International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Intelligent Safety Helmet with Alcohol Level Monitoring System

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***Abstract*—Alcohol-impaired driving and neglect of helmet usage are major contributors to road accidents and fatalities. To solve these problems, this study presents the creation of a Smart Helmet system integrating alcohol detection, helmet- wear detection, and an LED display, utilizing Arduino technol- ogy. An MQ-3 sensor installed within the helmet monitors the rider's breath for alcohol content. If the alcohol concentration exceeds a predefined threshold, the system displays immediate warning messages on the LED screen. Additionally, a helmet- wear detection mechanism confirms that the system only activates fully when the safety gear is properly worn, alerting the rider if the helmet is not in place. This dual-safety approach aims to promote responsible behavior without requiring modifications to the Engine start system. The design emphasizes real- time monitoring, cost-effectiveness, and user-friendly operation. Experimental results validate the reliability and responsiveness of the system, demonstrating its potential to enhance rider safety and significantly reduce alcohol-related and helmet-related road accidents.**

***Index Terms*—Smart Helmet, Alcohol Detection, Helmet-Wear Detection, Arduino, Road Safety, LED Display.**

I. INTRODUCTION

Traffic safety has become an increasingly critical concern in recent years, with alcohol-impaired driving and the neglect of protective gear such as helmets contributing significantly to traffic-related injuries and fatalities. According traffic safety measures, driving under the influence of alcohol drastically increases the risk of accidents, while failure to wear a helmet severely elevates the probability of head Identify applicable funding agency here. If none, delete this. injuries during motorcycle crashes. These issues highlight the urgent need for innovative, technology-driven solutions that can proactively mitigate risks and encourage safer riding behavior.

This project proposes the creation of a Smart Hel- met system that integrates alcohol detection, helmet-wear detection, and a real-time LED display, using Arduino-based technology. The system is made to monitor the rider's breathing for alcohol content through an MQ-3 sensor embedded within the safety gear. If the detected alcohol level exceeds a predefined safety threshold, the system immediately alerts the rider via the LED display, providing clear warnings. Furthermore, the helmet-wear detection feature ensures that the rider is reminded to wear the helmet properly, thereby promoting adherence to safety protocols.

Unlike conventional vehicle-based interventions that disable ignition systems, the proposed Smart Helmet focuses on informing and alerting the rider directly, making the solu- tion simpler, cost-effective, and easier to implement without modifying the vehicle's structure. The design prioritizes real-time monitoring, user-friendliness, and affordability, making it suitable for mass adoption, particularly in regions where two-wheeler usage is prevalent.

This paper details the design methodology, system archi-tecture, component selection, implementation process, and experimental validation of the Smart Helmet. The results simply and clearly demonstrate the system's effectiveness in enhancing rider safety by promoting responsible behavior and providing timely alerts regarding alcohol consumption and helmet usageLITERATURE REVIEW

A. Recent advancements in embedded systems and IoT

Recent advancements in embedded systems and IoT, particularly with Arduino platforms, have enabled the development of efficient, low-power wearable safety devices. The integration of microcontrollers like the Arduino Nano 33 IoT and sensors such as the MQ series allows real-time monitoring with minimal energy consumption. Compact display systems, including LEDs and OLED screens, facilitate immediate user feedback, while edge computing capabilities ensure faster response times without cloud reliance. Additionally, the rise of Arduino-based health monitoring devices has demonstrated growing acceptance of smart wearables. These innovations provide a strong base for building a smart helmets that can detect alcohol consumption, verify helmet- wearing, and deliver real-time alerts to enhance rider safety.

II. SYSTEM COMPONENTS AND ARCHITECTURE

The Safety Helmet system is composed of several integral components that collectively enhance rider safety. The Arduino Uno serves as the central processing unit, coordinating the operations of all subsystems. The MQ-3 Alcohol Sensor is responsible for detecting the presence of alcohol in the rider's breath, providing real-time monitoring. An IR Sensor or Helmet Switch makes sure that the helmet is properly worn, triggering an alert if it is not. The Accelerometer (ADXL345) detects sudden impacts or crashes, enabling the system to rec- ognize potentially hazardous events. The GPS Module (Neo- 6M) offers precise location tracking, allowing for location- based services. The GSM Module (SIM800L) is employed to send emergency alerts to pre-defined contacts in the event of an accident. Lastly, the Relay Module controls the ignition system, preventing the vehicle from starting if the alcohol concentration in the rider's breath exceeds predefined safety thresholds. Together, these components form a comprehensive and integrated solution to improve rider safety.

