ENHANCING TWO-WHEELER SAFETY

THE SMART HELMET SYSTEM

by

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A project report submitted to

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**ENHANCHING TWO-WHEELER SAFETY: THE SMART HELMET SYSTEM"** is a Bonafide work of **SHREYAVARSHINI SUBRAMANIAN – 23BEC1391, PEDDINTI GEETHA SRI - 23BEC1093 and JAYA KEERTHISHA- 23BEC1251 who** carried out the Project work under my supervision and guidance for **BECE403E-EMBEDDED SYSTEM DESIGN.**

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ABSTRACT

Two-wheeler riders account for a large portion of road accident fatalities, primarily due to not wearing helmets, driving under the influence of alcohol, and the delay in receiving medical assistance after accidents. To address these critical issues, this project presents a Smart Helmet for Accident Detection and Alert Generation that enhances rider safety using multiple sensing and communication technologies integrated with an Arduino Uno microcontroller.

The system operates on three main parameters: helmet usage detection, alcohol level monitoring, and accident (fall) detection. An infrared (IR) sensor detects whether the helmet is worn by the rider. An MQ-3 alcohol sensor monitors the rider's breath and identifies the presence of alcohol. If alcohol is detected or if the rider attempts to start the vehicle without wearing the helmet, the motor remains deactivated through a relay-controlled circuit, and a buzzer is activated as an alert. This ensures that the vehicle cannot be operated in unsafe conditions.

For accident detection, an MPU6050 accelerometer module continuously measures tilt and acceleration. In case of an abnormal fall or crash, the sensor data triggers an accident detection event. Upon confirming the rider is wearing the helmet at that moment, the system activates the GPS module (NEO-6M) to acquire real-time location coordinates. These coordinates are transmitted via the GSM module (SIM800L) to a pre-stored emergency contact number through SMS, including the location for quick location tracking.

The complete setup designed to be portable, energy-efficient, and easy to integrate into existing helmet and vehicle systems. The use of an Arduino Uno ensures cost-effectiveness, simplicity, and reliability in handling multiple sensor inputs and communication outputs simultaneously.

By combining helmet-wearing verification, alcohol detection, and automatic accident alert in one system, this project not only enforces safe riding habits but also drastically reduces response time after an accident. The proposed model, once implemented in real-world conditions, can contribute to reducing two-wheeler fatalities and ensuring faster medical aid through automated communication systems.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 MOTIVATION

Road safety has become a major concern in today's world, especially in developing countries like India, where two-wheelers are one of the most common modes of transport. A large percentage of road accidents involve two-wheeler riders who fail to wear helmets or drive under the influence of alcohol. Also, Accidents often result in severe head injuries and fatalities that could have been avoided with proper safety measures. Despite strict traffic rules, enforcement alone has not been sufficient to ensure consistent helmet usage and sober driving behaviour.

In addition to preventive safety, one of the most serious challenges after an accident is the delay in medical assistance. In many cases, the rider is left unconscious or unable to communicate, leading to delayed help and sometimes loss of life. Timely medical intervention within the "golden hour" is critical for survival, yet it heavily depends on someone witnessing the accident and calling for help.

This project is motivated by the need to build an intelligent system that not only enforces basic safety protocols such as wearing a helmet and avoiding drunk driving, but also provides an automatic alert mechanism in case of an accident. By combining sensing technology with communication modules, the proposed system aims to provide a cost-effective and reliable solution that enhances the safety of two-wheeler riders. The motivation also stems from the idea of using easily available microcontrollers and sensors to create a practical, scalable design that could be integrated into commercial helmets or vehicles in the future.

1.2 OBJECTIVES

1. Helmet Verification: To ensure that the vehicle can only start when the rider is wearing the helmet, thereby promoting mandatory helmet usage.
2. Alcohol Detection: To identify whether the rider has consumed alcohol and restrict motor operation in such cases, reducing drunk driving incidents.

