IOT BASED SMART HELMET WITH ALCOHOL DETECTION AND MOTION SENSOR

A project report submitted to

Jawaharlal Nehru Technological University Kakinada, in the partial Fulfillment for the Award of Degree of

BACHELOR OF TECHNOLOGY IN

ARTIFICIAL INTELLIGENCE & DATA SCIENCE

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(AUTONOMOUS)

An ISO 9001:2015 Certified institution, approved by AICTE & Reaccredited by NBA, NAAC 'A+' Grade (Affiliated to Jawaharlal Nehru Technological University, Kakinada) VENGAMUKKAPALEM, ONGOLE52272, A.P

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CERTIFICATE

This is to certify that the t*echnical report entitled "***IOT BASED SMART HELMET WITH ALCOHOL AND MOTION SENSOR** *is a bonafide work of the following final B Tech students in the partial fulfillment of the requirement for the award of the degree of bachelor of technology in ARTIFICIAL INTELLIGENCE AND DATA SCIENCE for the academic year 2025-2026.*

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ACKNOWLEDGEMENT

We thank the almighty for giving us the courage and perseverance in completing the project. It is an acknowledgement for all those people for all those people who have given us their heartfelt cooperation in making in making the major project a grand success.

We would like to place on record our deep sense of gratitude to the Honorable Executive Chairman **Dr. N.S.Kalyan Chakravarthy,** Honorable Executive Vice Chairman **Dr. N. Sri Gayatri Devi** and Principal **Dr. Y.V.Hanumantha Rao** for providing the necessary facilities to carry out the project work.

We express our gratitude to the Head of the Department of **AIDS**, **Dr.G.L.VaraPrasad** Project Guid*e* **Mrs.M.RAMA** and **Department faculty** for their valuable suggestions, guidance, and cooperation throughout the project.

We would like to express our thankfulness to **CSCDE & DPSR** for their constant motivation and valuable help throughout the project.

Finally, we would like to thank our Parents, Family and Friends for their cooperation in completing this project.

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ABSTRACT

The primary goal of this project is to enhance road safety by developing a smart helmet that prevents drunk driving. The system ensures the rider wears the helmet properly and is not under the influence of alcohol before starting the vehicle. Road safety is a critical concern worldwide, with a significant number of accidents caused by drunk driving and failure to wear helmets. This project proposes an IoT-based Smart Helmet designed to address these issues by integrating alcohol detection, helmet- wearing verification, crash detection, and real-time location tracking into a single safety system. The smart helmet utilizes an MQ-3 alcohol sensor to detect the presence of alcohol in the rider's breath. If alcohol is detected above a predefined threshold, the system disables the vehicle's ignition using a relay module, preventing the rider from operating the vehicle. A GPS module sends the rider's real- time location to preconfigured emergency contacts via the IoT communication module (Wi-Fi or GSM). This system is managed by a microcontroller (such as Arduino or Node MCU) and connected to a mobile application or cloud platform for remote monitoring.

Keyword: IoT-based smart helmet, alcohol detection, motion sensor, MQ-3 sensor, accelerometer, road safety, Arduino.

TABLE OF CONTENTS

1.INTRODUCTION

1.1 Introduction

The IoT-Based Smart Helmet with Alcohol and sensor Motion Sensor is an innovative safety system designed to reduce road accidents caused by drunk driving and failure to wear helmets, especially among two-wheeler riders. In today's fast-paced world, road safety remains a growing concern—especially for two-wheeler riders who are at higher risk during accidents. Many serious injuries and fatalities occur due to riders not wearing helmets or driving under the influence of alcohol.

To address this critical issue, this project introduces an IoT-Based Smart Helmet that combines alcohol detection, helmet-wearing verification, and accident detection using motion sensors. By using modern sensor technology and IoT communication, the system ensures that only a sober, helmetwearing rider can start the vehicle, helping prevent accidents before they happen.

The smart helmet is equipped with an MQ-3 alcohol sensor to detect alcohol in the rider's breath, a helmet detection sensor (such as an IR sensor or reed switch), and a vibration or motion sensor to identify sudden impacts or crashes. A microcontroller like Arduino, Node MCU, or ESP32 processes the input from these sensors.

If alcohol is detected or the helmet is not worn, the system automatically disables the vehicle's ignition via a relay, making it impossible to start the vehicle under unsafe conditions. In the event of an accident, the motion sensor triggers an alert, and the built-in GPS module captures the rider's location. This location data is then sent to emergency contacts through IoT modules such as Wi-Fi (ESP8266) or GSM (SIM800L), enabling a faster emergency response.

This project showcases how embedded systems and IoT technology can be harnessed to create intelligent, life-saving solutions. The smart helmet not only enforces responsible riding behavior but also adds a crucial layer of safety through real-time monitoring and alerts. It is a scalable, low-cost solution that has the potential to significantly reduce road traffic injuries and fatalities. With features like alcohol detection, accident notification, and helmet enforcement, this IoT-based system represents a forward-thinking approach to modern transportation safety.

