



Smart Helmet Ignition System: A Solution to Ensure Bike and Pillion Rider Safety

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Abstract. The prevalence of motorcycle accidents and the dire consequences of inadequate helmet usage underscore the imperative need for innovative safety measures. This research explores the development and integration of a Smart Helmet Ignition System, aiming to revolutionize motorcycle safety through technology-driven solutions. The proposed design comprises two modules: the Helmet module and the Bike module, intricately designed to ensure rider safety by enforcing proper helmet usage before motorcycle ignition. The Helmet Unit incorporates HC-SR04 sensor, microcontrollers (ESP32), and weight sensor (load cell), functioning collectively to authenticate the presence, correct placement, and secure wear of the helmet by the rider and passenger. Conversely, the Bike unit, interconnected with the Helmet unit via Bluetooth, manages the motorcycle's ignition system. It awaits confirmation signals from the Helmet Unit, allowing the engine to start only upon verification of proper helmet usage. This paper delves into the technical intricacies of each module, detailing the functionality of individual components and their integration into a cohesive system. It explores the efficacy and reliability of sensor-based authentication, microcontroller functionalities, and the seamless interconnectivity between the Helmet and Bike Modules.

Keywords: Pillion rider, Helmet module, Ignition control.

1 Introduction

The paper's goal is to ensure complete safety for bike drivers and pillion passengers. Recently Mumbai Police have made helmets mandatory for pillion rider [1], but still people ride without helmets. Each year, about 13 lakh people die in car accidents across the world [2]. An additional 2 to 5 crore individuals are affected by non-fatal injuries, with a number of people becoming handicapped due to their injuries. Although the majority of vehicle drivers know the general rules, regulations, and safety measures to take when driving on roads, accidents and collisions occur due to their disregard for safety. Pune city leads Maharashtra state in bike accidents. In recent years, the number of accidents has surged greatly. To decrease the number of accidents, there is a need to design a system for ensuring safety of drivers and passengers. According to the World Health Organization (WHO), India only covers 2

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out of 7 safety regulations recommended [3]. Nearly 1 in 4 deaths on the road are caused due to two-wheelers [4].

The proposed system sets out to address this critical safety gap through the development and implementation of a groundbreaking solution: the Smart Helmet Ignition System. Our innovative Bike Safety System is dedicated to improving road safety for riders. It guarantees that the bike will not turn ON the ignition unless the riders have put on their helmets. The motorcycle can only start if both helmets are confirmed to be worn properly. If one rider forgets to wear their helmet, the system steps in right away, stops the ignition, and keeps the motorcycle from starting. It uses special sensors in the helmets that connect wirelessly to the motorcycle's ignition system. This way, it ensures a fail-safe mechanism to promote safe riding by making helmet use a prerequisite for starting the bike.

Numerous efforts are underway to enhance the existing scenario. The government has elevated the monetary sanctions for various violations, and traffic officers now have advanced systems to efficiently monitor offenders. Additionally, roadside closed-circuit television (CCTV) cameras and speed-detection cameras are installed to accomplish the same objective. However, in regions with limited resources or lenient regulations, individuals tend to revert to established habits. Consequently, it is crucial to establish and promote systems that can address and correct these behaviors. In the event of an accident or unfortunate incident, such systems should also expedite the arrival of assistance to the injured party.

The rest of the document is structured as follows: Related work is addressed in Section 2. The system's technologies are covered in Section 3. Our proposed system for ensuring rider safety is fully explained in Section 4. The components of implementation and working are highlighted in Section 5. Results and a discussion of the developed system are the main topics in Section 6. The paper's conclusions are included in Section 7.

2 Related Work

There is plenty of literature available for rider safety. Ensuring the safety of riders is of utmost significance. Over time, various initiatives and systems have emerged to enhance the existing infrastructure and create safer roads. Several researchers have contributed diverse innovations in smart helmet technology to enhance rider safety. A few of them have been explained below.

Ajan Ahmed, Mohammad Monirujjaman Khan, Ipseeta Nanda [5], introduced an intelligent helmet designed to display the rear view to the driver while riding. The rear view is captured with the help of a Raspberry Pi camera. It also displays the current speed of the vehicle to help the driver in maintaining safe speed while driving. The system also detects accidents with the help of a heart rate sensor. The heart rate sensors also help to identify drowsiness while driving and alert the rider by vibration. The authors also implemented a system to send short message service (SMS) during

an accident using global positioning system (GPS) and global system for mobile communication (GSM) module. The SMS is sent to the appropriate authorities. Additionally, a turn signal is also implemented which indicates the direction in which the vehicle is going to turn.