3. Fall Detection: To detect sudden falls or accidents using motion sensors and determine if the rider needs assistance.
4. Accident Alert: To send an automatic SMS alert containing the rider's GPS location to a predefined emergency contact immediately after an accident is detected.
5. Motor Control: To control the motor relay based on sensor inputs and ensure that the vehicle cannot start under unsafe conditions.
6. Safety Enforcement: To combine all three safety parameters—helmet usage, alcohol detection, and fall detection—into a single integrated smart system.
7. Reliability and Affordability: To design the system using low-cost components without compromising reliability, ensuring that it can be implemented in large-scale production.

1.3 APPLICATIONS

2. Two-Wheeler Safety Systems: Can be implemented in motorcycles, scooters, and e-bikes to prevent unsafe riding conditions.
3. Smart Helmets: Applicable in next-generation smart helmets that can monitor the rider's condition and communicate with vehicles or emergency services.
4. Accident Detection Systems: Useful for developing automatic accident detection and alert units that can be integrated into existing vehicles.
5. Emergency Response Systems: Helps in sending real-time alerts to hospitals, family members, or police authorities, reducing response time after accidents.
6. Commercial Fleet and Delivery Services: Ensures safety compliance for delivery riders in logistics, food delivery, and courier services.
7. Law Enforcement and Public Safety: Supports traffic authorities by providing preventive control mechanisms against rule violations such as riding without helmets or drunk driving.
8. Cyclist and Personal Safety Gear: The same concept can be adapted for cyclists and sports riders to monitor impacts and provide emergency alerts in case of falls.
9. Educational and Research Projects: Serves as a practical embedded systems project to demonstrate sensor integration, IoT communication, and safety automation concepts.

2. EMBEDDED SYSTEM DESIGN PROCESS

2.1 REQUIREMENTS

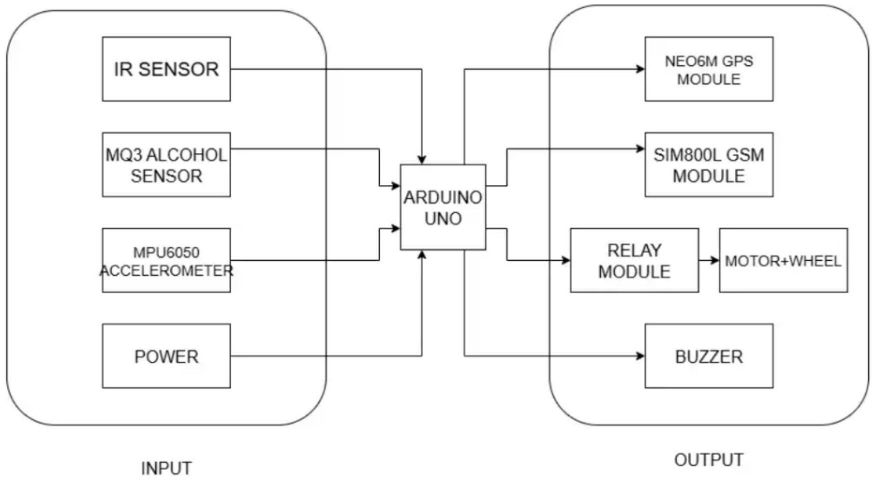
The system uses an Arduino Uno R3 as the main controller to process sensor data and control outputs. An IR sensor detects whether the helmet is worn, while an MQ-3 sensor identifies alcohol presence in the rider's breath. The MPU6050 accelerometer monitors sudden tilt or impact to detect falls. For communication, the SIM800L V2 GSM module sends SMS alerts and the NEO-6M GPS module provides location data. A 5V relay module controls the motor circuit, and a buzzer provides audible warnings. The setup is powered through a 5V supply directly compatible with all modules.

