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Smart Helmet with Accident Detection

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***Abstract*—This project presents the design and implementation of a Smart Helmet integrated with accident detection and emergency alert capabilities, aimed at enhancing rider safety and response time during road mishaps. The system employs an accelerometer (e.g., MPU6050) to monitor sudden impacts or abnormal motion patterns indicative of a crash. Upon detecting a potential accident, the helmet triggers a GSM module to automatically send an SMS alert containing GPS coordinates to predefined emergency contacts, enabling rapid assistance. Additional features include alcohol detection, helmet-wear verification, and real-time location tracking, ensuring compliance and proactive safety. The entire system is powered by an Arduino Uno or ESP32, offering modularity and low-cost deployment. This solution is particularly relevant in regions with high two-wheeler usage and limited emergency infrastructure, providing a scalable approach to reducing fatalities and improving post-accident response.**

***Index Terms*—Smart Helmet, Arduino UNO, Alcohol Detection, Bluetooth Communication, IoT Safety Systems, Embedded Systems, Accident Prevention, Two-Wheeler Safety.**

I. INTRODUCTION

Road safety for two-wheeler riders has become a critical issue due to the increasing number of accidents caused by negligence, such as not wearing helmets or riding under the influence of alcohol. Traditional helmets offer only physical protection and fail to enforce safety rules or prevent risky behavior. To overcome these limitations, modern embedded technologies can be applied to develop intelligent systems that actively monitor rider conditions and ensure safe vehicle operation. The Smart Helmet System aims to bridge this gap by integrating sensors, microcontrollers, and wireless communication modules into a compact and efficient design that enhances rider safety through automation.

The proposed Smart Helmet uses an IR sensor to detect helmet usage and an MQ-3 alcohol sensor to monitor the rider's breath for alcohol content. The system is powered by Arduino UNO, which serves as the central processing unit for collecting sensor data and executing safety logic. When the helmet is not worn, a Bluetooth module communicates with a mobile application developed in MIT App Inventor, sending a warning message to the bike's display and preventing ignition. If alcohol is detected, a buzzer and LCD display provide immediate alerts to the rider, and the vehicle remains disabled until safe conditions are restored. By combining embedded electronics with wireless communication, this system ensures that the bike operates only when the rider is sober and wearing a helmet. The integration of hardware and software components makes the Smart Helmet a cost-effective, user-friendly, and scalable safety solution. Beyond preventing drunk driving and enforcing helmet compliance.

II. RELATED WORK

CAN-Based Vehicle Safety and Automation System
The CAN-based vehicle safety and automation system focuses on improving road safety through sensor-based monitoring and centralized communication. It employs a Controller Area Network (CAN) bus to connect multiple vehicle sensors such as alcohol sensors, seat-belt detectors, and speed controllers. However, implementing CAN increases design complexity and cost, making it less practical for two-wheeler applications. The proposed Smart Helmet System adopts a simplified embedded design using Arduino UNO and Bluetooth communication, providing similar safety automation at a lower cost.

Smart Helmet Using Accelerometer and Arduino
Traditional accident detection models use Arduino

microcontrollers and accelerometers to identify sudden changes in movement or impact during a crash. While effective, these designs primarily focus on accident response rather than prevention. The Smart Helmet System emphasizes preventive safety measures by ensuring helmet usage and alcohol detection before ignition.

IoT-Based Smart Helmet System
IoT-based systems commonly use cloud servers and GSM modules to send accident alerts with GPS locations. Although effective, they depend on internet access and are costly. The proposed Smart Helmet System replaces internet-based communication with Bluetooth-based local connectivity, reducing system cost and power consumption.