Indra Yustiana and Somantri [6] focused on theft prevention and rider safety by linking the helmet with motorcycles, sending its location and immobilizing the bike when the helmet is not worn. This intelligent helmet is seamlessly connected to the ignition system. In the event of the motorcycle being distanced from the smart helmet, the engine will remain active, and the smart helmet will promptly relay the occurrence while pinpointing the incident's location to designated mobile phones. Furthermore, the helmet ensures that the rider cannot operate the motorcycle without its use. The system incorporates GSM module to send SMS when detecting a theft. A GPS module is used to get the precise location of the bike.

Smriti, Vikas Tiwari, Dr. Richa Srivastava, and Ms. Swati Sharma [7] concentrated on accident detection using SW420 sensors. One of its functionalities ensures that the motorcycle initiates only when the driver is wearing a helmet. If the driver removes the helmet, then the ignition of the bike will turn off. If the vehicle undergoes an accident while riding, then the GSM and GPS modems will transmit a message to the designated contact number via the installed subscriber identity module (SIM) card. Additionally, in cases of theft involving the bike or helmet, the device allows the owner to effortlessly determine the precise location of both items.

Valpadasu Hema, Allam Sangeetha, Ch. Nimisha Chowdary, Soleti Navya [8] developed a system for alcohol and helmet checks, impact sensor-driven accident alerts, and SMS notifications via a GSM module. The system proposed in this paper prevents drunk driving. The system is designed with an Arduino board acting as the main controller. An alcohol detection sensor is attached inside the helmet which checks the sobriety of the driver. If the driver exceeds the legal limit of alcohol, then the vehicle will not start. A sensor and transmitter installed in the helmet checks if the driver is wearing a helmet or not by transmitting a signal to the bike module. The bike module then turns the engine on only if the driver wears a helmet. An impact sensor installed helps to identify if the vehicle has faced an accident. When an accident is detected, a message alert is sent to police and an emergency contact number using GSM and GPS technologies.

Jannatul Ferdous Riya, Sujan Howlader, Sabrin Akter Usha, et al, [9] created a solar-powered smart helmet with GSM, GPS modules for accident tracking and ensuring safety of bike riders. Should the driver surpass the standard speed limit, the speed sensors will issue a warning. In case of an emergency, the rider can seek assistance by turning on the accident switch. The motorcycle will only start if the driver is properly wearing a helmet. The entire prototype is powered by solar energy. By analyzing the results, it has been determined that the developed system effectively ensures the safety of drivers by promptly relaying precise information on accidents in real-time.

The existing research papers discuss the solutions to ensure that the driver wears the helmet before starting the vehicle but do not take into consideration the pillion's helmet use. Also, these systems do not check if the driver is alone or with a pillion rider. To ensure complete safety, both the driver and pillion rider must wear a helmet.

3 Hardware Tools

3.1 HC-SR04

The HC-SR04 is an ultrasonic sensor. It consists of two components: a transducer acting as a transmitter and another transducer acting as the receiver. The transmitter works by generating 40 KHz ultrasonic sound pulses from the electrical signals. When the pulses arrive at the receiver, they generate an output pulse which is in direct proportion to the distance between the receiver and the object in front of it. Offering precise non-contact range detection within 0.02 m to 4 m, with an impressive accuracy of 3 mm. The sensor works effectively on a 5-volt system. This feature enables direct connectivity to microcontrollers with 5V logic.

3.2 HC-12

A contemporary multi channel integrated wireless data transmission module, the HC-12 is a wireless serial port communication module. Operating within the frequency range of 433.4-473.0MHz, it supports the configuration of multiple channels with increments of 400 KHz. The module's maximum transmitting power is 100mW (20dBm), and it achieves a receiving sensitivity of -117dBm at a baud rate of 5,000bps. In an open space environment, the communication distance can extend up to 1,000m. The module incorporates a micro controller unit (MCU), eliminating the need for separate programming. The module's effective handling of both receiving and sending serial port data simplifies its use while it is in the transparent transmission mode. Using AT commands, users can easily choose from a variety of serial port transparent transmission modes based on their individual usage requirements.

