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SMART HELMET FOR ALCOHOL DETECTION ACCIDENT DETECTION AND NOTIFICATION USING IOT

Dr.K.Karuppasamy
Head of the Department
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India.
karuppusamyrvs@gmail.com

P.Arunadevi
Assistant Professor
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India.
p_aruna_devi@yahoo.co.in

L.Keerthana
712822104023
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India.
loganathankeerthiiii@gmail.com

V. Jayarathinam
712822104016
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India.
jayarathinam61@gamail.com

M. Jeevanantham
712822104017
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India,
jeevananthamjeevanantham32@gmail.com

R.Monisha
712822104704
Dept of Computer Science & Engineering
RVS College of Engineering & Technology,
Coimbatore, India.
monisharajarathinam159@gmail.com

***Abstract*— Road accidents are a major cause of mortality worldwide, particularly among two-wheeler riders. A significant percentage of these accidents are attributed to drunk driving, non-usage of helmets, and delayed emergency response. To address these critical issues, this paper proposes a Smart Helmet system integrated with Internet of Things (IoT) technology for alcohol detection, accident detection, and real-time emergency notification. The system incorporates an alcohol sensor to detect alcohol concentration in the rider's breath and automatically disables vehicle ignition if the level exceeds a predefined safety threshold. An IR sensor ensures helmet usage before enabling ignition. A vibration sensor is employed to detect accident events by sensing sudden impacts or abnormal shocks. Upon detecting an accident, the system retrieves the rider's real-time geographical coordinates using a GPS module and transmits alert messages via a GSM module to predefined emergency contacts and nearby medical services. The entire system is controlled using an ESP32 microcontroller, enabling efficient sensor integration and real-time decision-making. The proposed IoT-based smart helmet enhances preventive and reactive safety measures, thereby reducing road fatalities and improving intelligent transportation systems.**

***Keywords*— Internet of Things (IoT), Smart Helmet, Alcohol Detection, Accident Detection, ESP32, GPS, GSM, Road Safety, Embedded Systems.**

INTRODUCTION

Road safety has become one of the most critical public health concerns worldwide, especially in developing countries where rapid urbanization and increasing vehicle ownership have led to a rise in traffic-related accidents. Two-wheelers such as motorcycles and scooters are among the most commonly used modes of transportation due to their affordability, fuel efficiency, and convenience in congested urban areas. However, riders of two-wheelers are highly vulnerable to severe injuries because they lack the protective structure available in cars and other four-wheeled vehicles. As a result, even minor accidents can lead to life-threatening consequences.

According to transportation safety reports and global road safety statistics, a significant percentage of fatal accidents occur due to drunk driving, overspeeding, and delayed medical assistance.

immediate medical help because the accident location is unknown or reported too late. This delay in emergency response significantly increases the mortality rate.

Although wearing helmets has been made mandatory in many regions and has proven to reduce the severity of head injuries, traditional helmets serve only as passive safety equipment. They do not provide any mechanism to monitor the rider's condition, detect alcohol consumption, verify proper helmet usage, or automatically alert emergency services during an accident. Therefore, there is a need for an intelligent safety system that goes beyond basic protection and actively contributes to accident prevention and emergency response.

With the rapid advancement of the Internet of Things (IoT), embedded systems, and wireless communication technologies, it is now possible to design smart safety solutions capable of real-time monitoring and automated communication. IoT-based systems combine sensors, microcontrollers, GPS modules, and communication devices such as GSM or Wi-Fi to collect data from the environment, process it efficiently, and transmit alerts instantly. These systems enable continuous monitoring, remote tracking, and automated decision-making without human intervention.

The proposed IoT-based Smart Helmet system aims to enhance rider safety by integrating multiple safety features into a single compact and efficient framework. The system incorporates:

- Alcohol detection using a gas sensor to prevent vehicle ignition if alcohol is detected.
- Helmet detection to ensure that the rider is wearing the helmet before starting the vehicle.Accident detection using vibration or tilt sensors to identify crash situations.
- GPS and GSM modules to automatically send real-time location alerts to emergency contacts or medical services in case of an accident.