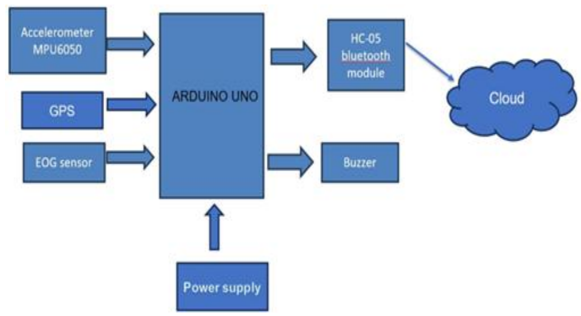
Embedded System for Smart Helmet
Embedded systems for accident detection typically integrate microcontrollers, sensors, and GSM modules. While accurate, GSM systems require network availability and increase maintenance costs. The Smart Helmet System simplifies this approach using Arduino UNO, MQ-3 alcohol sensor, IR helmet sensor, and Bluetooth communication.

Bluetooth-Enabled Smart Helmet System
Bluetooth-based accident alert systems enable short-range communication between sensors and smartphones. The proposed Smart Helmet System integrates Bluetooth with Arduino UNO, enabling wireless communication with the MIT App Inventor app for real-time alerts.

III. PROPOSED SYSTEM

The proposed Smart Helmet System introduces an intelligent safety solution that enforces safe riding practices through embedded automation. The system is built using an Arduino UNO microcontroller as the main processing unit, interfaced with an IR sensor, MQ3 alcohol sensor, Bluetooth module (HC-05), LCD display, and buzzer. The m sensor detects whether the helmet is being worn. If the helmet is not detected, the system sends a signal via Bluetooth to a mobile application developed using MIT App Inventor, displaying a warning and preventing the ignition. Once the helmet is properly worn, the MQ3 sensor continuously monitors the rider's breath for alcohol presence. If alcohol is detected beyond the threshold, the system triggers the buzzer and displays a warning on the LCD, ensuring that the vehicle remains off. Through Bluetooth communication, real-time notifications are also transmitted to the mobile application, ensuring the rider is alerted immediately. This integrated system thus combines safety enforcement and real-time monitoring, making it highly effective for two-wheeler riders.

BLOCK DIAGRAM



Arduino UNO:
Acts as the brain of the system. It collects input signals from sensors, processes them, and controls outputs such as the buzzer, LCD, and Bluetooth module.

IR Sensor (Helmet Detection):
Detects whether the helmet is worn by sensing the presence of the rider's head or proximity of an object. If not detected, ignition is disabled.

MQ3 Alcohol Sensor:
Continuously monitors the rider's breath for alcohol concentration. When alcohol exceeds a predefined threshold, the system triggers safety alerts.

Bluetooth Module (HC-05):
Establishes wireless communication between Arduino and the mobile app developed in MIT App Inventor. It sends real-time safety status and warning notifications.

LCD Display (16x2):
Displays system messages such as “Wear Helmet”, “Alcohol Detected”, or “Safe to Start”.
Buzzer: Provides an audible warning whenever unsafe conditions are detected.

Helmet Setup:
Physically integrates all components, making the system wearable and compact.

IV. WORKING PRINCIPLE

When the system is powered ON, the Arduino checks the IR sensor to verify helmet usage.

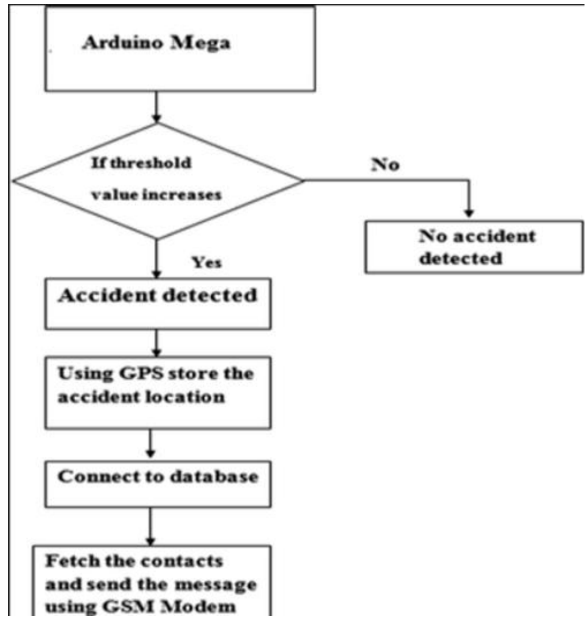
- If the helmet is not worn, the LCD shows a warning and the buzzer sounds an alert.
- If the helmet is wom, the MQ3 sensor analyzes the rider's breath.
- If alcohol is detected, the buzzer activates and the LCD displays “Alcohol Detected.”
- If both conditions are safe (helmet worn and no alcohol), the system sends a “Safe to Ride” signal via Bluetooth to the MIT App, allowing ignition to start. The system logic is implemented in Embedded C language using Arduino IDE. The code performs the following operations sequentially: I

