Smart Helmet and Vehicle Speed Control Using IR Technology

P. Devi[1], M. Rajkumar[2], P. Darnesh[3], B. Thamaraiselvan[4], G. Sanjay[5]
[1]Department of Electronics and Communication Engineering, Sri Ramakrishna Institute of Technology, Coimbatore -641108, Tamil Nadu, India.
[1]Email: devi.ece@sritcbe.ac.in
[2]Email: rajkumar.82104035@sritcbe.ac.in
[3]Email: darnesh.21040302@sritcbe.ac.in
[4]Email: thamaraiselavan.82104037@sritcbe.ac.in
[5]Email: sanjay.82104035@sritcbe.ac.in

Abstract - Ensuring road safety is crucial in today's fast-paced world, and this paper introduces an innovative solution with the Smart Helmet and Vehicle Speed Control system utilizing IR technology. The system is designed to prioritize rider safety by ensuring the vehicle starts only when the rider wears the helmet, has a normal body temperature, and is free from alcohol consumption. This is achieved through an integrated setup comprising a push-on switch, alcohol sensor, and temperature sensor. Wireless communication between two microcontrollers enables seamless data transfer between the helmet and the vehicle, ensuring the verification of safety measures in real-time. In addition, IR sensors control vehicle speed automatically in restricted zones, reducing human error and ensuring compliance with speed limits. Each sensor corresponds to specific areas with predefined speed limits, while an OLED display provides user feedback by showing rider conditions and current travel zones. This prototype offers a scalable and practical solution, blending hardware efficiency with intelligent technology to reduce accidents and enhance traffic safety. With features such as automated speed regulation and rider condition monitoring, this system aims to transform road safety standards, paving the way for broader applications in smart transportation systems.

Keywords – Infrared (IR) Technology, Smart Helmet, Wireless Communication, ESP328 Microcontroller, Automatic Speed Regulation, Road Safety Technology, OLED display.

I. Introduction

A. Overview

Road safety remains a pressing concern globally, with countless accidents resulting from negligence in following safety protocols and traffic laws. Addressing this issue requires innovative solutions that can enforce compliance while prioritizing rider convenience. This paper introduces the Smart Helmet and Vehicle Speed Control system powered by IR technology, designed to improve rider safety and ensure automatic speed regulation in restricted zones. The system integrates a series of sensors, microcontrollers, and wireless communication mechanisms to establish a seamless and intelligent safety framework.

The Smart Helmet ensures that a rider can start the vehicle only when the helmet is worn, the body temperature is within a normal range, and no alcohol consumption is detected. A push-on switch installed in the helmet sends signals to the transmitting microcontroller, Node MCU1, which wirelessly communicates with the receiving microcontroller, Node MCU2, on the vehicle side. This real-time verification of safety conditions ensures maximum protection for riders.

Moreover, the system employs IR sensors to detect restricted zones and automatically adjust the vehicle speed based on predefined speed limits. Each IR sensor corresponds to a specific zone, ensuring accurate and effective speed control. The OLED display complements the system by providing visual feedback about the rider's condition and current zone. By combining rider safety checks, automated speed control, and real-time feedback mechanisms, this system offers a scalable and practical solution to modern transportation challenges. It exemplifies the integration of smart technology in addressing road safety concerns, paving the way for a safer and more intelligent future for transportation systems.

B. History

The evolution of road safety measures has been driven by technological advancements aimed at reducing accidents and fatalities. Helmets have long been a fundamental safety requirement, but their compliance remains inconsistent, necessitating the introduction of smart systems. Similarly, vehicle speed control in restricted areas has relied on manual intervention, which often leads to human errors. The concept of integrating smart technology into helmets and vehicles emerged as a solution to address these challenges.

The application of sensors and wireless communication technologies in safety systems has paved the way for innovations like the Smart Helmet and Vehicle Speed Control system. Infrared (IR) technology, widely used for precise detection in industrial and consumer applications, has been adapted to regulate vehicle speeds effectively. By combining helmet usage verification, rider condition monitoring, and automated speed control, this system represents a modern approach to road safety, enhancing compliance and reducing accidents through intelligent automation.