By combining preventive measures (such as alcohol detection and ignition control) with responsive mechanisms (such as automatic accident notification), the system provides a comprehensive approach to road safety. This dual-layer safety architecture significantly reduces the probability of accidents and ensures faster emergency assistance when accidents occur.

This paper presents the detailed design, hardware components, software implementation, system architecture, and working methodology of the IoT-based Smart Helmet. The primary objective of this project is to minimize road accident fatalities, improve emergency response efficiency, and promote intelligent transportation safety using modern IoT technologies.

LITERATURE SURVEVY

Sharma et al. (2023) proposed an IoT-based smart helmet system for accident detection and alcohol monitoring [1]. Their system integrated an MQ-series alcohol sensor to prevent drunk driving and a vibration sensor to detect crash events. Emergency alerts were transmitted using GSM technology to predefined contacts. Although effective in reporting accidents, the system lacked a comprehensive helmet verification mechanism and did not implement a fully integrated ignition control architecture.

Patil et al. (2024) developed a Smart Helmet system using IoT for road safety applications [2]. Their design focused on real-time accident monitoring and alert generation using GPS and GSM modules. While the system demonstrated improved emergency communication efficiency, it did not fully integrate alcohol detection with ignition restriction logic within a unified and compact framework.

Kumar and Raj (2022) introduced an alcohol detection and accident prevention system using IoT modules [3]. The proposed system successfully disabled vehicle ignition when alcohol concentration exceeded a predefined threshold value. However, the design did not incorporate GPS-based real-time location tracking, limiting its capability to provide immediate emergency assistance during accident scenarios.

Al-Mansoori et al. (2023) presented an intelligent transportation safety system using IoT and wireless sensor networks to enhance vehicular safety [4]. Their work emphasized automated data acquisition, cloud connectivity, and emergency alert mechanisms. However, the solution was vehicle-mounted rather than helmet-based, reducing portability and rider-centric monitoring capabilities.

Ramesh et al. (2022) developed an accident detection and emergency alert system using GSM and GPS technologies [5]. The system effectively transmitted accident location coordinates to predefined contacts upon detecting a crash using vibration sensors. Despite improving emergency response time, the system did not integrate alcohol monitoring or helmet verification features.

Singh and Kaur (2024) investigated smart wearable devices for road safety and accident prevention [6]. Their research highlighted the importance of embedding sensors and communication modules into wearable systems to enhance user safety. However, the study mainly focused on physiological parameter monitoring such as heart rate and body temperature rather than combining alcohol detection and accident notification mechanisms.

Joshi et al. (2022) proposed an IoT-based smart helmet for real-time accident monitoring [7]. Their system utilized vibration sensors and GSM modules for crash detection and alert transmission. While the accident detection feature was effective, preventive measures such as alcohol detection and ignition interlocking were not included in the design.

Verma et al. (2023) designed a microcontroller-based smart helmet integrated with Bluetooth communication for vehicle control [8]. The system ensured that the bike engine would start only when the helmet was properly worn. Although helmet verification was successfully implemented, the system lacked alcohol sensing and automated accident alert functionalities.

Rahman et al. (2024) developed a cloud-connected road safety monitoring system using IoT devices [9]. Their architecture enabled real-time data transmission and storage for traffic analysis and emergency handling. However, the system focused more on centralized monitoring rather than individual rider-level preventive mechanisms such as ignition control and alcohol detection.

Gupta and Mehta (2023) proposed an integrated smart safety framework combining alcohol detection, GPS tracking, and GSM communication [10]. The system demonstrated improved accident response efficiency and ignition control mechanisms. Nevertheless, the components were implemented as separate modules rather than a fully optimized, compact, helmet-mounted solution.

PROPOSED METHODOLOGY

The proposed Smart Helmet system is designed as an IoT-based embedded safety architecture that integrates preventive control mechanisms and post-accident emergency response within a unified framework. The architecture combines real-time sensing, embedded data processing, and wireless communication to enhance rider protection and reduce accident-related fatalities. The ESP32 microcontroller serves as the central processing unit due to its efficient performance, integrated Wi-Fi capability, and compatibility with multiple sensors and communication modules. The methodology emphasizes continuous monitoring, intelligent decision-making, and automated alert transmission as suggested in recent IoT-based road safety frameworks [11], [15].

