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Design Smart Helmet System with GSM for Safety Monitoring Systems

P.V. Hari Krishna Babu*, L. Yasodha, D. Jagadeesh, M. Devi, N. Anusha, P. Riya
Department of ECE, Baba Institute of Technology and Sciences (A), Vishakhapatnam, India

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ABSTRACT

The increasing frequency of motorcycle accidents globally calls for innovative safety measures, with smart helmets emerging as a vital advancement. This paper presents the design and implementation of a smart helmet system integrating multiple sensors and communication technologies to monitor rider safety in real time. The system employs dual Arduino Uno microcontrollers—one embedded in the helmet and the other on the motorcycle—communicating via a 433 MHz RF link. An alcohol sensor embedded in the helmet restricts motorcycle operation under intoxicated conditions, while an MPU6050 accelerometer and gyroscope detect head movements and impacts. The vehicle unit includes a GSM module for sending emergency alerts and a relay-driven headlight control system. Experimental results confirm that this integrated system can effectively detect critical safety events and enhance emergency response capabilities. The proposed smart helmet design demonstrates high potential for reducing accident severity and enforcing responsible riding behaviour.

Keywords: Smart Helmet, Embedded Systems, Arduino, RF Communication, Alcohol Detection, MPU6050, GSM, Motorcycle Safety

I. INTRODUCTION

Motorcycle riders are particularly vulnerable to road accidents due to exposure, high speeds, and limited safety gear compliance. According to WHO reports, over 28% of road traffic deaths involve two-wheeled vehicle riders. A substantial number of these incidents involve alcohol-impaired driving, lack of helmet usage, and delayed emergency response. The integration of embedded systems in wearable safety gear like helmets can significantly improve accident prevention and post-incident response.

This research proposes a smart helmet system that incorporates real-time monitoring, safety enforcement, and emergency communication capabilities. The system comprises helmet-mounted sensors, wireless RF communication, and a GSM module for location-aware emergency alerting. It aims to address impaired driving, non-compliance with helmet usage, and inefficient accident reporting.

II. LITERATURE REVIEW

Various projects and studies have attempted to enhance road safety using sensor-based approaches. Existing smart helmets primarily focus on fall detection and Bluetooth-based communication. However, limitations such as single-controller systems, lack of integration with the vehicle, or no alcohol detection remain. This project expands upon prior work by combining dual-controller architecture, alcohol detection, real-time motion monitoring, and GSM-based emergency response.

III.SYSTEM ARCHITECTURE AND DESIGN

3.1 Overview

The smart helmet system consists of two core modules:

- **Helmet Unit:** Includes an Arduino Uno, MQ3 alcohol sensor, MPU6050 motion sensor, RF receiver, and GSM module.
- **Motorcycle Unit:** Includes a second Arduino Uno, RF transmitter, GSM module, relay, and headlight control system.

These two units communicate via a 433 MHz RF link, allowing bidirectional, real-time synchronization between the helmet and the vehicle.

Motorcyclists face high risk of accidents and fatalities due to reckless driving, alcohol consumption, and lack of safety gear. Existing safety measures are inadequate, leading to delayed emergency responses and increased risk of severe injuries, highlighting the need for an innovative solution to enhance motorcyclist safety.

- Design an IOT-controlled LED sign board system.
- Enable remote content management.
- Provide real-time updates.- Offer flexible display capabilities.
- Enhance efficiency in advertising and information dissemination.

Proposed Solution

Smart Helmet System: An Integrated Safety Solution for Motorcyclists

The proposed smart helmet system is a cutting-edge safety solution designed to enhance rider safety and improve communication while on the road. This intelligent helmet integrates a variety of sensors and communication technologies to provide real-time feedback, accident detection, and emergency response capabilities.

At the core of the smart helmet is a microcontroller that serves as the central processing unit, responsible for managing data collected from the integrated sensors. Key sensors include an **accelerometer and gyroscope**, which work together to monitor the rider's movement and detect sudden impacts or abnormal tilts that may indicate an accident. In the event of a crash, the system can automatically trigger an alert to predefined emergency contacts or rescue services, providing the rider's location using an embedded **GPS module**.