A. Architecture flow

When the bike is powered on, the LED display initially shows the message "Smart Helmet with Alcohol Detection," indicating that the system is active. The system then checks whether the rider is wearing the helmet by utilizing the IR sensor or helmet switch. If the helmet is detected, the LED displays the message "Helmet Detected," confirming the rider is wearing the helmet. If the safety helmet is not worn, the LED prompts the rider with the message "Wear Helmet," encouraging proper safety. Simultaneously, the MQ-3 alcohol sensor monitors the rider's breath for alcohol content. If alcohol is detected, the LED will display the message "Alcohol Detected," alerting the person who rides bike to the unsafe condition. This real- time feedback makes sure that the rider is both wearing the helmet and sober, contributing to enhanced safety before the bike can be operated.

Working Methodology

- The rider wears the helmet, and the IR sensor confirms its presence. If the helmet is properly worn, the system proceeds to the next step.
- The MQ-3 alcohol sensor checks for the presence of alcohol vapors in the rider's mouth or nose. If alcohol is detected at levels above a predefined threshold, the LED display shows the message "Alcohol Detected," indicating the rider is unfit to operate the vehicle.
- If the rider is sober and the helmet is securely worn, the system enables the relay module, which allows the vehicle's engine to be turned on, enabling the rider to start the vehicle and proceed with the ride.
- During the ride, if the accelerometer (ADXL345) detects an abnormal force, such as a crash or fall, it triggers an alert. The system then takes immediate action, potentially sending notifications to emergency contacts or displaying a relevant warning on the LED.

B. Software requirements

The development of the Intelligent Safety Helmet with Alcohol Level Monitoring system was conducted using the Arduino programming tool, version 1.8.x and above. Arduino IDE was selected due to its ease of use, extensive library support, and compatibility with a variety of micro-controllers. It facilitated writing, compiling, and uploading embedded C/C++ programs to the Arduino board, enabling seamless interaction between the helmet's sensors and ac-tuators. Specific sensor modules, such as the MQ-3 alcohol sensor, were interfaced using relevant libraries, while wireless communication functionalities employed the SoftwareSerial library. The Serial Monitor tool within the IDE was extensively utilized for real-time data visualization, system debugging, and sensor calibration. For devices requiring I2C communication, such as accelerometers for crash detection, the Wire library was integrated. Overall, the Arduino IDE provided a versatile and reliable platform to implement the software logic, ensuring efficient operation of the safety helmet system.

C. Hardware requirements

The Intelligent Safety Helmet with Alcohol Level Monitoring system was developed using a variety of electronic components carefully selected for their functionality and reliability. An Arduino Uno board served as the central microcontroller, providing the necessary processing power and I/O control for sensor integration and system operation. Basic electronic components such as capacitors and resistors were used for signal condi- tioning, noise filtering, and circuit stabilization. An oscillator was incorporated to maintain consistent clock signals, ensuring precise timing for critical operations. A potentiometer was uti- lized for adjustable voltage control, particularly useful during sensor calibration and sensitivity adjustments. A power switch was integrated to control the ignition system, allowing the microcontroller to enable or disable the bike's start function based on safety conditions. To enhance user interaction, a buzzer was installed to play sound when needed for events such as alcohol detection or improper helmet usage. Additionally, an LED screen was included to display system status messages, sensor readings, and user prompts. Together, these hardware elements formed a comprehensive and efficient framework for the implementation of the smart helmet system.

D. Results and Discussion

The Safety Helmet with Alcohol Level Monitoring was successfully tested using the MQ-3 sensor and an Arduino microcontroller. When alcohol vapors were detected above the calibrated threshold, the system activated a buzzer and displayed "Alco- hol Detected" on the LED screen. Additionally, if the safety helmet was not put on properly, the system displayed "Wear Helmet" as a warning to the rider. The sensor responded within two seconds, providing quick and effective visual and audio alerts. Electronic components such as capacitors, resistors, and an oscillator ensured stable signal processing and reliable system performance. Across multiple tests, the helmet consistently alerted users to unsafe conditions, encouraging responsible behavior without any ignition control involvement.

E. Conclusion

The Smart Helmet with Alcohol Detection system was successfully designed and implemented to enhance rider safety by providing real-time alerts. By using an MQ-3 alcohol sensor and helmet detection mechanism, the system effectively identified unsafe conditions such as alcohol consumption or failure to wear a helmet. Warnings were promptly displayed on an LED screen, accompanied by a buzzer alert, ensuring the rider was notified before starting their journey. The use of basic electronic components and the Arduino platform made the design cost-effective, reliable, and suitable for practical use. This project highlights a simple yet impactful solution to promote responsible riding and reduce road accidents caused by human negligence.

F. Future Scope

The Smart Helmet with Alcohol Detection system can be further developed to include additional safety features, such as integration with a vehicle's ignition system for automatic vehicle lock when alcohol is detected. Future enhancements could include the use of wireless communication (e.g., Bluetooth) to send alerts to connected mobile devices or cloud-based systems for real-time monitoring. The alcohol sensor could be improved for better accuracy in varying environmental conditions, and the system could be extended to incorporate GPS tracking for emergency response in case of an accident. Additionally, the system can be refined for broader use in other safety-critical applications, such as commercial vehicle fleets.

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