Initialization Phase:
The system initializes all sensors and output devices. The LCD displays “SMART HELMET SYSTEMS” “Initializing...” messages. Bluetooth serial communication begins at 9600 baud rates.

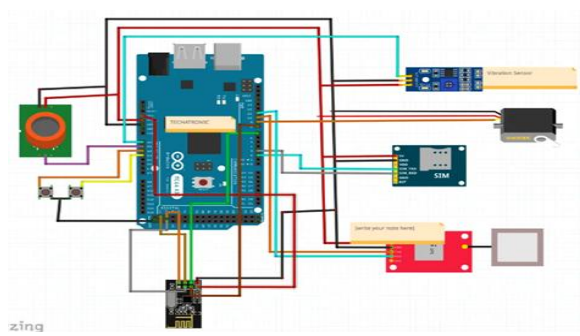
Helmet selection phase:
If the helmet is not worn, the buzzer is activated, ignition is turned OFF, and the LCD shows “Wear Helmet!!!”. A corresponding message (“Helmet not detected! Ignition OFF.”) is sent to the MIT App via Bluetooth.

Alcohol Detection Phase:
When the helmet is worn, the system reads analog data from the MQ-3 sensor. If alcohol concentration is higher than the preset threshold (300), the buzzer turns ON, LCD shows “Alcohol Detected!”, and ignition remains OFF. A message (“Alcohol detected! Ignition OFF.”) is sent via Bluetooth. Safe Condition Phase: If the helmet is worn and no alcohol is detected, the buzzer turns OFF, ignition is ON, and the LCD displays “Check Passed — Safe to Ride”. The system sends “Safe to ride. Ignition ON.” to the MIT App. This embedded program automates rider safety using conditional logic, continuous sensor monitoring, and real-time feedback.

FLOW CHART



V.DESIGN AND IMPLEMENTATION

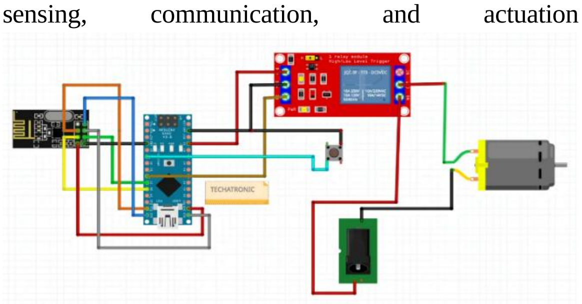


Schematic diagram of transmitter section

This wiring diagram illustrates a complex Arduino Uno–based system that integrates multiple sensors, communication modules, and an actuator to create a versatile smart project. At the center is the Arduino Uno, which serves as the main controller, processing signals from connected devices and coordinating their functions. The input side includes a vibration sensor to detect shocks or disturbances, a push button for manual control, an ultrasonic or proximity sensor to measure distance or detect intrusions, and a touch or fingerprint sensor for authentication. These inputs allow the system to monitor its environment and respond to user interaction.

On the communication side, the SIM module provides GSM capabilities, enabling the system to send SMS alerts or make calls, while the ESP8266 Wi-Fi module allows data to be transmitted over the internet for remote monitoring or cloud integration. The output side features a servo motor, which can perform mechanical actions such as locking, unlocking, or moving components in response to sensor triggers. All modules are connected through power (VCC), ground (GND), and signal lines, ensuring proper operation and synchronization.