Road safety is a critical global concern, especially in countries with high rates of traffic accidents involving two-wheeler vehicles. According to the World Health Organization (WHO), road traffic injuries are among the leading causes of death worldwide, with a significant portion attributed to the lack of safety measures, drunk driving, and delayed emergency response.

1.2 Objective of the Project

The main objective of this project is to design and implement a smart helmet system that enhances rider safety using IoT technology. The helmet is designed to detect alcohol consumption, monitor motion, and enable real-time communication, thereby reducing the risk of road accidents and improving emergency response in case of crashes.

The key objectives are:

Alcohol Detection System:
To integrate an alcohol sensor (such as the MQ-3 sensor) into the helmet that detects the presence of alcohol in the rider's breath. If the concentration exceeds a predefined threshold, the vehicle ignition system is disabled to prevent the rider from driving under the influence.

Motion and Accident Detection:
To use motion sensors such as accelerometers or gyroscopes (e.g., MPU6050) to continuously monitor the helmet's movement. The system can detect unusual motion patterns like sudden impact, fall, or crash, which indicates an accident.

Helmet Usage Enforcement:
To ensure that the helmet is worn properly by the rider before the vehicle starts. A pressure sensor or IR sensor can be used to detect whether the helmet is being worn, encouraging riders to comply with helmet safety rules.

Emergency Alert System:
To implement wireless communication (GSM or Wi-Fi module) for sending alert messages, including the GPS location, to registered emergency contacts in case of an accident.

Real-Time Monitoring:
To enable remote monitoring and tracking of rider safety data, including motion and alcohol status, for use in smart traffic management and connected vehicle ecosystems.

Integration of IoT Technology:
To apply Internet of Things (IoT) principles by integrating sensors, microcontrollers, and communication modules into a wearable safety device.

Low-Cost and Scalable Solution:
To develop a prototype that is affordable, energy-efficient, and scalable for use in various types of two-wheeler vehicles, especially in developing countries where such technology can save lives.By fulfilling these objectives, the project seeks to provide a comprehensive safety mechanism that enforces responsible driving behavior and enhances emergency response using real-time data.

1.3 Motivation of the Thesis

The motivation for this thesis arises from the urgent need to improve road safety, especially for two-wheeler riders, who are among the most vulnerable road users globally.

Key Factors Driving Motivation:

Rising Road Accidents:
Road traffic accidents are one of the leading causes of death and serious injuries globally. According to data from the World Health Organization (WHO), more than 1.3 million people die annually due to road crashes, with a large percentage involving motorcycles and scooters.

Drunk Driving Incidents:
A major cause of these accidents is driving under the influence of alcohol, which impairs judgment, coordination, and reaction time. Despite laws and awareness campaigns, many riders continue to operate vehicles while intoxicated, putting themselves and others at risk.

Negligence in Helmet Usage:

In many countries, especially developing nations, helmet usage is either neglected or improperly enforced, resulting in increased head injuries and fatalities in accidents. A smart helmet that ensures proper usage can significantly reduce the severity of injuries.

Lack of Immediate Emergency Response:

Many accident victims do not receive timely medical attention because the accident location and severity are not communicated promptly. A helmet that can detect a crash and send an automatic alert with location data can be a life-saving feature.

Technological Opportunity with IoT:

The growing accessibility of IoT technology, low-cost sensors, and embedded systems offers a practical solution to implement smart safety systems. These technologies can be leveraged to address real-world problems and save lives on the road.

Contribution to Smart Transportation:

As cities evolve into smart cities, the transportation system must also evolve. This smart helmet concept aligns with the goals of intelligent transport systems (ITS) and smart mobility solutions by making safety an integral part of the rider's equipment.

Personal Interest and Social Responsibility:

This thesis is also driven by a personal interest in embedded systems, IoT, and real-time applications. Moreover, there is a deep social responsibility to contribute to innovations that solve real-life problems, such as preventable road accidents.

1.4 Organization of the Thesis

This thesis is divided into several chapters, each focusing on a specific aspect of the project. The organization is as follows:

Introduction

This chapter provides a background of the problem, defines the objectives of the project, outlines the motivation behind the work, and presents the structure of the thesis.

Literature Review

Presents a review of related research work, existing technologies, and commercial solutions relevant to smart helmets, alcohol detection systems, and motion sensing in IoT applications. It also identifies the limitations of existing systems and establishes the research gap.

System Architecture and Design

Describes the proposed architecture of the smart helmet system. It includes detailed block diagrams, selection of sensors and modules, and integration methods. It also discusses the logical flow of data and interaction between hardware components.

