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Multi-Domain Smart Safety Helmet

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Abstract

Motorcycle accidents and head injuries are critical concerns globally, especially where helmet non-compliance is prevalent. To address this, a multi-domain smart safety helmet is proposed for rider safety and accident prevention through advanced sensor technology. This smart helmet integrates sensors like an MQ-3 alcohol sensor and helmet detection sensors to ensure safety conditions before the motorcycle engine starts. If alcohol levels exceed a threshold, the ignition system disables, preventing intoxicated riding. Helmet detection promotes helmet use, reducing head injury risk. The scalable sensor infrastructure enables multi-domain applications beyond motorcycles. This helmet can integrate into industries like coal mining and firefighting. In coal mining, it monitors environmental conditions and worker vital signs. In firefighting, it detects hazardous gases and monitors firefighter status. During motorcycle operation, the helmet continuously monitors critical parameters—speed, tilt, and environment—providing immediate feedback on unsafe behaviours. In accidents, the helmet's accelerometer detects impacts, activating GPS to pinpoint the location and GSM to alert emergency contacts. This smart helmet aims to enhance motorcycle safety, prevent accidents, and expedite emergency responses. It represents progress towards reducing motorcycle-related injuries and fatalities, with adaptable features for broader safety applications across industries and domains.

***Keywords:** Smart Safety Helmet, IoT, ESP32, ESP-Now Protocol, Motorcycle Safety, Sensor Technology, Multi- Domain Application, Alcohol Detection, Helmet Compliance, Accident Prevention, Scalable Sensor, GPS Integration, GSM Technology, Emergency Notifications, Impact Detection, Accelerometer, Rider Safety Enhancement.*

1. Introduction

Road accident has become a huge concern in our everyday living. Due to this enormous amount of population, many people are facing very high road accident fatalities and official figures indicate 60 deaths per 10,000 motor vehicles [1]. It is estimated that many bike riders die every-day in road accidents and due to insufficient information regarding to the accidents, those riders cannot be saved as they merely find helpafter the accident's occurrence. However, with the increasing number of people, the motorcycles are also increasing on the roads and streets. Motorcycle accidents pose significant risks to rider safety, particularly in regions where safety measures such as helmet usage are frequently neglected. In response to this critical concern, innovative solutions leveraging advanced technologies are increasingly being explored to enhance motorcycle safety and accident prevention. This paper introduces a novel approach through the development of a Smart Helmet system integrated with Internet of Things (IoT) capabilities, specifically utilizing ESP32 modules and ESP Now Protocol for

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efficient data transmission. The system incorporates various sensors for alcohol detection and helmet status monitoring, coupled with GPS and GSM technology for location tracking and emergency messaging. By seamlessly integrating these components, the proposed system aims to address key challenges in motorcycle safety, including alcohol-impaired riding and timely response to accidents [2]. Through detailed exploration of its architecture, functionality, and potential impact, this paper seeks to contribute to the ongoing efforts in advancing motorcycle safety technology and reducing the incidence of accidents on the road. Furthermore, in addition to addressing these challenges, the Smart Helmet system also incorporates scalable sensor capabilities, making it a multi-domain solution for enhanced rider safety. By integrating various sensors, including those for alcohol detection and helmet status monitoring, the system ensures comprehensive oversight of critical safety conditions before and during motorcycle operation. This multi-domain functionality enables the Smart Helmet to adapt to diverse safety requirements across different riding scenarios and environments, further enhancing its effectiveness in preventing accidents and protecting riders [3].

1.1. System Architecture

The Smart Helmet system comprises two primary components: a transmitter unit housed within the helmet and a receiver unit positioned externally. The transmitter unit incorporates sensors for alcohol detection and helmet status monitoring, an ESP32 module, and utilizes the ESP Now Protocol for data transmission. Conversely, the receiver unit features an ESP32 module, GPS module, GSM module, and an emergency response mechanism. It receives data from the transmitter unit, processes it, and dispatches emergency messages in case of accidents [4]. Overall, the architecture integrates sensor technology, wireless communication protocols, and real-time emergency response mechanisms to bolster motorcycle safety.