The system operates in two primary stages: preventive safety verification before ignition and emergency response activation after accident detection. All sensors are interfaced with the ESP32, which continuously reads sensor outputs, evaluates threshold conditions, and executes control actions accordingly.

A. Preventive Safety Mechanism (Helmet and Alcohol Detection)

The preventive mechanism ensures that unsafe riding conditions are eliminated before the vehicle starts. This approach aligns with intelligent helmet systems proposed in embedded safety research [16]. The system integrates helmet detection and alcohol monitoring into a single ignition control logic to enforce rider compliance and prevent drunk driving.

Helmet detection is implemented using an infrared (IR) sensor positioned inside the helmet. The sensor operates based on the principle of infrared reflection. When the rider wears the helmet properly, reflected IR signals are detected and interpreted as confirmation of compliance. If the helmet is not worn, the absence of reflection prevents ignition activation. The ESP32 processes this digital signal and controls a relay module connected to the vehicle's ignition system. This ignition interlocking mechanism ensures that the vehicle cannot start without helmet confirmation, similar to approaches discussed in helmet-based ignition control systems [12].

Alcohol monitoring is achieved using an MQ-series alcohol sensor placed near the rider's mouth region. The sensor measures alcohol concentration in breath and generates an analog voltage proportional to the detected level. The ESP32 reads this analog signal through its ADC and compares it against a predefined threshold. If the alcohol concentration exceeds the permissible limit, the ignition system remains disabled regardless of helmet status. Integrated alcohol detection and accident prevention strategies have been widely discussed in recent safety system studies [18].

Only when both conditions—helmet usage and safe alcohol level—are satisfied does the ESP32 activate the relay, enabling the vehicle ignition system. This dual-verification logic enhances preventive road safety and aligns with the principles of smart wearable transportation safety devices [13].

B. Accident Detection Mechanism

Once the vehicle is operational, the system transitions into active monitoring mode. The accident detection mechanism continuously observes abnormal impact conditions using a vibration sensor embedded within the helmet. IoT-enabled accident detection frameworks emphasize real-time sensing and automated response for effective emergency handling [11], [17].

Under normal riding conditions, vibration levels remain within a safe range caused by road disturbances. However, during a severe collision or fall, the vibration intensity rises sharply beyond the normal threshold. The ESP32 continuously reads the vibration sensor output and compares it with a calibrated limit. When the measured value exceeds this threshold, the system classifies the event as an accident.

Threshold calibration is performed during system testing to ensure accurate differentiation between normal road irregularities and critical crash events. This minimizes false alarms while maintaining detection sensitivity. Similar ESP32-based accident alert systems demonstrate the importance of calibrated impact detection for reliability [15]. By automating crash identification, the system ensures immediate emergency activation even if the rider is unconscious.

C. Emergency Notification and Communication System

Upon confirming an accident event, the emergency communication module is automatically activated. A GPS module retrieves real-time geographical coordinates, including latitude and longitude, from satellite signals. The ESP32 processes this location data and formats it into a readable message for transmission. GPS and GSM-based vehicle monitoring systems have proven effective in enhancing emergency response efficiency [14].

After obtaining accurate location information, the GSM module sends an SMS alert to predefined emergency contacts such as family members, hospitals, or local authorities. The alert message includes accident notification details along with precise GPS coordinates. IoT-based emergency response systems highlight the importance of automated real-time notification in reducing rescue delays [17], [20].

In addition to SMS transmission, the system can support wireless communication and cloud-based monitoring extensions as described in smart transportation frameworks [19]. This enables future scalability for centralized monitoring and analytics. A local buzzer alert may also be activated to attract nearby assistance immediately after crash detection.

Overall, the proposed methodology integrates preventive verification, intelligent accident detection, and automated emergency communication into a compact IoT-enabled helmet framework. By combining embedded processing, wireless communication, and real-time sensing, the system aligns with modern road safety enhancement strategies and contributes toward minimizing accident fatalities through rapid intervention and preventive enforcement [11], [20].