Implementation and Development

Details the implementation phase of the project, including the programming of the microcontroller, sensor interfacing, data processing logic, and testing of modules. It includes hardware setup, flowcharts, and pseudocode to explain system behavior.

Results and Evaluation

Provides the results of testing the prototype under various scenarios. The chapter evaluates the system's performance in detecting alcohol, sensing motion, and sending alerts. It also includes observations, accuracy analysis, limitations, and possible areas of improvement.

Conclusion and Future Scope

Summarizes the overall contribution of the project, revisits the goals achieved, and discusses challenges faced during development. It also explores the potential future enhancements such as integration with cloud platforms, AI-based accident prediction, and mass deployment strategies.

2.Literature Review / Background

Recent advancements in the Internet of Things (IoT) have paved the way for intelligent safety systems, especially in transportation. Smart helmets integrated with IoT capabilities are gaining attention for enhancing rider safety. Studies have explored the integration of alcohol sensors to detect the presence of ethanol vapors from a rider's breath, thereby preventing intoxicated individuals from operating vehicles. Research by Sharma et al. (2021) utilized the MQ-3 sensor to detect alcohol levels, while accelerometers and gyroscopes like the MPU6050 have been used for motion and fall detection. IoT modules such as NodeMCU or ESP8266 enable real-time data transmission to mobile apps or cloud platforms. Additionally, some systems include GPS for accident tracking and emergency alerts. Despite various approaches, challenges remain in sensor calibration, false positives, and real-time processing. This literature survey indicates a growing interest in integrating safety, connectivity, and automation in smart helmet designs for road safety.

2.1 Basic Concepts

The project is based on integrating safety features into a helmet using modern technology. The main idea is to use the Internet of Things (IoT) to connect the helmet with a mobile device or cloud system for real-time monitoring and alerting. An alcohol sensor is placed near the mouth area inside the helmet to detect if the rider has consumed alcohol. If alcohol is detected beyond a safe limit, the system can stop the bike from starting, promoting safe driving habits.

Additionally, a motion sensor is included to monitor the rider’s movement. If the helmet detects a fall or an accident through sudden changes in motion, it can send an alert with the location to emergency contacts. A microcontroller, like an Arduino or NodeMCU, collects data from the sensors and manages the communication. The goal is to reduce drunk driving and improve rider safety through smart, automated monitoring.

2.2 Review of Related Work

The field of personal safety devices is broad, featuring numerous projects and products that offer various methods to tackle the issue.

Md. Atiqur Rahman, et.al(2024),Road traffic accidents are a major global issue, particularly in countries with high two-wheeler usage.According to the World Health Organization (WHO), a large number of road fatalities are due to drunk driving and not wearing helmets.Traditional helmets provide passive protection but lack intelligent safety features.

Road safety has become a significant concern globally, especially in countries with high twowheeler usage. Studies from the World Health Organization (WHO) show that a large portion of road accidents is due to alcohol-impaired driving and not wearing helmets. In response, researchers and developers have explored a variety of technological approaches to improve rider safety, particularly through sensor-based and IoT-enabled systems.