1.2. Transmitter Unit

Embedded within the Smart Helmet, the transmitter unit incorporates sensors for alcohol detection and helmet status monitoring [5]. It is equipped with an ESP32 module responsible for data processing and transmission. The communication between the transmitter and receiver units is facilitated by the ESP Now Protocol, ensuring efficient wireless data transfer. Upon processing sensor data, the transmitter unit wirelessly transmits it to the receiver unit, enabling real-time monitoring.

1.3. Receiver Unit

Positioned externally, the receiver unit receives, processes, and responds to data transmitted by the transmitter unit. It features an ESP32 module for data reception and control, and integrates an AI Thinker A9G module for GPS and GSM capabilities [6]. The AI Thinker A9G module enable location tracking and cellular communication. In the event of an accident, the receiver unit activates the GPS and GSM modules to promptly send distress signals, including the accident location, to predefined emergency contacts. This cohesive integration of components enhances motorcycle safety and facilitates rapid accident response.

2. Method

The multi-domain smart safety helmet is designed to enhance safety across various domains and environments, with a primary focus on motorcycle helmet functionality [7]. Central to its design are two ESP32 modules facilitating seamless communication between the transmitter and receiver units. These units incorporate a range of sensors and modules meticulously integrated to monitor the rider's safety effectively. The transmitter unit of the ESP32 is equipped withboth an IR sensor and an MQ3 sensor. Utilizing theESP Now communication protocol, it establishes communication between the transmitter and receiver. Additionally, the sensors integrated into the helmet are adaptable, enabling customization tosuit different operational domains. The receiver unit complements the transmitter unit's

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functionality by incorporating an LCD display, an MPU6050 accelerometer, and an AI Thinker A9G module [8]. The LCD display facilitates user interaction and feedback, while the MPU6050 accelerometer enhances the system's accident detection capabilities. Moreover, the AI Thinker A9G module enables GSM and GPS operations essential for real-time tracking and emergency messaging. Communication protocols are optimized, with the LCD display utilizing I2C communication and the AI Thinker A9G module employing UART communication for efficient data transmission in Figure 1& 2.