Taken together, this setup demonstrates how Arduino can act as the hub for a smart monitoring and control system. It can detect events like vibrations or intrusions, authenticate users via touch or fingerprint, communicate alerts through GSM or Wi-Fi, and physically respond using the servo motor. Such a design is well-suited for applications in home security, accident detection, or smart access control, where sensing, communication, and actuation



Schematic diagram of receiver section

This schematic shows a more advanced Arduino Nano–based project designed for remote motor control using wireless communication. At the heart of the system is the Arduino Nano, which acts as the microcontroller, coordinating signals between the input, communication, and output devices.

On the communication side, the NRF24L01 wireless transceiver module is connected to the Nano. This module allows the Arduino to send and receive data wirelessly, making it possible to control the motor remotely from another Arduino or compatible transmitter. It uses SPI (Serial Peripheral Interface) pins for communication, so multiple-colored wires connect it to the Nano's MOSI, MISO, SCK, and CE/CSN pins, along with power and ground.

For input, a push button is wired to the Nano. This button acts as a manual control switch, enabling the user to send a signal to the Arduino to turn the motor on or off. The Arduino interprets the button press and then communicates with the relay module.

The relay module (JQC-3FF-S-Z DC5V) is a crucial part of the circuit. Since the Arduino cannot directly power high-current devices like motors, the relay acts as an electrically operated switch. The Nano sends a low-power signal to the relay, which then closes or opens the circuit connected to the motor's power supply. This allows safe and reliable control of the motor without overloading the Arduino.

The DC motor is connected through the relay and powered by an external supply. When the relay is activated, the motor receives power and starts running; when deactivated, the motor stops. The external power supply connector ensures that the motor and relay have sufficient voltage and current, separate from the Arduino's limited onboard supply.

Altogether, this setup demonstrates how an Arduino Nano can be used to wirelessly control a DC motor. The push button provides local input, the NRF24L01 enables remote communication, and the relay safely switches the motor's power. This type of design is commonly used in IoT, automation, and robotics projects, where motors need to be controlled remotely and reliably.

CIRCUIT CONFIGURATION

Component	Arduino mega pin	Module pin
MQ-3Alcohol sensor	5v	VCC
	GND	GND
	A0	A0
Servo motor (SG90)	5V	Red
	GND	Black
	Digital PWM	Orange (DATA)
GSM SIM800L	D2	Rx
	D3	TX
	5V	VCC
	GND	GND
GPS NEO-6M Module	D10	Rx
	D11	Tx
	5V	VCC
	GND	GND
Vibration sensor	A1	Din
	5V	VCC
	GND	GND
NRF24LO1 Module	D50	MISO
	D51	MOSI
	D52	SCK
	D8	CSN
	D7	CE

VI. RESULT

The Smart Helmet System was successfully implemented and tested to ensure improved road safety for two-wheeler riders through intelligent control and monitoring. The system was designed using an Arduino UNO, m sensor, MQ-3 alcohol sensor, Bluetooth module, LCD display, and buzzer, all working in coordination with a mobile application developed using MIT App Inventor .

During testing, the system correctly detected the presence or absence of the helmet and accurately measured alcohol levels in the rider's breath. It was observed that the entire setup operated efficiently, with a quick response time and stable communication between the helmet unit and the mobile app. When the helmet was not worn, the IR sensor failed to detect the rider's head, triggering a safety alert. The buzzer emitted a warning sound, and the LCD display showed the message "Wear Helmet!!!", while a Bluetooth message "Helmet not detected! Ignition OFF." was transmitted to the mobile application. In this condition. The ignition circuit remained off, ensuring the bike could not start. This functionality guarantees that the rider adheres to safety protocols before attempting to operate the vehicle. When the helmet was wo correctly and no alcohol was detected by the MQ-3 sensor. the system indicated safe conditions for riding.