Additionally, the helmet is equipped with **Bluetooth communication**, enabling hands-free phone calls and audio navigation by connecting to a rider's smartphone. This ensures that riders can stay connected without compromising their safety. Some advanced versions also include **voice recognition** for easy interaction with the system, allowing the rider to issue commands without removing their hands from the handlebars.

To enhance road awareness, the helmet includes **proximity sensors** or **blind spot detection**, which alert the rider to nearby vehicles or obstacles. A built-in **rear-view camera** or heads-up display (HUD) can further assist by projecting essential information like speed, navigation cues, and warning messages directly

into the rider's line of sight.

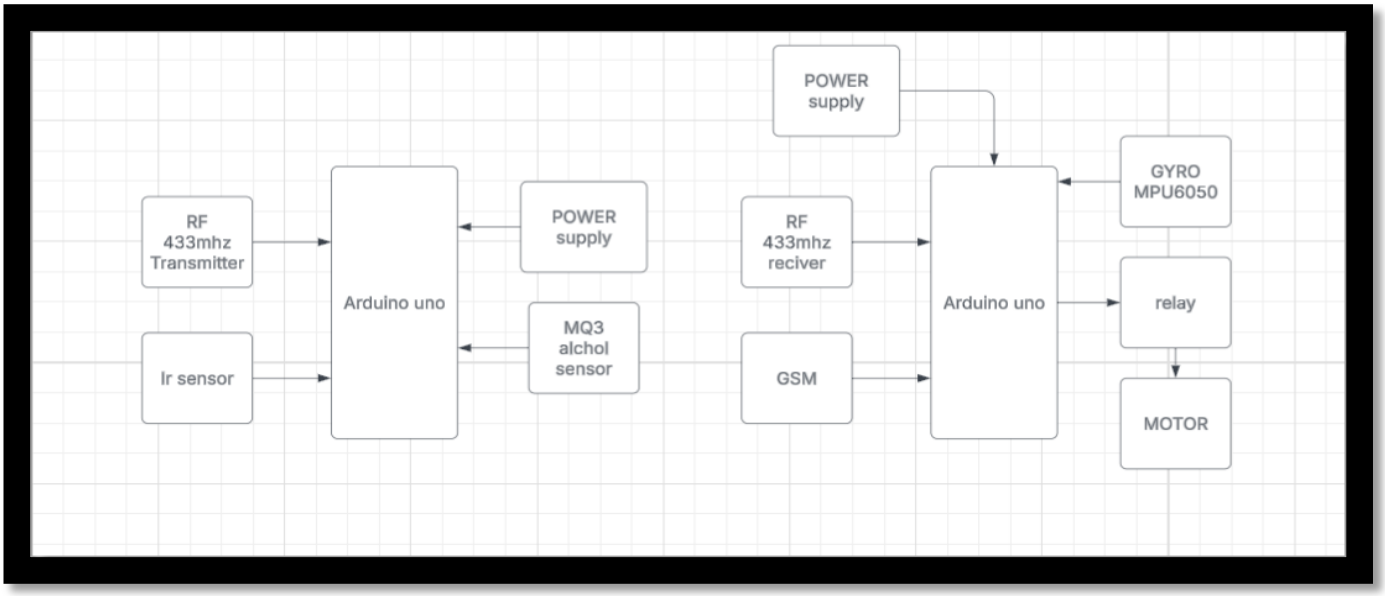
For night-time visibility, the helmet integrates **LED lights** or **reflective panels**, improving the rider's visibility to others on the road. Some versions may include environmental sensors such as a **temperature or air quality monitor**, offering insights into riding conditions and alerting the user to potential health risks.

Overall, this smart helmet system not only enhances the rider's situational awareness but also provides a critical safety net in emergency situations. With its fusion of technology and ergonomic design, it represents a significant step forward in personal safety and modern transportation solutions for motorcyclists.