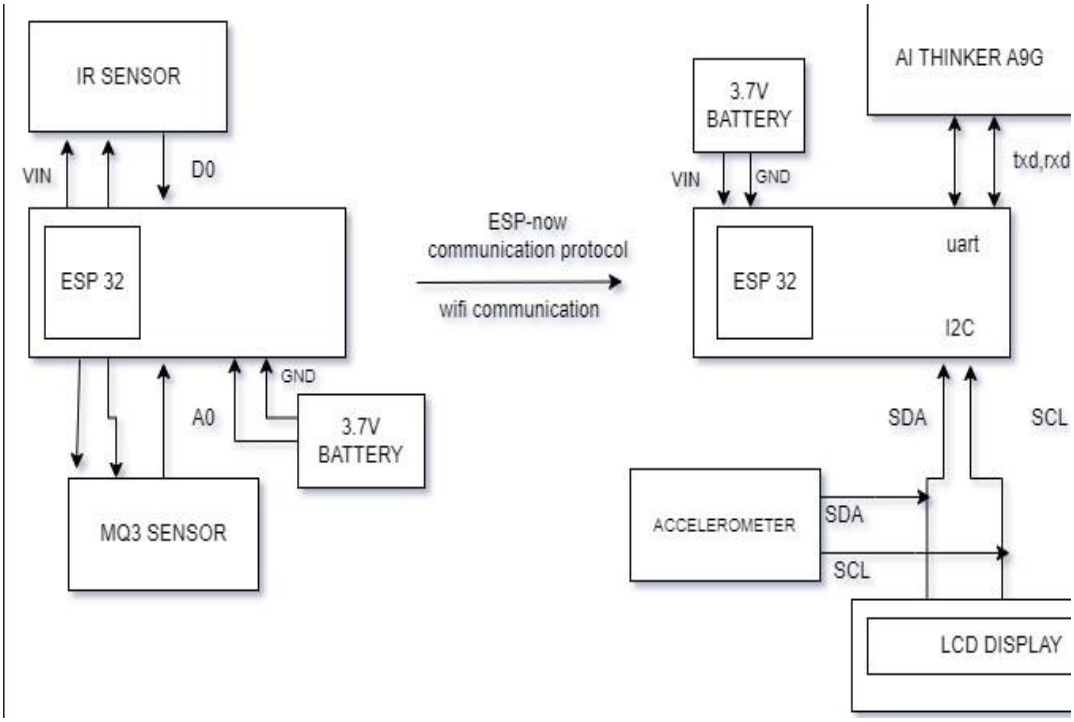

Figure 1 Block Diagram of the Multi Domain Smart Safety Helmet

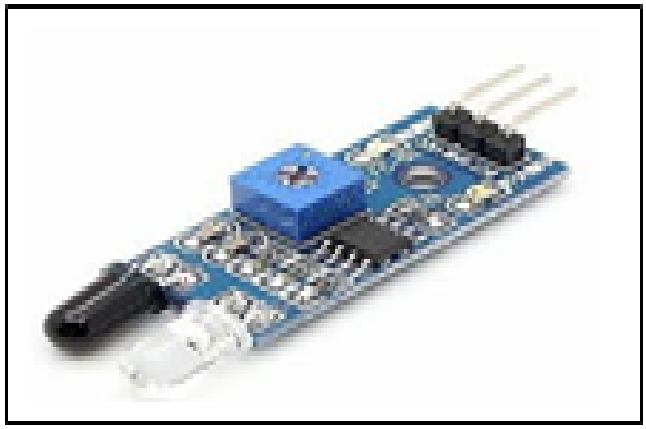

Figure 2 IR Sensor

The transmitter unit in the Smart Helmet collects data from sensors like IR and MQ3 for monitoring helmet usage and alcohol levels.

Figure 3 AI thinker A9g Module

An ESP32 microcontroller processes this data and uses the ESP Now protocol to wirelessly transmit it to thereceiver unit. This enables real-time monitoring and intervention, ensuring rider safety Figure 3.