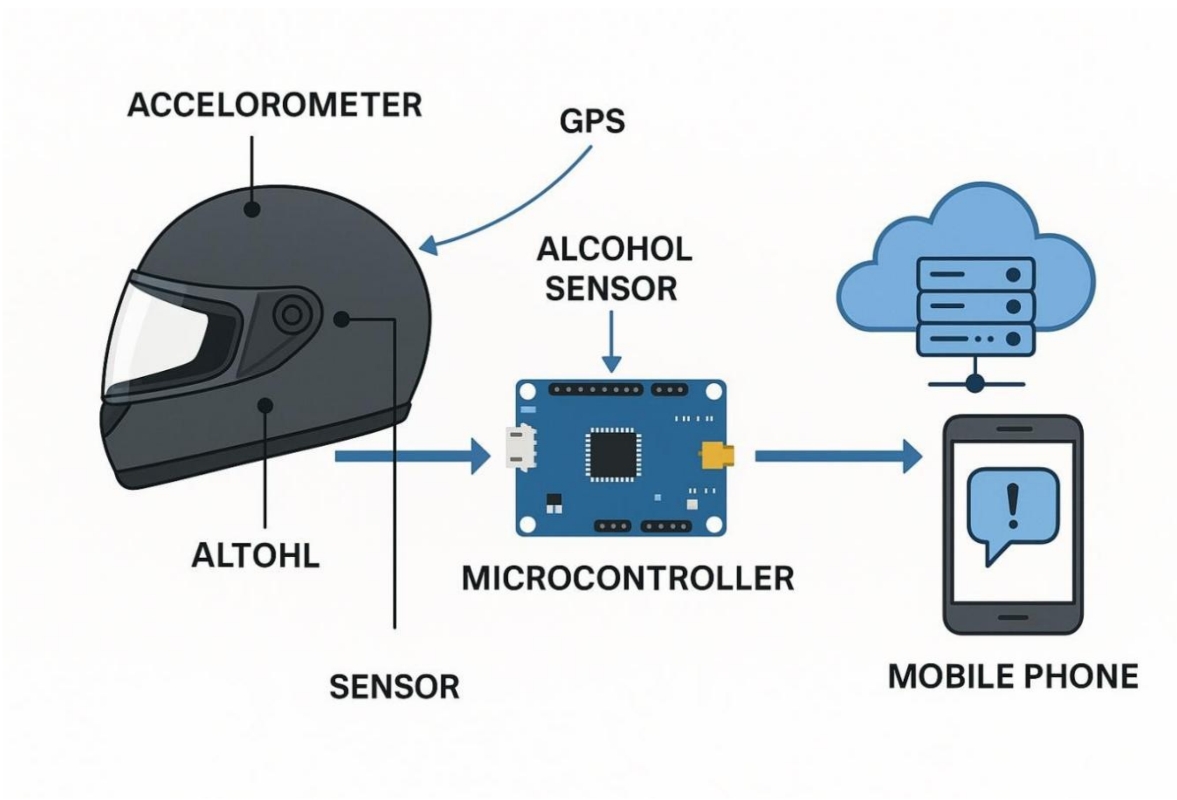
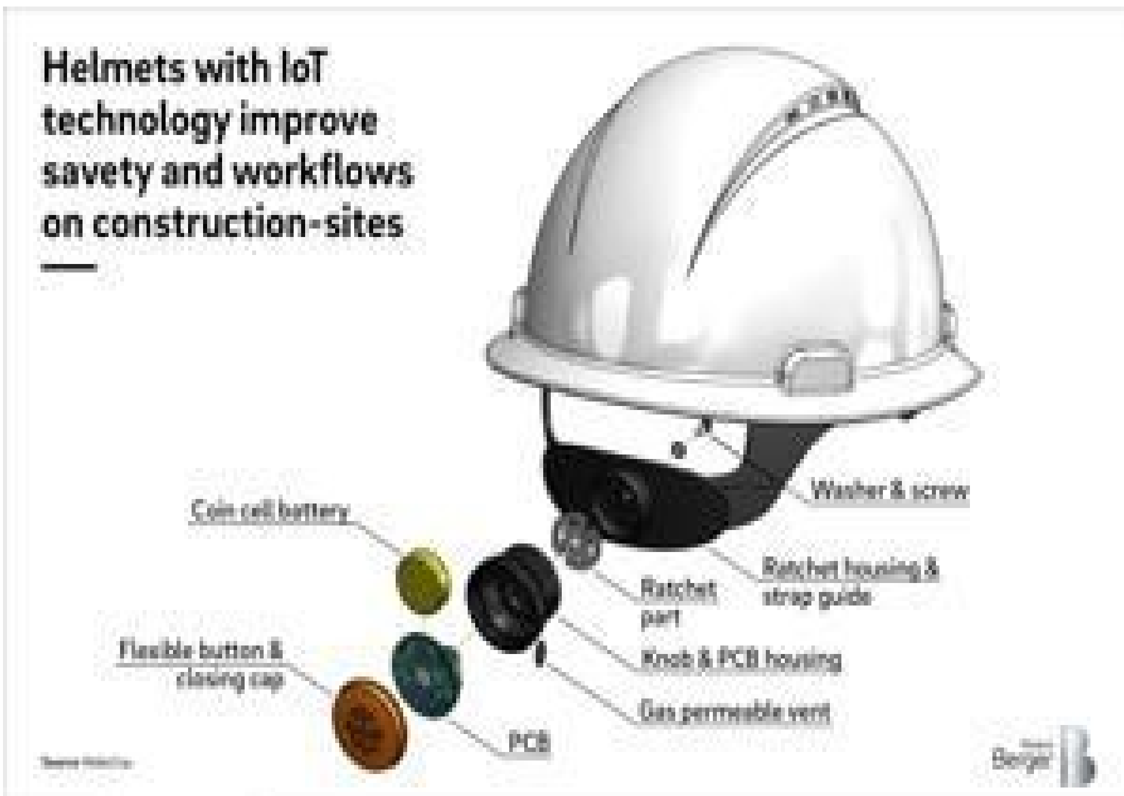


Fig-1:Road Safety Context

Sudharsana Vijayan, et.al(2025),Developed a breath-analyzer system using the MQ-3 alcohol sensor to prevent vehicle ignition if alcohol is detected.