C. Applications

The Smart Helmet and Vehicle Speed Control system serves as an innovative solution to enhance road safety through advanced automation. It ensures that vehicles only operate when riders comply with helmet usage, maintain normal body conditions, and abstain from alcohol consumption. Additionally, the system employs infrared sensors to regulate vehicle speed automatically within restricted zones, reducing human errors and promoting traffic compliance. This versatile system can be applied in private vehicles, public transportation, and traffic management programs. By integrating intelligent safety measures, it fosters accident prevention and advances safer road practices, supporting the development of smarter and more sustainable transportation systems.

II. Existing Method

The existing methodology for implementing smart transportation systems primarily focuses on leveraging sensors, microcontrollers, and wireless communication technologies. These systems ensure rider compliance with safety measures and regulate vehicle operations based on external conditions. For rider safety, methods have been developed to monitor helmet usage, alcohol consumption, and physical conditions, such as body temperature. Sensors such as alcohol detectors, temperature monitors, and pressure switches are integrated into helmets, transmitting signals to the vehicle's control unit. Wireless communication protocols, such as Wi-Fi or RF communication, allow seamless data exchange between the helmet and the vehicle.

For automated vehicle speed control in restricted zones, the use of infrared (IR) sensors has gained prominence due to their precision and efficiency. IR sensors detect zone-specific markers and transmit signals to the vehicle's microcontroller, enabling it to adjust speed based on predefined limits. These methodologies reduce human errors, enforce traffic compliance, and adapt to dynamic road conditions. Systems are complemented by user feedback mechanisms, such as OLED displays, to provide riders with information about their safety status and zone-specific speed limits.

Microcontrollers like Node MCU or ESP devices are widely utilized for processing sensor data and executing programmed logic, ensuring real-time responsiveness and reliability. Integration with drive circuits and motors enables physical control over the vehicle's operation, enhancing functionality. While the methodology has advanced significantly, existing systems face challenges such as sensor accuracy, environmental interference, and scalability for diverse vehicle models. Researchers continue to refine these methodologies by integrating GPS for dynamic mapping, improving sensor reliability, and optimizing hardware designs for commercial production. While the methodology has advanced significantly, existing systems face challenges such as sensor accuracy, environmental interference, and scalability for diverse vehicle models. Researchers continue to refine these methodologies by integrating GPS for dynamic mapping, improving sensor reliability, and optimizing hardware designs for commercial production.

The existing methodologies provide the foundational framework for projects like the Smart Helmet and Vehicle Speed Control system, illustrating a practical approach to integrating intelligent technologies into transportation for improved safety and operational efficiency.

III. Proposed Method

The proposed methodology for the Smart Helmet and Vehicle Speed Control system is focused on leveraging advanced technologies to ensure rider safety and enforce automatic speed regulation in restricted areas. The system is divided into two major modules: the helmet module and the vehicle module, each playing a critical role in delivering a seamless and intelligent safety solution. The helmet module is equipped with several sensors and a push-on switch to ensure safety compliance. The push-on switch verifies whether the rider is wearing the helmet, while additional sensors check for alcohol consumption and body temperature. These measures ensure that the rider is sober and in a normal physical condition before operating the vehicle. Node MCU1, a microcontroller integrated into the helmet, gathers this data from the sensors and transmits it wirelessly to Node MCU2 in the vehicle module, reducing the reliance on physical connections and enhancing convenience.

The vehicle module validates the transmitted data through Node MCU2. When all conditions are met—helmet detection, alcohol-free status, and normal body temperature—the driver circuit is activated, allowing the motor to start. For enforcing speed control, the system incorporates three IR sensors positioned to detect specific zones with predefined speed limits. These sensors provide zone-specific inputs to the vehicle’s microcontroller, enabling automatic speed regulation based on the corresponding zone. This feature helps prevent over speeding in restricted areas, significantly reducing the likelihood of accidents.