2.2 SPECIFICATIONS

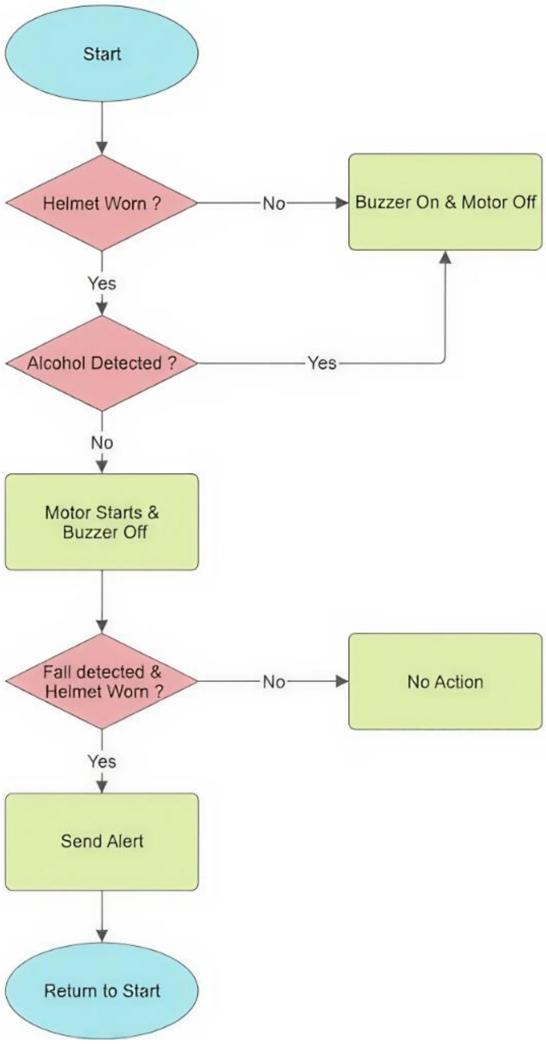
- Arduino Uno R3 Microcontroller
- IR Sensor for Helmet detection
- MQ-3 Alcohol Sensor to detect presence of alcohol
- MPU6050 Accelerometer for fall detection
- SIM800L GSM Module to send SMS
- NEO-6M GPS Module to detect location
- Relay Module to control the motor
- Buzzer to indicate unsafe conditions
- 9V battery and battery cap for the motor to run
- Motor & Wheel (prototype simulation)
- Breadboard, jumper wires (Male -Male, Male-Female, Female-Female)
- Perf Board, soldering kit

2.3 ARCHITECTURE

HARDWARE:



SOFTWARE:



2.4 COMPONENTS

Hardware Requirements

- Arduino Uno R3
- IR Sensor
- Alcohol Sensor
- Accelerometer
- GSM Module
- GPS Module
- Relay Module
- 9V battery and battery cap
- Buzzer
- Motor & Wheel (prototype simulation)
- Breadboard, jumper wires
- Perf Board, soldering kit

Software Requirement - Arduino IDE

2.5 SYSTEM INTEGRATION

The system integrates sensing, control, and communication units into a single intelligent safety framework managed by the Arduino Uno microcontroller. All input sensors—helmet detection, alcohol detection, and fall detection—continuously provide real-time data to the controller. The IR helmet sensor ensures the vehicle can only operate when the rider is wearing the helmet, while the MQ-3 alcohol sensor checks for alcohol vapor before ignition. Both of these inputs act as preventive measures by enabling the relay and motor circuit only when safety conditions are satisfied.

Once the initial safety conditions are validated, the system allows the motor to operate normally. During operation, the MPU6050 accelerometer and gyroscope module constantly monitors the rider's motion and orientation to detect any abnormal tilt or sudden impact that may indicate a fall or accident. When such an event is detected, the controller automatically initiates an emergency alert sequence. The NEO-6M GPS module collects the rider's precise geographical coordinates, while the SIM800L V2 GSM module transmits these details to a predefined emergency contact through an SMS alert. The message includes the accident notification and the exact location, enabling rapid response and assistance.

All modules are powered through a stable 5V regulated supply, ensuring consistent performance and noise-free communication between components. The microcontroller coordinates data flow between sensors and communication modules, ensuring reliable decision-making and real-time action. This integrated approach effectively combines preventive and responsive safety mechanisms—preventing unsafe vehicle operation and ensuring immediate help in emergencies.