Chaudhary and Patel, et.al(2024): Proposed an IoT-based alcohol detection system using GSM and Arduino for alerting authorities and disabling ignition. These systems are mostly vehicle-mounted, not wearable; hence not suitable for two- wheelers. This project aims to fill that gap by combining all these features into a cost-effective, IoT-enabled smart helmet. It offers alcohol detection, helmet usage



verification, crash detection through vibration sensors, GPS-based location tracking, and real-time alerts via GSM or Wi-Fi. By addressing the num limitations of current technologies, this project advances the field of intelligent transport systems and provides a practical solution for enhancing two-wheeler rider safety.

Fig-2:Existing Research on Alcohol Detection

Rao et al,(2024) : Developed a smart helmet using motion and alcohol sensors, which detects

accidents and alerts contacts. IIT Roorkee Project: A smart helmet prototype that prevents ignition if the helmet is not worn.Lack of GPS tracking, real-time IoT alerts, and full system integration. Research into smart helmets has also grown, focusing on detecting helmet usage and crash events. Rao et al. (2021) introduced mart helmet equipped with motion sensors to detect accidents and notify emergency contacts.However, their system lacked alcohol detection and real-time GPS tracking. On the commercial side,companies like LIVALL and Sena offer helmets with Bluetooth connectivity and crash alerts, but they are costly and do not include alcohol sensing or ignition control features.

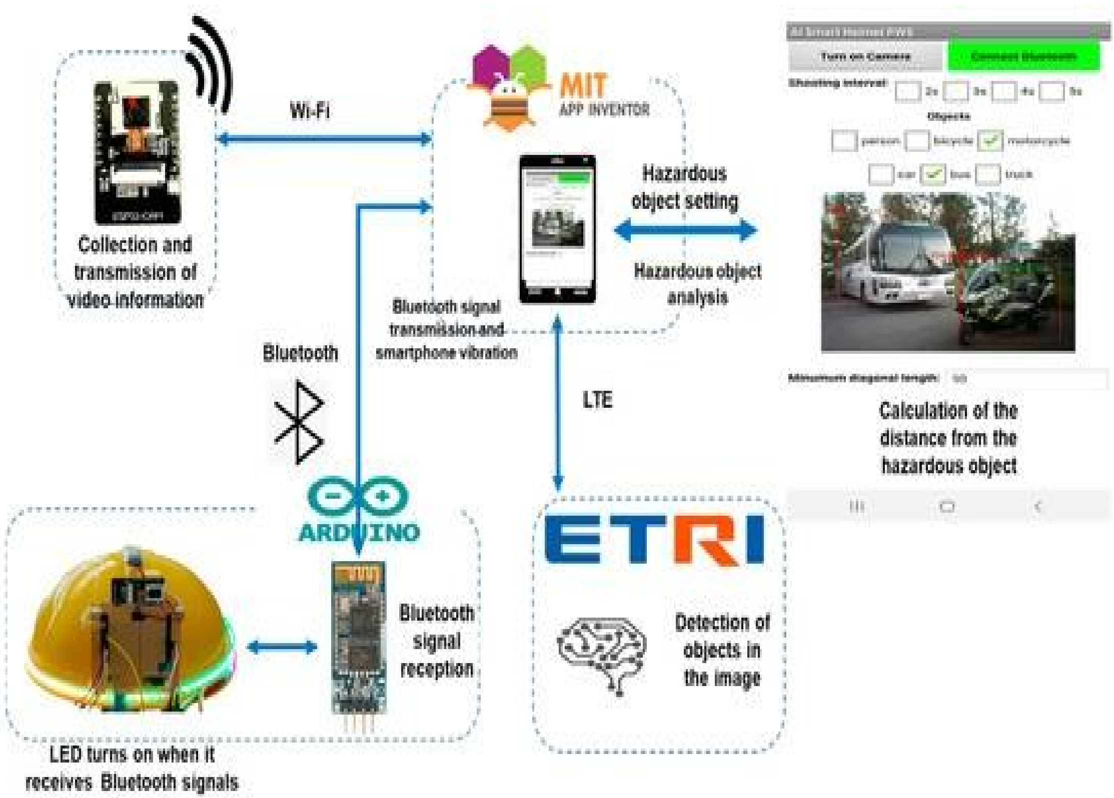


Fig-3:Smart Helmets with Sensors

Shikha Gupta,et.al(2024):A motorcycle frequently called motorbike or two-wheelers, which is the mos used than another form of automobiles because of its low price. But another side, this is the most unsafe automobile. The accident can happen for driving fast or drunk driving.

Safety and security in vehicle traveling are a pre-eminent concern for all. With the rapid urbanization and staggering growth of transport networks like two-wheeler vehicles, safety on the roads and security on the bike has emerged as an inescapable priority for us. It has expanded the rate of accidents, which leads to several damages with loss of lives. In many circumstances, we cannot able to detect the accident's location.

A helmet is a form of protecting gear worn to keep safe the head from injuries. More specifically, the helmet aids the skull in protecting the brain. A smart helmet can detect the accident's locations also save lives and makes two-wheeler driving safer from previously. This paper propounds a smart helmet system to avoid the accident. The system divides into three parts helmet circuit, automobile circuit, and mobile application.