To further enhance user interaction, the system features an OLED display that provides real-time feedback to the rider. The display indicates the rider’s status, including helmet compliance and condition, as well as the zone the vehicle is currently traveling in. This ensures the rider is well-informed and aware of their compliance with the system's safety protocols. The testing and validation of the prototype involve evaluating the performance of the sensors for accuracy and reliability, as well as assessing the seamless communication between the helmet and the vehicle modules. Observations from testing aim to ensure efficiency and effectiveness in achieving the system’s objectives.

This proposed methodology highlights a structured, scalable approach to addressing road safety challenges. By combining intelligent technology, automation, and real-time feedback, it paves the way for safer transportation systems while emphasizing the importance of rider compliance and automatic traffic regulation. It demonstrates a practical application of smart systems in modern transportation to reduce human error and enhance safety practices.

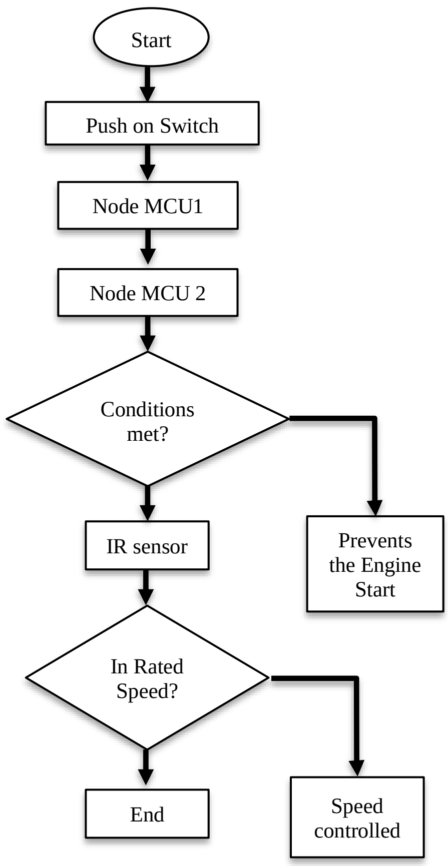

Figure 1: Flowchart of the proposed method

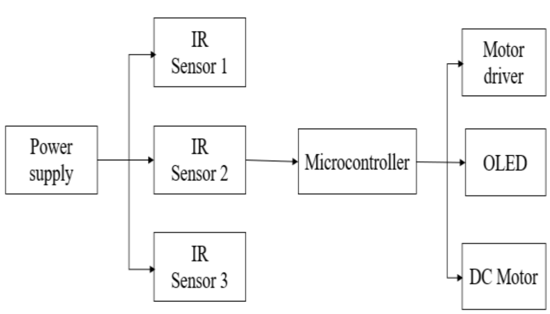

Figure 2: Block Diagram

The block diagram and flowchart of the Smart Helmet and Vehicle Speed Control system illustrate its seamless functionality. The block diagram emphasizes key components: sensors (alcohol, temperature, and IR), microcontrollers for wireless communication, and the OLED display. It showcases how data flows from helmet sensors to verify rider conditions, enabling vehicle ignition only when criteria are met. The flowchart explains the step-by-step process: rider conditions are checked, data is transmitted wirelessly, and ignition control responds accordingly. IR sensors regulate vehicle speed in restricted zones, ensuring safety compliance. Together, these diagrams highlight an efficient integration of safety features and intelligent technology.

IV. Implementation

A. *Assembly of Smart Helmet Components*

The implementation begins with the assembly of the Smart Helmet components. The helmet is equipped with key sensors including a push-on switch, an alcohol sensor, and a temperature sensor. The push-on switch detects whether the helmet is worn, while the alcohol sensor checks for alcohol consumption. Simultaneously, the temperature sensor monitors the rider's body temperature. These sensors are connected to a microcontroller inside the helmet, which processes data and sends it wirelessly to the vehicle's microcontroller using a transmitter. Proper wiring, calibration, and testing of the sensors ensure accurate readings during operation.