3. SYSTEM IMPLEMENTATION

3.1 SOFTWARE –CODING AND ANALYSIS

The software for the Smart Helmet system is developed using the Arduino IDE, which provides an integrated environment for writing, compiling, and uploading code to the Arduino Uno R3 microcontroller. The program is written in Embedded C/C++, using built-in Arduino libraries to simplify hardware interfacing and sensor communication.

The main objective of the software is to continuously monitor inputs from the helmet, alcohol, and fall detection sensors, process the data in real-time, and control the corresponding outputs such as the relay, buzzer, GSM, and GPS modules. The code begins with the initialization of all pins, sensor calibration, and serial communication setup for GSM and GPS modules using the SoftwareSerial library.

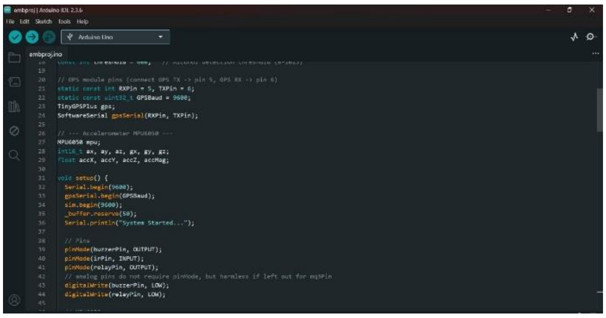
The logic follows a sequential flow:

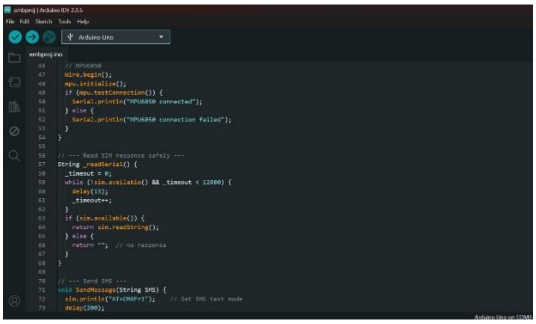
1. **Helmet Detection:** The IR sensor is read first. If the helmet is not worn, the buzzer is activated and the relay controlling the motor remains OFF.
2. **Alcohol Detection:** If the helmet is worn, the system reads the MQ-3 sensor value. When the sensor detects alcohol above the threshold level, the relay is kept OFF and the buzzer sounds a warning.
3. **Fall Detection:** The MPU6050 sensor continuously measures acceleration and angular velocity. When a sudden large deviation or tilt is detected, it triggers the accident detection flag.

4. **Communication Stage:** Once a fall is confirmed, the Arduino communicates with the NEO-6M GPS module to acquire location coordinates. The coordinates are then sent through the SIM800L V2 GSM module as an SMS to the registered emergency contact.

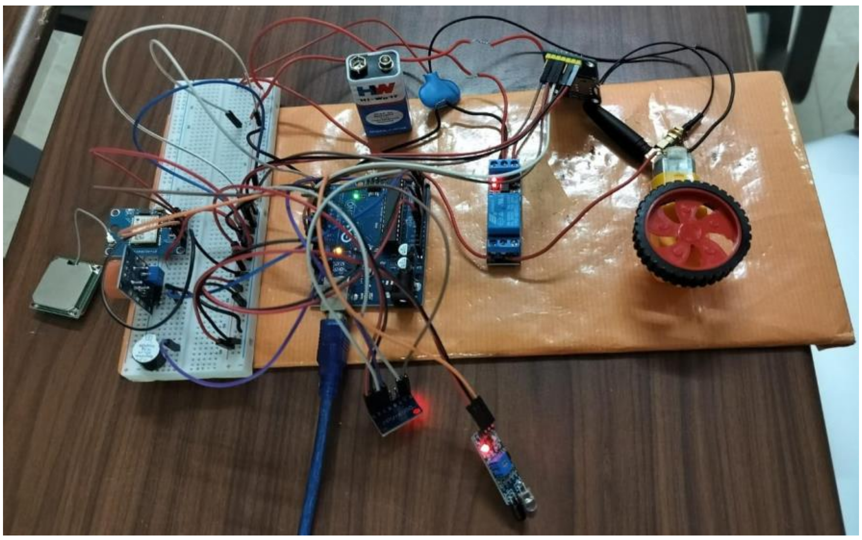
The system is programmed to operate in a continuous loop(), ensuring constant real-time monitoring of the rider's condition. Thresholds for alcohol detection and fall sensitivity are determined experimentally to minimize false alarms. Conditional statements and interrupts are used to handle critical events without delay.