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3. Flowchart

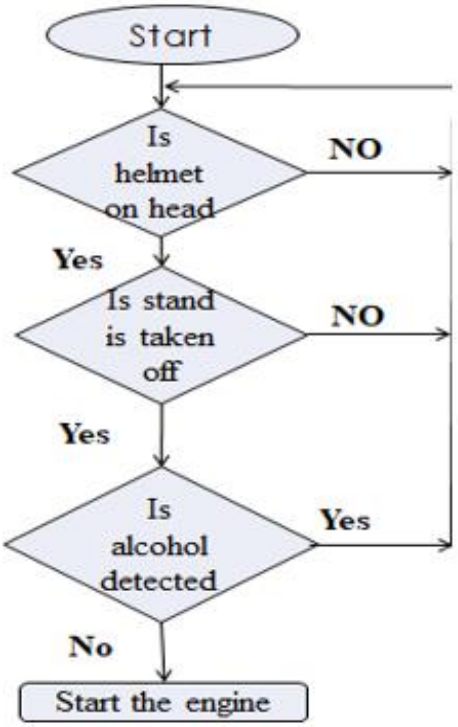

Figure 4 Flow Chart of Helmet Operation

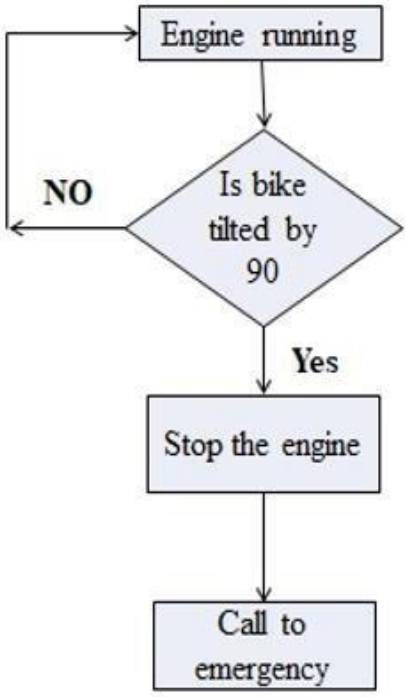

Figure 5 Flowchart of Accident Detection

Figure 6 ESP32 Wroom Module

The use of ESP devices is imperative because of the employment of ESPNow communication, which exclusively functions with ESP devices featuring Wi-Fi capabilities Figure 4,5&6.

4. Results and Discussion

4.1. Results

The outcomes involve the creation of a smart helmet capable of detecting alcohol levels and helmet usage, thereby preventing intoxicated riding and enhancing safety. Furthermore, it swiftly notifies emergency contacts in the event of accidents, enhancing response efficiency and potentially preventing fatalities. The outcomes of the smart helmet testing demonstrate notable advancements in rider safety and accident prevention. In instances where the helmet is not worn, the receiver promptly notifies the rider by displaying "helmet not worn," emphasizing the importance of safety protocols before riding. Conversely, upon detecting the presence of the helmet, the receiver displays "helmet worn," affirming proper safety compliance. Furthermore, the incorporation of the MQ3 sensor enables real-time monitoring of alcohol levels. If the alcohol concentration surpasses the predefined threshold established in the transmitter unit Figure 7,8&9, the receiver promptly alerts the rider by displaying "alcohol detected." This immediate feedback fosters responsible decision-making and discourages intoxicated riding. The integration of an accelerometer enhances the smart helmet's safety capabilities. By continuously monitoring

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for sudden changes in acceleration, the accelerometer can detect potential accidents or collisions. In the event of an impact, the receiver alerts the rider, facilitating prompt response and potentially mitigating the severity of injuries. Additionally, the AI Thinker A9G module further enhances the functionality of the smart helmet. By enabling GSM and GPS operations, it allows for real-time tracking of the rider's location and facilitates emergency messaging in the event of an accident. This feature ensures timely assistance and intervention, enhancing overall rider safety in Table 1.

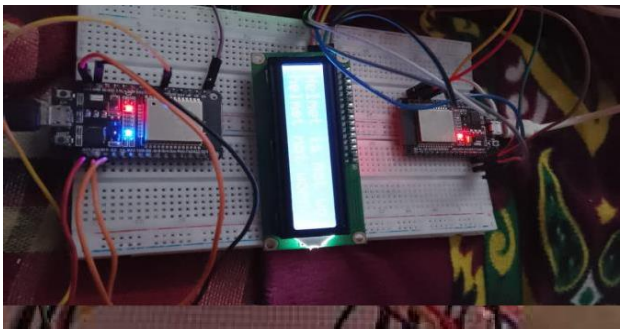

Figure 7 Transmitter and Receiver Unit

Figure 8 If Helmet is Worn

Figure 9 If Helmet is Not Worn

Table 1 Different User Condition Due to Mq-3 Sensor Reading

User Condition	MQ3 sensor reading	Condition of thebike
Drunk and No Helmet	Positive	0
Drunk and Wearing Helmet	Negative	0
Sober and No Helmet	Positive	0
Sober and Wearing Helmet	Positive	1

Figure 10 If Alcohol Exceeds Limit

Figure 11 If Accident is Detected

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4.2.Alert Test Message Sent to Mobile