3.2 Hardware Components

- **Arduino Uno:** ATmega328P-based microcontroller, chosen for ease of integration, cost-effectiveness, and community support.
- **MQ3 Alcohol Sensor:** Detects ethanol vapor in the rider's breath. Prevents ignition if alcohol exceeds a set threshold.
- **MPU6050 Gyroscope and Accelerometer:** Monitors head movement and orientation. A sudden impact or abnormal motion triggers emergency alerts.
- **GSM Module (SIM800L):** Sends SMS alerts with GPS coordinates to emergency contacts upon accident detection.
- **433 MHz RF Transmitter/Receiver:** Facilitates wireless communication between helmet and motorcycle.
- **Relay Module:** Controls ignition and headlight circuits.
- **Touch Sensor:** Ensures helmet is worn; engine does not start otherwise.

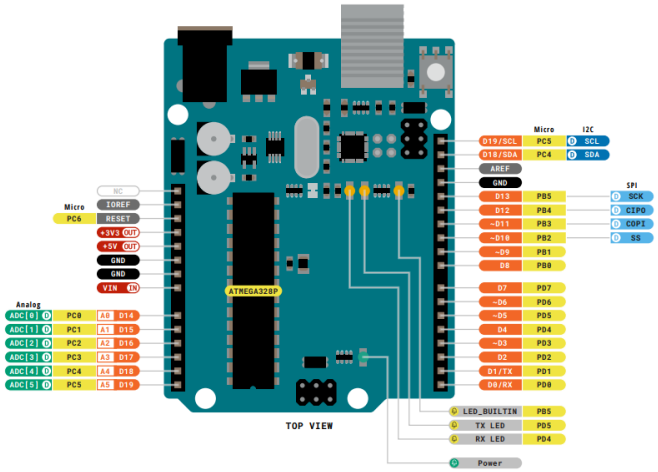
Block Diagram



The block diagram of our proposed smart helmet system features two primary units: the Helmet Unit and the Motorcycle Unit, connected via a 433 MHz RF communication link. The Helmet Unit is centered around an Arduino controller which processes inputs from an alcohol sensor and an MPU6050 gyroscopic sensor to monitor the rider's condition and movements. It also includes an RF receiver and a GSM module for emergency communications. The Motorcycle Unit, also managed by an Arduino controller, uses an RF transmitter to maintain synchronization with the helmet and controls the motorcycle's electrical systems such as headlights and indicators through a relay system. This setup ensures

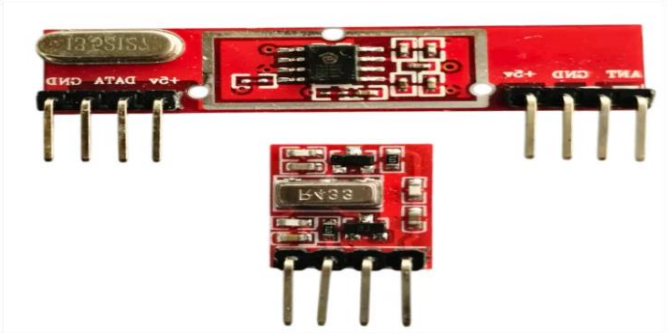
real-time, reliable interaction between the rider and motorcycle, enhancing safety and responsiveness

3.3 Arduinouno



The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller, widely recognized for its reliability, simplicity, and versatility. It features 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button, allowing seamless interaction with various electronic components. One of the key advantages of the Arduino Uno is its open-source hardware and software ecosystem, which encourages innovation and collaboration within a vast global community. The board supports a wide variety of shields and modules, enabling users to expand its functionality for specific tasks like motor control, sensor integration, and wireless communication. Due to its plug-and-play nature and compatibility with the Arduino IDE, the Uno is a favorite among both hobbyists and professional developers for prototyping embedded systems. It also plays a significant role in educational settings, helping students understand the fundamentals of electronics and coding. The ATmega328P's built-in features make the board suitable for applications involving automation, IoT devices, robotics, and wearable technology. Its robust design ensures stable operation even in demanding environments. Overall, the Arduino Uno stands as a cornerstone platform in the maker movement and continues to drive innovation in embedded electronics.