3.3 Load Cell

A load cell serves as a transducer that transforms applied force into a measurable electrical output. While several types of load cells exist, those based on strain cages are the most prevalent. Strain-gage load cells convert the applied load into electrical signals by affixing gauges to a deformable beam or structural element. To guarantee optimal sensitivity and temperature correction, four strain gauges are usually used. Of these, two gauges are connected to compensatory adjustments and are in tension, while the other two are in compression. The application of weight causes the strain, altering the electrical resistance offered by the gauges which is directly proportional to the load. As advancements in accuracy and reductions in unit costs persist, strain gage load cells are overshadowing other types, gradually diminishing their prominence.

3.4 ESP 32

The ESP32 Microcontroller is equipped with an ARM 32-bit Cortex-M3 CPU core, working at a maximum frequency of 72 MHz. When implemented on the blue pill board, this MCU presents several specifications. In terms of memory, it possesses 64 Kbytes of Flash and 20 Kbytes of SRAM. Additionally, it features 32 GPIO pins with external interrupt capability, along with three 16-bit timers and one 16-bit PWM timer. The MCU offers 15 PWM pins, 10 channels of 12-bit ADC for analog functionality, and two I2C peripherals. Moreover, it includes three USART peripherals with hardware control, two SPI peripherals, and various other peripherals such as USB 2.0 Full Speed and CAN 2.0B. These specifications collectively contribute to the versatility and functionality of the ESP32 Microcontroller.

4 Proposed Work

The block diagram of proposed design is shown in Fig 1. The system can be divided into 2 parts, a Helmet component and Bike component. Fig 1 shows the connection between Helmet module and Bike module made using Bluetooth module (HC-12).

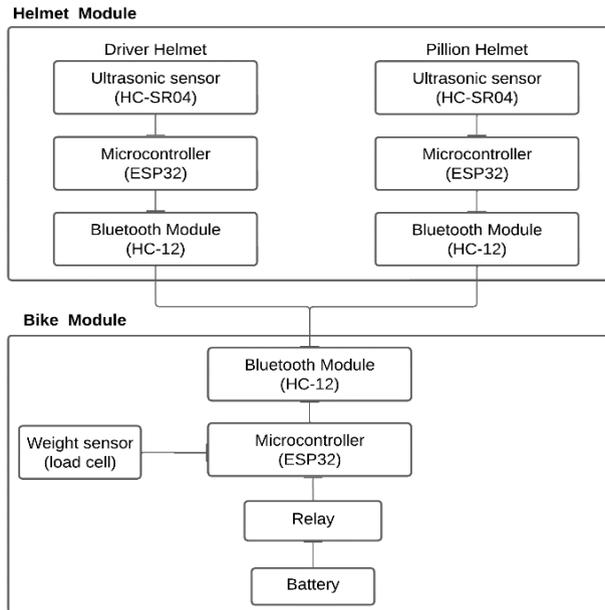


Fig. 1. Block Diagram of System

The Helmet Module consists of ultrasonic sensor (HC-SR04), Bluetooth module (HC-12) and microcontroller (STM32) connected to the helmets of bike drivers and pillion rider. The microcontroller is powered by a 9V battery as it is a low power consumption microcontroller.

The Bike module consists of a load cell, Bluetooth module, relay, and a microcontroller to control these components. The load cell is used to determine whether the driver is alone or if the driver is riding with a pillion rider.