This software design ensures that the system is responsive, modular, and reliable under various riding conditions. The integration of sensors and communication modules through efficient coding enables the Smart Helmet to perform complex tasks such as decision-making, location tracking, and message transmission using minimal hardware resources.

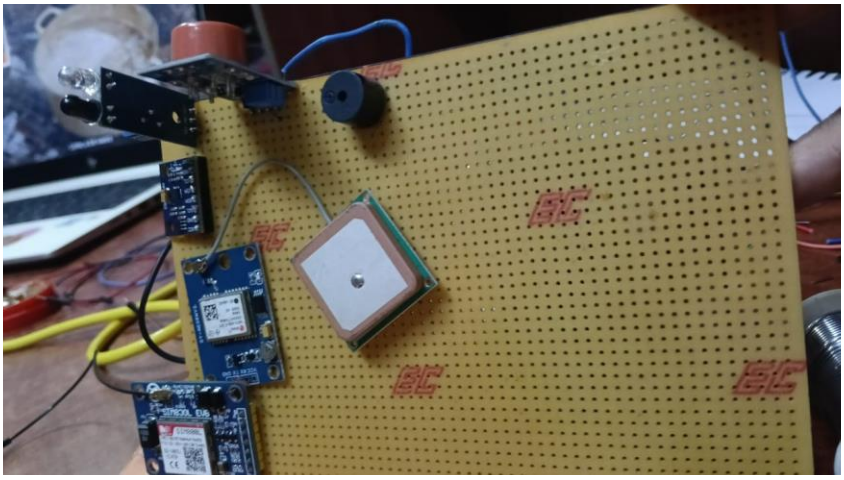




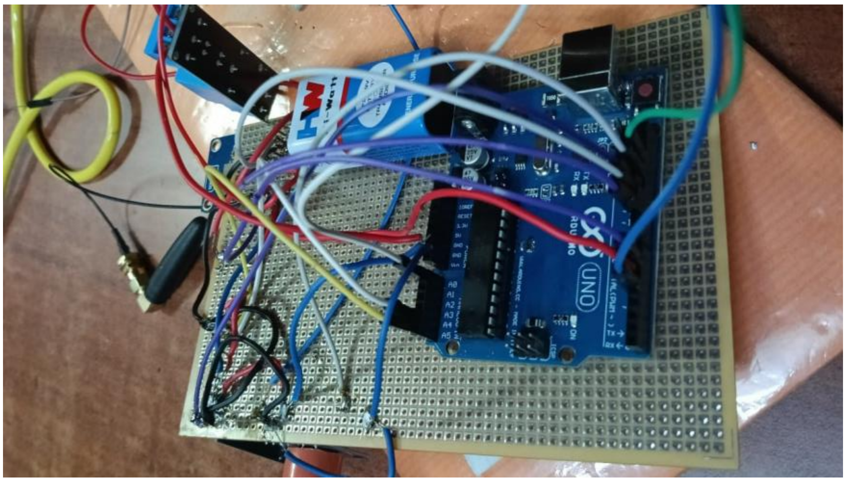
3.2 HARDWARE – CONNECTION DIAGRAM/SCHEMATIC, PCB DESIGN SCREENSHOTS, PHOTOS OF HARDWARE IMPLEMENTATION