RESULT AND DISCUSSION

The proposed Smart Helmet prototype was successfully implemented using ESP32, an IR sensor, an MQ-series alcohol sensor, a vibration sensor, a GPS module, and a GSM module. The hardware components were integrated and programmed to function as a unified IoT-based safety system. The prototype was tested under various operating conditions to evaluate system performance, response time, and reliability in real-time scenarios.

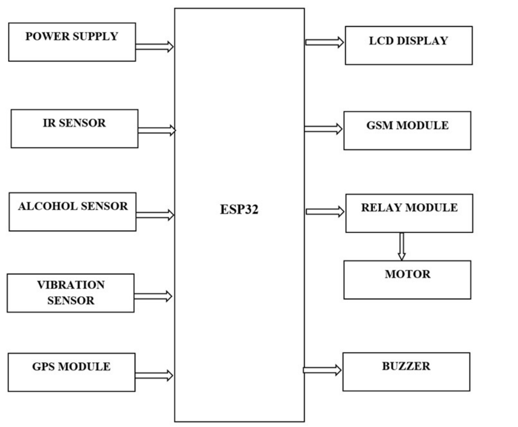
During preventive mechanism testing, the IR sensor accurately detected whether the helmet was worn properly. The ignition system was enabled only when the helmet was correctly positioned, and it remained disabled when the helmet was removed. The alcohol sensor effectively measured breath alcohol concentration and prevented vehicle ignition whenever the detected value exceeded the predefined threshold. These observations confirm that the integrated preventive safety mechanism operated correctly and enforced both helmet compliance and alcohol restriction.

The accident detection module was evaluated using controlled vibration impacts to simulate crash conditions. The vibration sensor successfully identified high-intensity impact signals while ignoring normal riding vibrations and minor road disturbances. This indicates that proper threshold calibration was achieved, minimizing false alarms while maintaining sensitivity to actual crash events.

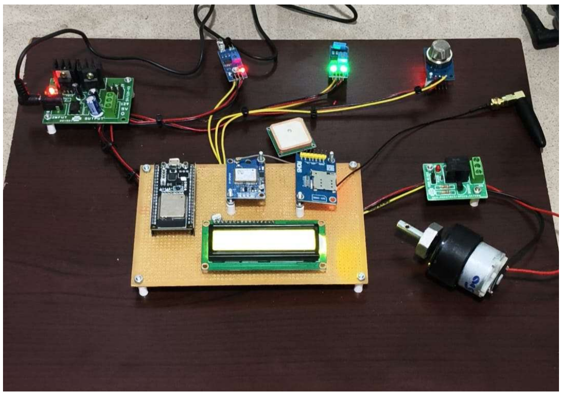
Once an accident was detected, the GPS module accurately retrieved real-time geographical coordinates. The GSM module then transmitted alert messages to predefined emergency contacts within a few seconds. The emergency message included precise location details, enabling quick identification of the accident site. The communication process was consistent and reliable during repeated testing.

Overall, the system demonstrated stable real-time performance and efficient coordination between sensing, processing, and communication modules. The experimental results validate that the proposed IoT-based Smart Helmet enhances rider safety through automated preventive measures and rapid emergency notification, thereby contributing to reduced accident risk and improved emergency response efficiency.

BLOCK DIAGRAM



EXPERIMENTAL SETUP



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CONCLUSION

The preventive mechanism effectively restricts vehicle ignition when unsafe conditions such as alcohol consumption or absence of helmet usage are detected. In addition, the accident detection module reliably identifies high - impact events and automatically triggers emergency alerts containing precise GPS location details via GSM communication. Experimental validation of the prototype demonstrates stable performance, accurate sensor coordination, minimal response delay, and reliable message transmission under various operating conditions.

The integration of intelligent monitoring and automated communication significantly reduces the risk associated with drunk driving, non-compliance with helmet usage, and delayed medical assistance. Therefore, the proposed Smart Helmet system represents a practical and scalable solution for improving rider safety and supporting the development of safer and more intelligent transportation systems. The results indicate strong potential for real-world deployment and further enhancement through cloud connectivity and advanced analytics in future smart mobility applications.

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