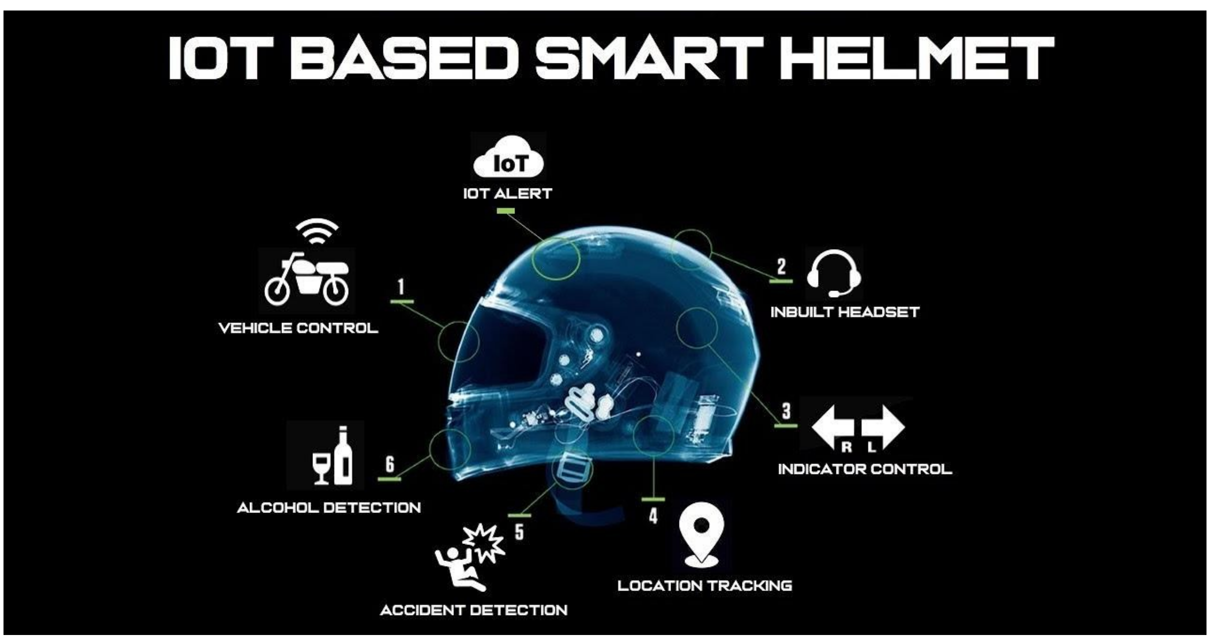


Fig-4:IoT Based Smart Helmet and Accident Identification System

Piyush Mishra,et.al(2024):A traffic accident is defined as any vehicle accident occurring on a public highway These accidents therefore include collisions between vehicles and animals, vehicles and pedestrians, or vehicles and fixed obstacles. In higher-income countries, road traffic [1] accidents are already among the top ten leading causes of disease burden in 1998 as measured in DALYs (disability- adjusted life years).

In less developed countries, road traffic accidents were the most significant cause of injuries, ranking eleventh among the most important causes of lost years of healthy life. In Indian road system, widening of the road is not an alternative solution to avoid traffic in such a cities [2]. The problems with state drunk driving control systems can be solved in many ways.