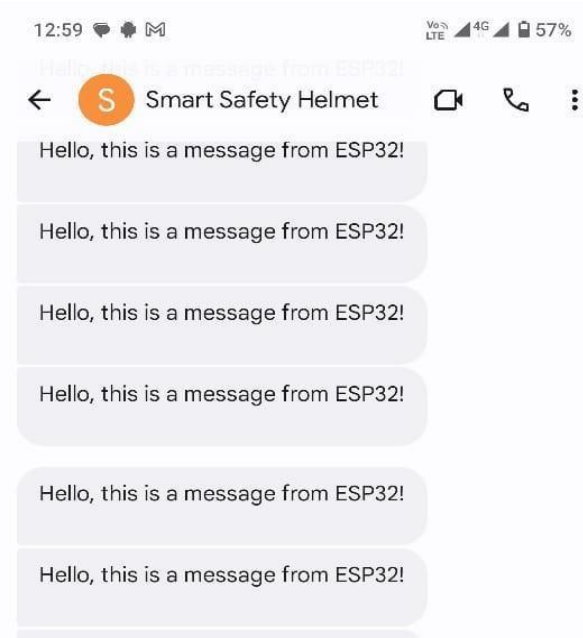

Figure 12 If Accident is Detected Alert Message

4.3.GPS Location SMS

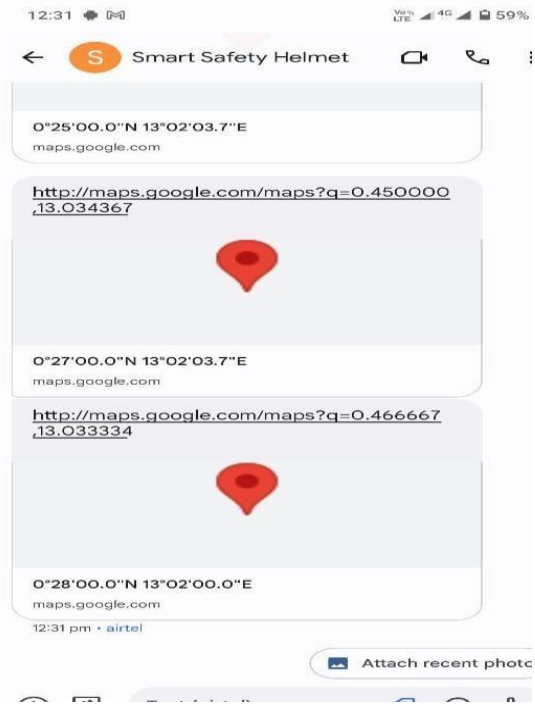

Figure 13 If Accident is Detected GPS Location is Sent to the Mobile Number

4.4. Discussion

In the discussion, we focus on the smart helmet's effectiveness in enhancing rider safety and addressing critical challenges. Key points include its ability to monitor alcohol levels, helmet usage, and detect accidents in real-time. Additionally, its emergency response capabilities and user experience are highlighted. Considering regulatory compliance and future research directions, we emphasize collaboration for continuous improvement in motorcycle rider safety technology Figure 10,11,12&13.

Conclusion

The multi-domain smart helmet we studied is a game-changer for motorcycle safety and other domains of safety helmets. It uses fancy sensors to keep an eye on things like whether the rider is wearing their helmet or if the and also monitor its environment and checks if they have been drinking.If it detects a problem, it can stop the bike from starting and even send out alerts for help in case of an accident. Looking ahead, we need to keep improving and working together to make safety of every individual to have proper safety environmentand equipment to help them.

Acknowledgement

We would like to express our sincere appreciation to Prof. Kavitha S for their invaluable guidance throughout this project. We also extend our thanks to the participants for their contributions. Lastly, we commend the efforts of all involved in developing the smart helmet system. Thank you to everyone fortheir support and collaboration.

Warm regards,

- Tammineni
- Loksai Vanna
- Balaji Naidu
- Shiva kumar
- Venkatesha B

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