B. Integration of Vehicle Systems

The vehicle system is designed to receive data from the Smart Helmet. Another microcontroller acts as the receiver in the vehicle and handles commands based on the helmet’s input. The microcontroller controls the ignition system, ensuring the vehicle starts only when the rider meets all safety conditions—helmet is worn, body temperature is normal, and no alcohol is detected. For efficient data transfer, the wireless communication module is configured to seamlessly pair with the helmet’s transmitter. The integration requires testing compatibility between the microcontrollers and the ignition system to avoid operational delays.

C. Incorporating IR-Based Speed Control

Infrared (IR) sensors are installed on the vehicle to facilitate automatic speed regulation in restricted zones. Each IR sensor corresponds to specific travel zones that have predefined speed limits. When the vehicle enters a restricted zone, the IR sensor detects signals emitted by transmitters installed in those zones, and the microcontroller adjusts the speed of the vehicle automatically to comply with the limit. The connection between the IR sensors and the microcontroller must be secured and tested to ensure accurate speed control without human intervention.

D. Display Integration for Rider Feedback

An OLED display is incorporated into the system to provide real-time feedback to the rider. The display shows information such as the rider's condition (e.g., helmet status, alcohol detection, and body temperature) and current travel zones. This feedback ensures the rider is aware of the system's monitoring and operation at all times. Programming the microcontroller to update the OLED display promptly is crucial for real-time communication. Testing the display under different scenarios helps validate its responsiveness and reliability.

E. Collecting Waste in Smart Bin

Once classified, the waste is directed to its respective bin using a conveyor belt and servo motors. The ESP-32 microcontroller controls the conveyor and activates the servo motors based on the classification results. If the waste is identified as e-waste, the servo motor slides the material into the e-waste bin. Normal waste is transported to the end of the conveyor belt, where it is dumped into a separate bin. Ultrasonic sensors in the bins monitor their fill levels, ensuring efficient collection and disposal. This automated process reduces human intervention, enhances accuracy, and improves operational efficiency.

F. Testing the Communication System

The wireless communication system connecting the helmet and vehicle microcontrollers is a vital component of the Smart Helmet and Vehicle Speed Control project. This system ensures reliable data exchange between the transmitter located in the helmet and the receiver embedded in the vehicle. Seamless communication is essential to implement safety measures such as helmet verification, alcohol detection, and real-time temperature monitoring. Any disruption in the communication process can compromise the system's accuracy, leading to delays or errors in activating the vehicle's ignition or regulating speed. To validate the communication system's efficiency, extensive testing is conducted under various simulated conditions. These simulations include scenarios such as the rider wearing the helmet correctly, entering restricted zones with speed limits, and ensuring proper transmission of rider condition data to the vehicle. Each simulation evaluates the performance of the wireless modules, detecting potential interference or communication breakdowns. Special attention is paid to the pairing process between the transmitter and receiver modules, as this step is critical for uninterrupted data flow.

The testing phase also involves a detailed review of data logs generated during these simulations. These logs provide insights into the system's operation, allowing developers to identify discrepancies or inconsistencies that may arise in real-world applications. Adjustments are made to enhance the communication range, stability, and responsiveness, ensuring optimal system functionality. This rigorous approach guarantees the reliability of the wireless communication system, a cornerstone of the project's overall design.

G. Scalability and Future Enhancements

The final step involves exploring scalability and future extensions of the system. The prototype's design should allow for easy upgrades, such as incorporating GPS for broader navigation features or integrating the system into smart city infrastructure. Future enhancements could include better sensor technology, compatibility with electric or autonomous vehicles, and expansion to monitor traffic violations.