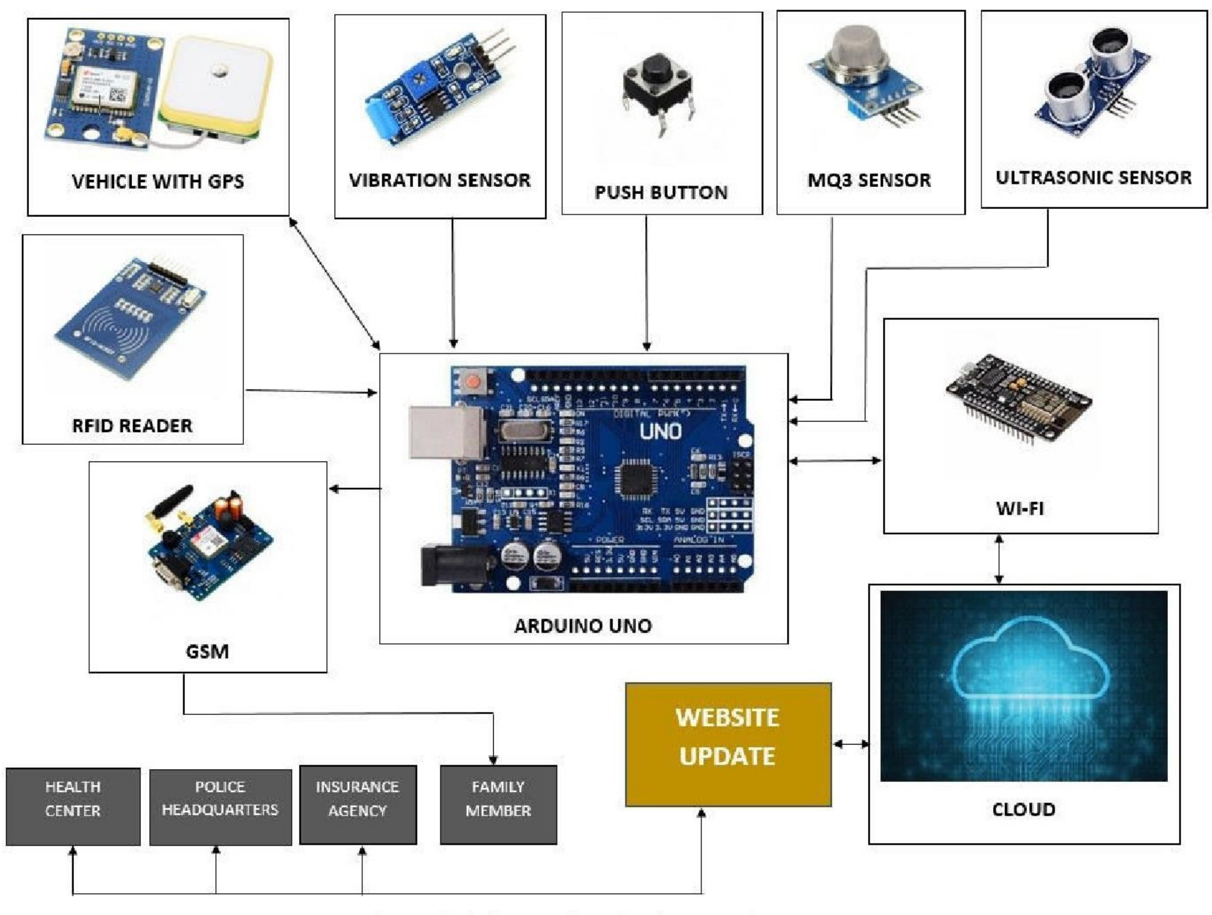


Fig-5:ALCOHOL DETECTION USING SMART HELMET SYSTEM

A.Sathiyaraj,et.al(2024): Since the invention of the first motor vehicle, the automobile industry has been advancing by leaps and bounds. Two-wheelers are no exception, but the safety of the driver is still a precarious situation.

Due to the very built and design of the two-wheeler, the rider is more vulnerable to accidents as compared to the traditional four-wheeler vehicle. Therefore, in this paper we propose a holistic solution for the safety of the driver of a two-wheeler. The proposed solution aims to perform three main tasks. Firstly, alcohol detection which would be required to detect whether the rider is under the influence of alcohol. Secondly, a fall detection system which would be required to send notifications to the emergency contacts in case of an accident or a serious fall from the two-wheeler. Lastly, a navigation system to enhance the user experience.