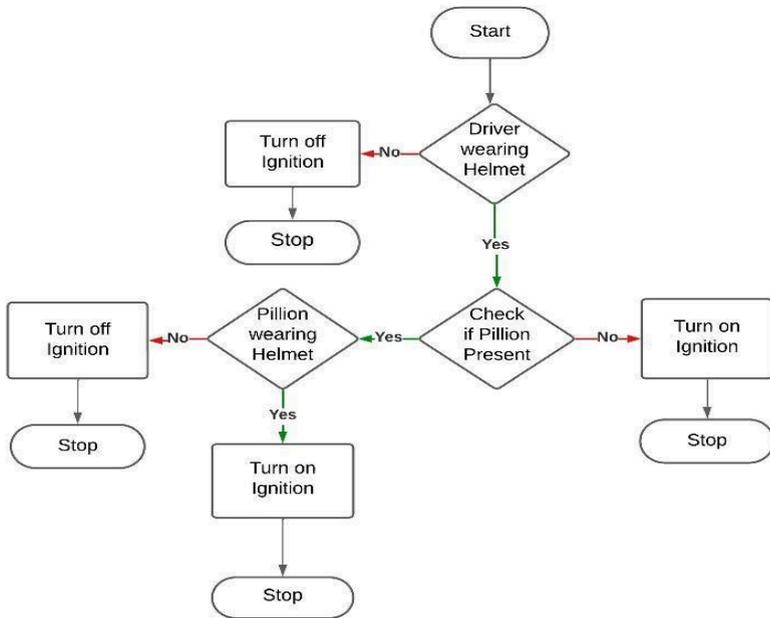


Fig. 2. Flowchart of System

The load cell is connected to the footrest of the bike which is provided to give support to the pillion riders foot when travelling. We do not need the capacity of the load cell to be high. We can use a load cell with a capacity of 1 kilogram because our purpose is only to determine if the pillion rider is sitting or not. The load cell is strategically placed on the footrest such that it will be triggered only when the pillion rider keeps his foot on it. We have chosen not to place the load cell on the bike seat as the driver of the bike may be carrying a heavy or bulky backpack which will give us false readings.

The relay connected to the bike module is responsible for controlling the ignition of the bike. The relay acts as a bridge between the ignition system and our system as shown in Fig. 4, Fig. 5, Fig.6, Fig.7. The signal to relay to start the bike will be sent only if the helmet is worn, otherwise the bike will not start. The whole system is explained in Fig. 2.



Fig. 3. Load cell connected to the footrest



Fig. 4. Helmet module connected to helmet



Fig. 5. Bike module connected to battery

When the system is turned on, it will first check if the driver has worn the helmet or not. If the driver's helmet is detected, then we will check for load cell status. If it sends a low signal, it indicates that pillion is not present. In such a case, the bike will start. If it sends a high signal, it indicates that a pillion rider is present. In such a case, pillion should also wear a helmet. The bike will start only when both the driver and pillion are wearing a helmet.

5 Results And Discussion

The deployment and assessment of the Smart Helmet Ignition System yielded compelling outcomes, affirming its efficacy in enhancing motorcycle safety. Extensive testing and simulations validated the system's core feature—precise authentication of helmet usage leveraging the HC SR04 ultrasonic sensor. The transition to the ESP32 microcontroller within the Bike Unit marked a significant advancement, empowering the system with enhanced control and coordination capabilities. This upgrade facilitated seamless and rapid communication between the Helmet and Bike Units, allowing swift interpretation of authentication signals.

Consequently, the ignition was exclusively operational when the helmet was securely and accurately positioned, reinforcing the system's fundamental safety protocol. Practical trials in real-world scenarios further affirmed the system's effectiveness. Notably, the Smart Helmet Ignition System exhibited a marked reduction in instances of unauthorized ignition attempts when helmets were not worn correctly, reinforcing responsible rider behavior. Moreover, it actively discouraged and prevented engine activation in such scenarios, effectively advocating for and enforcing safe riding practices.