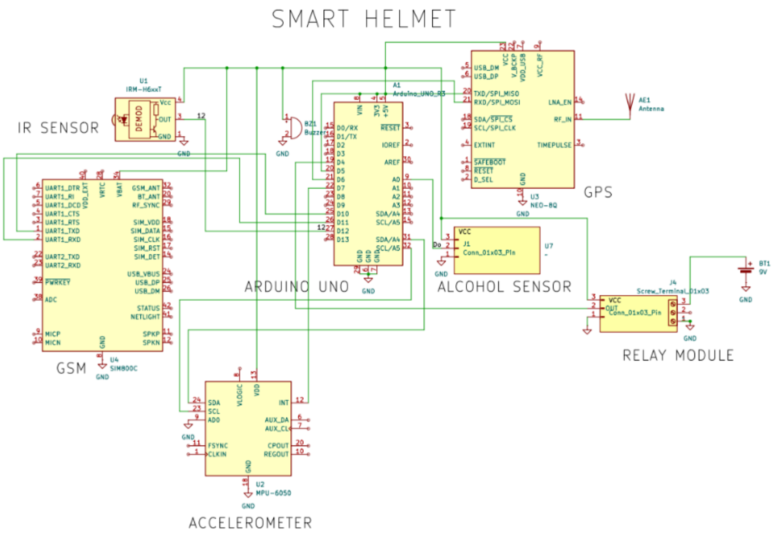
FRONTSIDE OF PERF BOARD:



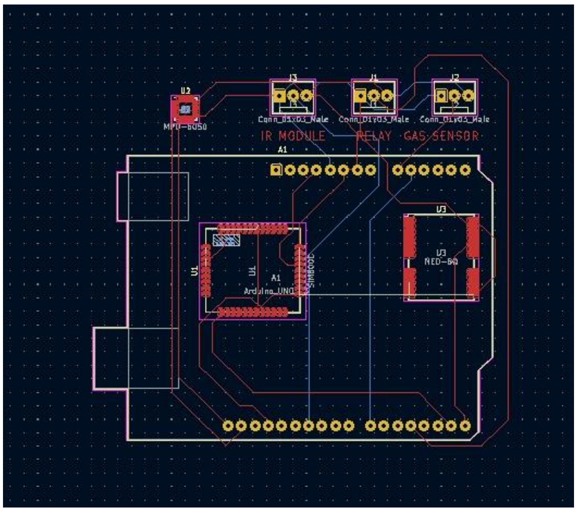
BACKSIDE OF PERF BOARD:

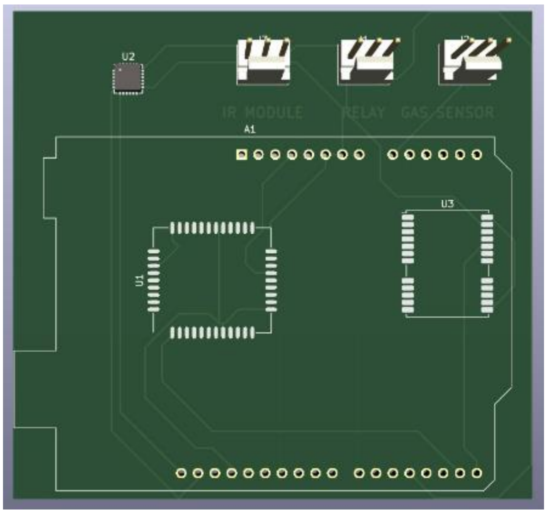


PCB SCHEMATIC:



PCB LAYOUT:





3.3 RESULTS & DISCUSSION

The Smart Helmet for Accident Detection and Alert Generation system was successfully designed, programmed, and tested on a prototype model. Each module and sensor was individually verified before integrating them into the complete system. The integration was carried out on a breadboard setup powered by a regulated 5V supply. The Arduino Uno effectively managed the input signals from the IR helmet sensor, MQ-3 alcohol sensor, and MPU6050 accelerometer, and produced the corresponding outputs through the relay, buzzer, GSM, and GPS modules.

During testing, the helmet detection system worked accurately — the motor relay remained inactive when the helmet was not worn, and the buzzer immediately alerted the user. Once the helmet was worn properly, the motor was enabled, confirming successful interlock operation. Similarly, the alcohol detection feature reliably prevented motor activation when the MQ-3 sensor detected alcohol vapor above the calibrated threshold. The system displayed quick response time, indicating stable sensor-to-microcontroller communication and effective logic control.

