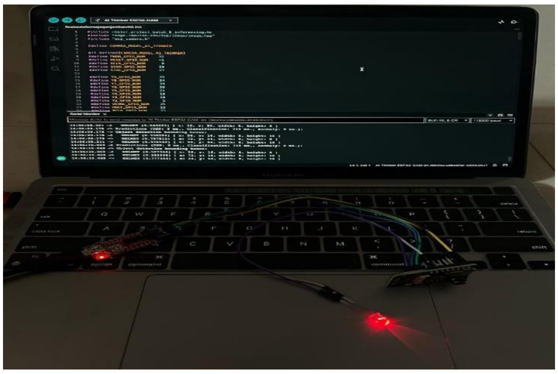

Figure 3 Implementation

This project is an ignition safety system meant to guarantee that ignition happens only when the rider is wearing a helmet and a seat belt. It employs an ESP32-CAM module, which takes live images and executes an image classification model presumably trained on Edge Impulse to identify helmet use. The system looks for the availability of a helmet in the captured image, and upon detection, it permits the ignition to go ahead otherwise, it initiates an alert, emulated here with red LED. The configuration comprises an FTDI module for communication and programming, and the red LED as an indicator of successful verification. The serial monitor output in above image displays real-time output from the ESP32-CAM as it performs helmet detection using a trained machine learning model reflecting the model's decision-making process. This safety feature is designed to minimize the chances of injuries by making sure that necessary safety equipment is worn before a vehicle can be started.

Figure 4 Output

The Serial Monitor displays real-time detection results from the ESP32-CAM, including the confidence level (as a percentage), location of the helmet in the frame (bounding box coordinates), and the time taken for various stages of inference. This helps verify that the model is working correctly and allows for debugging or performance evaluation. the same mechanism can be implemented in parallel to detect seat belt usage. The goal of this system is to ensure that the vehicle ignition is only enabled when safety conditions are met. This automated system promotes responsible safety behavior and helps reduce road injuries by enforcing essential safety gear before vehicle use, shown in Figure 4.

Conclusion

This system has been successfully implemented and tested so that vehicle ignition will happen only if both a helmet is put on and a seat belt is correctly fastened. Using the ESP32-CAM module and an image classification model based on machine learning, the system successfully detects the donning of a helmet and utilized to check for seat belt wearing too. The serial monitor displays verify accurate real-time detection using confidence scores and bounding box information, ensuring validation of the functioning of the system. The project is successful in ensuring road safety by mandating the use of necessary protective wear and can be implemented in actual vehicles to reduce the risk of accidents and injury.

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