The buzzer turned off, the LCD displayed "Safe to Ride," and a Bluetooth message "Safe to ride. Ignition ON." was sent to the MIT App. In this mode, the ignition signal was enabled, demonstrating that the system functioned as intended by only allowing operation under safe and compliant conditions. The Bluetooth communication between the Arduino and the app was reliable, maintaining consistent data transmission even during continuous testing.

VII. CONCLUSION

The Smart Helmet System provides an innovative and practical approach to improving road safety for two-wheeler riders. With the increasing rate of accidents due to negligence and drunk driving, this project offers a technological solution that combines automation, sensing, and communication to ensure responsible riding behavior. By integrating the Arduino UNO as the main controller, the system effectively coordinates multiple sensors and modules to monitor the rider's condition and take preventive action when unsafe conditions are detected.

One of the key features of the system is the helmet detection mechanism using an IR sensor. This feature ensures that the vehicle will not start unless the rider is wearing the helmet properly. Such a function directly enforces safety compliance and prevents riders from operating the vehicle without essential protective gear. This simple yet impactful automation helps in significantly reducing the number of head injuries resulting from accidents involving helmet negligence.

Another major aspect of the system is the use of the MQ3 alcohol sensor to detect alcohol consumption. The sensor continuously monitors the rider's breath and sends the data to the Arduino for analysis. If the alcohol concentration exceeds a predefined limit, the system immediately activates the buzzer and displays a warning message on the LCD. Simultaneously, the vehicle ignition is disabled to prevent the rider from starting the bike, thereby avoiding potential accidents caused by drunk driving.

The Bluetooth module plays a crucial role in wireless communication between the helmet system and the mobile application developed using MIT App Inventor. Through this app, the system can send real-time alerts and warnings to the rider's smartphone, providing additional layers of monitoring and control. This connectivity makes the system user-friendly and enhances its capability to deliver timely notifications that can save lives.

VIII. FUTURE SCOPE

- Future versions of this software can include several advanced features to enhance functionality and performance:
- Integration with GPS and IoT: To automatically send accident or alcohol alerts to family members or emergency contacts with live location data.
- Integration with GPS and IoT: To automatically send accident or alcohol alerts to family members or emergency contacts with live location data.
- Cloud Data Storage: Uploading rider safety data for analysis and reporting
- AI-based Monitoring: Using machine learning algorithms to detect riding patterns or drowsiness from sensor data.

- System Calibration Menu: Allowing users to set alcohol threshold levels through the mobile app interface.
- enhancements would make the Smart Helmet System more robust, scalable, and suitable for real-world smart These transportation environments.
- Helmet not detected! Ignition OFF. Alcohol detected! Ignition OFF. Safe to ride. Ignition ON.
- The data sent via the HC-05 Bluetooth module, allowing developers to cross-check the communication between the Arduino and the MIT App.
- Integration with 5G Connectivity: Enable faster, low-latency communication for real-time alerts and cloud synchronization.
- Voice Assistant Support: Incorporate voice commands for hands-free operation, emergency calling, or navigation assistance.
- Solar/Rechargeable Power Supply: Add renewable energy options to extend battery life and reduce maintenance.
- Accident Severity Analysis: Use accelerometers and gyroscopes to classify accident severity and trigger appropriate emergency responses.
- Health Monitoring Sensors: Integrate heart rate, blood oxygen, or fatigue detection sensors to monitor rider health.
- Automatic Emergency Calling: Directly dial emergency services (e.g., 112/911) when critical conditions are detected.
- Augmented Reality (AR) Display: Provide navigation, speed, and hazard warnings directly on a visor HUD.
- Multi-Language Alerts: Support regional languages in the mobile app and LCD display for wider adoption.
- Data Analytics Dashboard: Offer riders and authorities a web portal to analyze riding patterns, accident statistics, and compliance.
- Integration with Smart Vehicles: Communicate with vehicle ECUs for advanced safety features like automatic braking or speed limiting.
- Geo-Fencing: Restrict vehicle operation in sensitive zones (school areas, alcohol-restricted zones) using GPS.
- Community Safety Network: Share anonymized alerts with nearby riders or traffic authorities to improve collective safety.

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