V. Results and Discussion

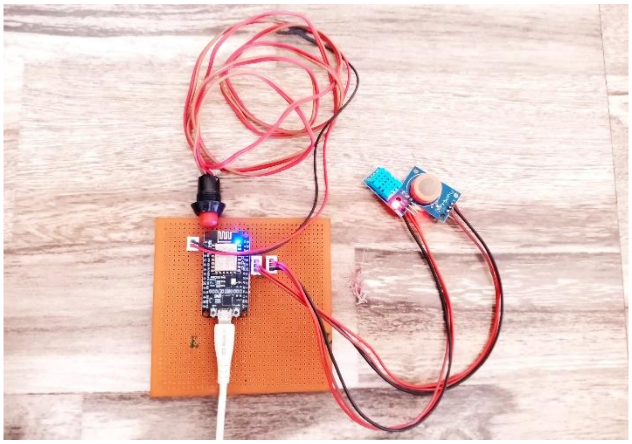

Figure 3: Transmitting Side

The transmitting side of the prototype effectively establishes a communication link between Node MCU1 and Node MCU2, ensuring accurate data transfer. The process is initiated when the push-on button is engaged, signifying that the rider has worn the helmet. This feature acts as a critical safeguard, as the system will only function under appropriate conditions, encouraging responsible usage. Once activated, Node MCU1 collects data from the alcohol sensor and humidity sensor. The alcohol sensor is a pivotal component, designed to monitor the rider's sobriety and prevent the vehicle from starting if alcohol levels exceed a certain threshold. This functionality underscores the system's commitment to enhancing road safety by addressing impaired driving. Simultaneously, the humidity sensor measures moisture levels within the helmet, which can help in evaluating internal conditions that may affect rider comfort and alertness.

The data collected by Node MCU1 is transmitted efficiently to Node MCU2, showcasing the reliability and responsiveness of the system. This communication mechanism allows real-time monitoring and ensures the prototype operates as intended. The design of the transmitting side highlights the seamless integration of sensors, user input, and data transmission, emphasizing practicality and innovation in its application.

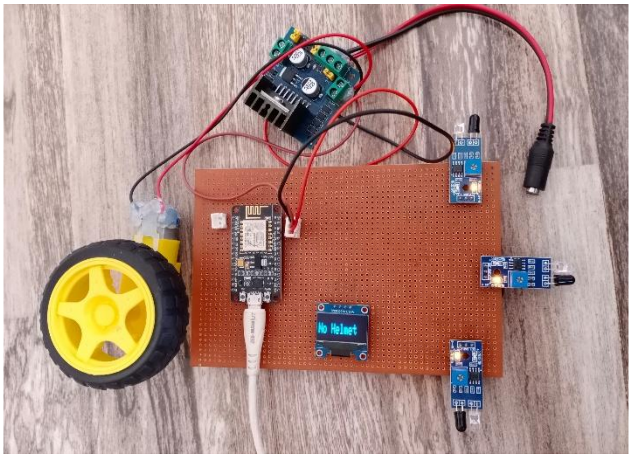

Figure 4: Receiving Side

The system effectively controls the motor speed based on environmental conditions monitored by the IR sensors. NodeMCU1 transmits data to NodeMCU2, ensuring real-time verification and activation of the vehicle. The motor driver responds dynamically, reducing speed in designated areas according to the programmed limits. This automation improves safety, energy efficiency, and operational accuracy. Observations confirm smooth transitions between speed zones, with minimal delay in response time. Overall, the integration of multiple IR sensors and microcontrollers provides precise control, making the system suitable for various applications requiring regulated movement.

VI. Conclusion

The system effectively automates speed regulation using IoT-driven technologies, integrating Node MCU controllers and IR sensors for precise control. Seamless communication between NodeMCU1 and NodeMCU2 ensures real-time data verification, allowing dynamic speed adjustments in designated zones. The motor driver responds intelligently to sensor inputs, optimizing performance and improving safety. One of the key benefits of this approach is the reduction in human intervention while maintaining efficiency. The automated speed control mechanism enhances reliability, making it ideal for applications such as autonomous vehicles and industrial automation. The results validate the effectiveness of IoT-based solutions in optimizing controlled movement. Future advancements may focus on refining sensor accuracy, implementing machine learning for adaptive regulation, and expanding the system's capabilities. This project highlights IoT's potential to revolutionize speed control, paving the way for intelligent automation in various real-world applications.

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