3.4 RF 433MHz Transmitter and Receiver

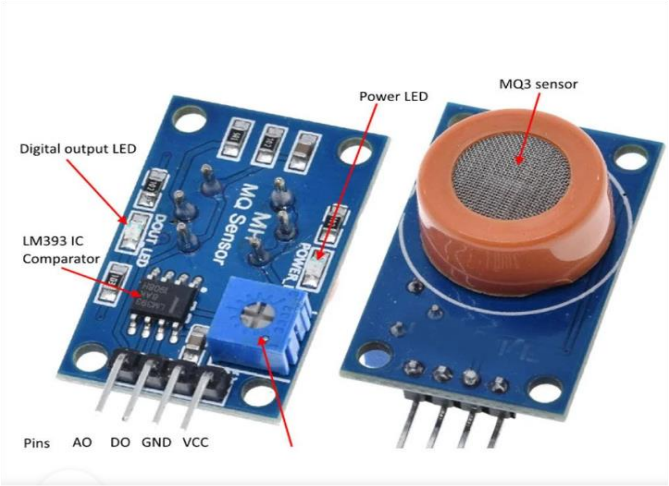


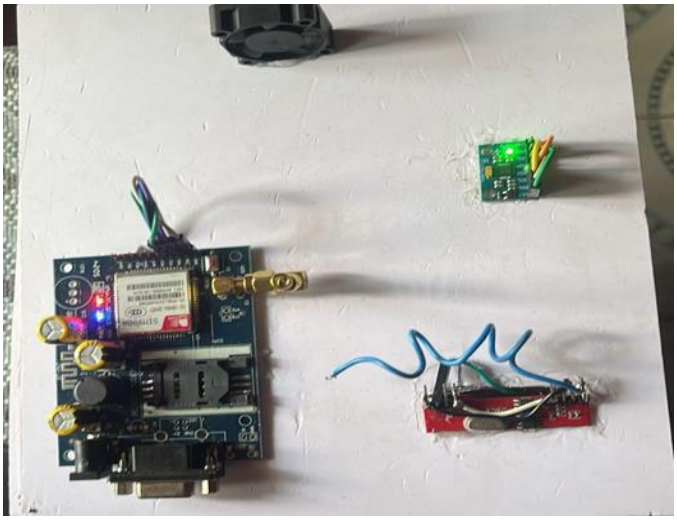
Introduction: The RF 433MHz Transmitter and Receiver modules are widely used in remote control, telemetry, and wireless communication applications. These modules operate at a frequency of 433 MHz, which is within the ISM (Industrial, Scientific, and Medical) radio band, commonly used for low-power, short-range communication.

3.5 GSM Module

GSM (Global System for Mobile Communications) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second-generation (2G) digital cellular networks used by mobile phones. Since its inception in the 1990s, GSM has become the world's most widely adopted mobile network technology. GSM modules are embedded systems that leverage this technology, enabling devices to use a mobile network to transmit and receive data.

3.6 MQ3 Alcohol





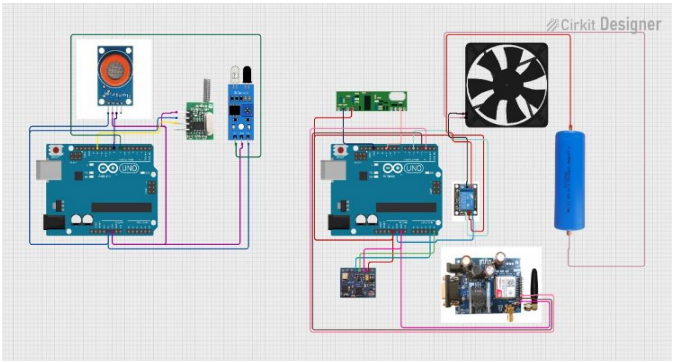
IV. RESULTS AND TESTING

Testing was performed under the following conditions:

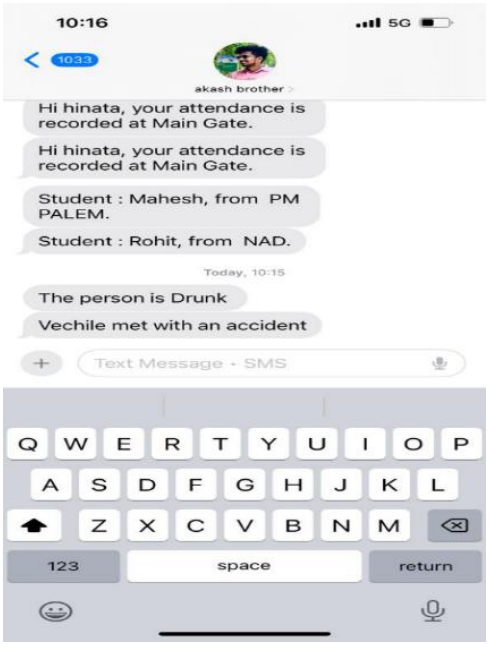
Test Scenario	Expected Outcome	Result
Helmet not worn	Engine remains off	Passed
Alcohol detected	Engine ignition disabled; alert sent	Passed
Normal driving	Headlight auto-adjusts, no alerts triggered	Passed
Simulated accident	Emergency SMS sent with location	Passed

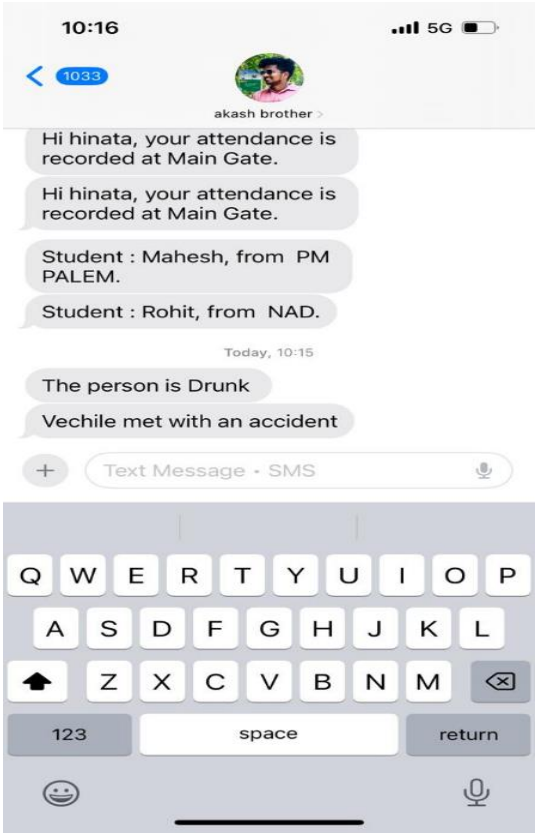
Sample alert messages sent:

- **Drunk Driving Alert:** "Alcohol detected. Ignition disabled. Please ride responsibly."
- **Accident Alert:** *"Accident detected. Location: Lat 17.6868, Long 83.2185. Please respond immediately."*



4.1 Drunk and drive Alert Message Accident Message





V. DISCUSSION

The system effectively integrates safety-critical features without requiring user intervention during operation. Alcohol detection, headgear verification, and accident monitoring offer a proactive approach to rider safety. Limitations include GSM signal dependency and power consumption, which may affect continuous monitoring. Future versions may integrate solar charging, edge AI for better motion analysis, and voice control for interaction.

also a need for robust software integration and user-friendly interfaces to make the system practical for everyday use.

Nevertheless, the potential of this technology to drastically reduce fatalities and injuries caused by drunk driving and road accidents makes it a highly promising area for continued research and development. By combining safety enforcement with proactive monitoring, the smart helmet system offers a comprehensive solution that not only protects riders but also instills a sense of accountability. With further refinement and support from governments, manufacturers, and safety organizations, this system could become a standard safety feature for two-wheeler riders worldwide.

VI. CONCLUSION

The smart helmet system presents a comprehensive solution to some of the most critical problems faced by motorcyclists. With functionalities such as alcohol detection, accident monitoring, helmet compliance enforcement, and GSM-based alerting, it offers a robust, scalable platform for future enhancements. The system stands as a strong prototype for improving road safety, reducing fatalities, and encouraging responsible riding behaviour.

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