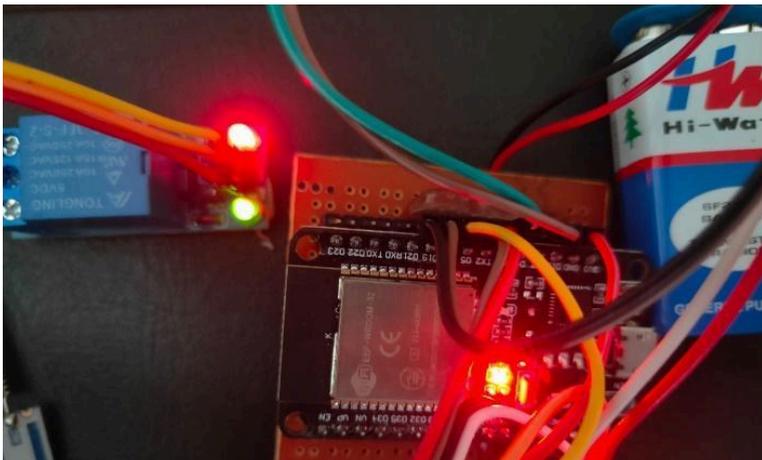


Fig. 6. ON status of relay

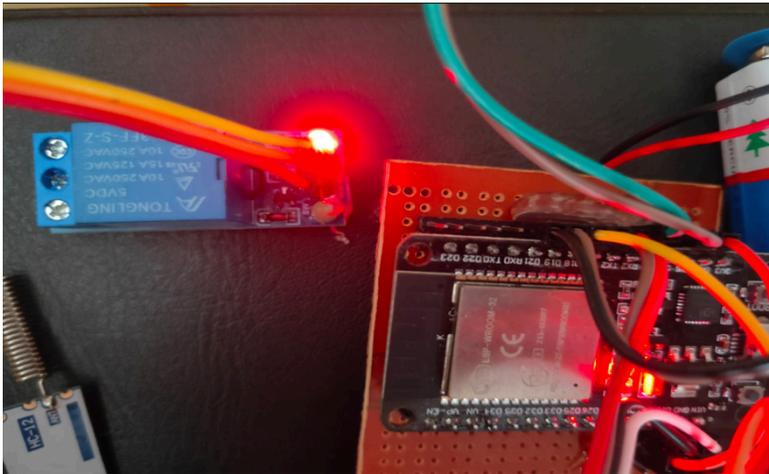


Fig. 7. OFF status of relay

Table 1. Ignition status based on helmet use

Driver’s Helmet status	Load cell reading	Pillion’s helmet status	Ignition
Not wearing	Low	Not checked	OFF
Wearing	Low	Not checked	ON
Wearing	High	Not wearing	OFF
Wearing	High	Wearing	ON

Table 2. Comparison of our system with previous systems

Parameter	Previous system design	Proposed system design
Driver helmet status	Checked	Checked
Pillion Helmet status	Not checked	Checked
Ignition status	Depends only on driver helmet	Depends on both driver and pillion helmet

The results in table 1 and table 2, collectively highlight the system's transformative potential in revolutionizing motorcycle safety. By fostering a culture of responsible helmet usage and augmenting rider safety protocols, the system has demonstrated tangible steps toward mitigating avoidable accidents and head injuries. The robustness and reliability showcased in trials underscore its promise as an innovative intervention, with the capacity to significantly elevate safety standards in the motorcycle riding community.

6 Conclusion And Future Scope

The Smart Helmet Ignition System offers numerous possibilities for future development and expansion. First and foremost, there is potential for enhanced safety features through the integration of additional sensors that monitor environmental conditions, such as weather and road conditions. This would enable the adaptation of safety measures accordingly. Moreover, the implementation of AI-based systems, such as collision avoidance and blind-spot monitoring, could further enhance real-time hazard detection.

Secondly, the system could benefit from IoT integration, including Vehicle-to-Everything (V2X) communication. This expansion of connectivity options would facilitate interaction with surrounding vehicles and infrastructure, contributing to overall safety. Improving the user interface is another avenue for development. This could involve the creation of a user-friendly mobile app for seamless system integration and management. Additionally, incorporating voice-command functionality would enable hands-free operation and interaction.

The utilization of collected data for analytics and insights is also a promising direction. Insights on riding patterns, environmental conditions, and user behavior could inform safety trends and personalized recommendations. Machine learning algorithms could be employed for predictive analytics, anticipating potential safety hazards. Ensuring regulatory compliance and setting industry standards is crucial. Collaborating with regulatory bodies to establish certifications for Smart Helmet Systems would ensure adherence to safety regulations across different regions.

Customization and adaptability are key considerations for future development. Offering adjustable sensitivity for helmet detection and personalized safety alerts allows for customization. Moreover, ensuring compatibility with different motorcycle models and helmet types broadens the system's applicability. Global accessibility is vital, with plans for expansion and adaptation of the system for use in diverse geographical regions. This involves accounting for varying riding cultures, road conditions, and legal frameworks. Industry collaboration and partnerships are strategic initiatives. Working with motorcycle manufacturers to integrate the system into new vehicle models or offering it as an aftermarket accessory is a possibility. Partnerships with insurance companies could result in potential incentives or discounts for riders using Smart Helmet Systems.

In conclusion, the future scope for the Smart Helmet Ignition System involves continuous innovation, leveraging technological advancements, and addressing safety needs to create a comprehensive and adaptable solution for riders worldwide.

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