The fall detection module, implemented using the MPU6050 sensor, successfully identified sudden changes in acceleration and tilt. On detecting a fall condition, the Arduino initiated the communication sequence, where the NEO-6M GPS module accurately retrieved real-time location coordinates. The SIM800L GSM module then sent an SMS alert to a pre-stored emergency contact number containing both the accident message and a Google Maps link with the rider's location. This sequence confirmed the effectiveness of the system in emergency response automation.

The prototype demonstrated reliable performance under multiple test conditions. The modules functioned without interference, and communication between sensors and the microcontroller remained stable. Minor variations in MQ-3 sensor readings were observed during calibration due to environmental alcohol vapor traces, which were corrected through threshold adjustment in the code. The average delay between accident detection and alert transmission was found to be within 5–7 seconds, which is acceptable for emergency use cases.

Overall, the results validate that the system successfully meets its objectives. It ensures that the vehicle cannot start under unsafe conditions, and provides immediate accident alerts with location tracking. The project thus proves the feasibility of integrating low-cost embedded systems for improving road safety and emergency communication in real-world scenarios.

3.4 COST ANALYSIS

S. No	Product	Rate
1	GEAR MOTOR	45
2	MOTORWHEEL	6
3	MQ3 ALCOHOL SENSOR	120
4	ARDUINO UNO R3 DIP	565
5	BREADBOARD	65
6	UNO CABLE BLUE (30 CM)	40
7	RELAY MODULE	58
8	JUMPERS M-M (40 PCS)	48
9	JUMPERS M-F (40 PCS)	48
10	JUMPERS F-F (40 PCS)	48
11	BREAD BOARD WIRE (2 MTS)	18
12	SIM 800L FULL SET	495
13	NEO6M GPS	290
14	MPU6050	160
15	IR MODULE	32
16	Buzzer	15
17	Perf Board	100
18	Soldering kit	200
	Total	**2353**

4. CONCLUSION AND FUTURE WORK

4.1 CONCLUSION

The Smart Helmet for Accident Detection and Alert Generation system successfully achieves its primary goal of enhancing two-wheeler rider safety through real-time monitoring and intelligent control. The integration of sensors and communication modules with the Arduino Uno ensures that the vehicle operates only under safe conditions. Helmet usage and alcohol detection act as preventive measures, while the fall detection and alert system provide a responsive safety mechanism in case of accidents.

Experimental results demonstrate that the system effectively detects helmet status and alcohol concentration, disables the motor in unsafe situations, and accurately identifies falls or accidents. The GPS and GSM modules functioned reliably, transmitting the rider’s real-time location to a predefined emergency contact within seconds. The design is compact, cost-effective, and suitable for integration into existing helmet and vehicle systems.

This project not only addresses critical road safety issues but also showcases the potential of embedded systems in developing intelligent, automated safety solutions. By combining prevention, detection, and communication features, the smart helmet system provides a holistic approach to reducing accident-related fatalities and improving emergency response times.

4.2 FUTURE WORK

Although the prototype performs efficiently, there is scope for improvement and further development to make the system suitable for large-scale and commercial applications. Future enhancements may include:

1. Integration with IoT Platforms: The system can be connected to cloud-based IoT services for real-time tracking, data storage, and accident analytics.
2. Mobile Application Interface: A dedicated smartphone app could be developed for live monitoring, automatic alert acknowledgment, and emergency tracking.

3. Enhanced Power Management: Incorporating rechargeable batteries and energy-efficient modules can improve system portability and runtime.
4. Helmet Strap Detection: Replacing the IR sensor with a strap-based detection mechanism to ensure the helmet is worn correctly.
5. Voice and Health Monitoring: Adding heart rate or voice recognition sensors to assess the rider's physical condition during and after accidents.
6. Integration with Vehicle ECU: For newer bikes with electronic control units, the system could directly communicate with the ECU to control ignition and safety features.
7. Miniaturization and Enclosure Design: Developing a compact PCB and waterproof casing for long-term use and durability.

With these advancements, the Smart Helmet system could evolve from a prototype into a reliable, market-ready solution for real-world deployment, contributing significantly to improving road safety standards and saving lives.

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