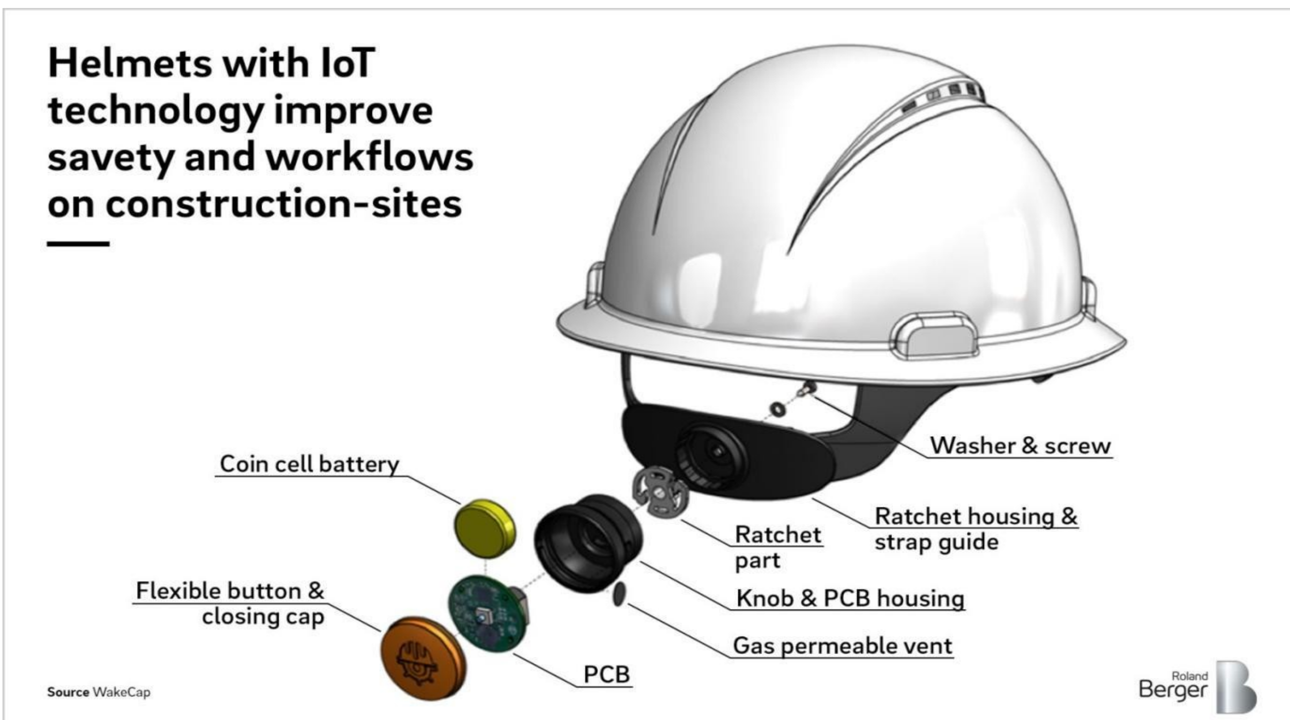


Fig-6:Implementation of A Smart Helmet with Alcohol and Fall Detection

P. **Pradeesh,et.al(2023):**As a form of the Internet of Things (IoT)–gateways, a smart helmet is one of the core devices that offers distinct functionalities. The development of smart helmets connected to IoT infrastructure helps promote connected health and safety in various fields. In this regard, we present a comprehensive analysis of smart helmet technology and its main characteristics and applications for health and safety.

A summary of existing smart helmet systems is presented with a review of the sensor features used in the prototyping demonstrations. Overall, we aimed to explore new possibilities by examining the latest research, sensor technologies, and application platform perspectives for smart helmets as promising wearable devices.

III. METHODOLOGY

A. System Architecture

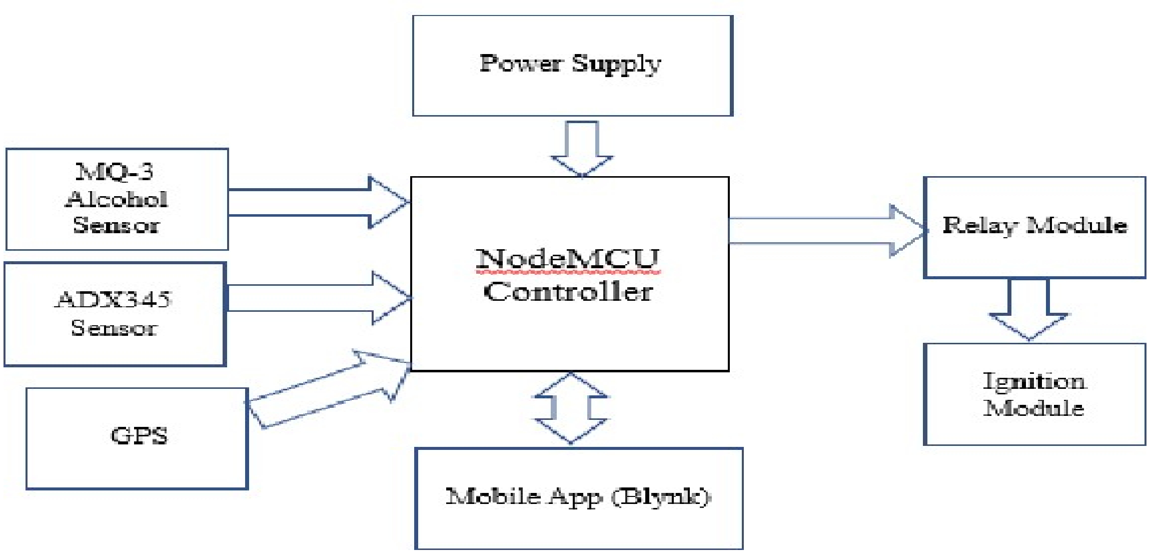


Fig-7:Trends in Smart Helmets With Multimodal Sensing for Health and Safety

Selva,et.al(2022): The concept of Smart Helmet aims to provide the same for Bikes. With features like built-in Black Box, GPS logging which will keep track of the rider's location and can be accessed in case of emergency.

A collision sensor will alert in case the rider meets with an accident and or is drunken driving. The helmet makes use of ATMega32u4 with AI Thinker's A7 GSM-GPS module for GPS logging, collision sensing and sending emergency SMS. The article also details the 2017 ILAE classification system, which categorizes epilepsy based on seizure type, aiming for more accurate diagnosis and effective treatment.

It describes four main categories of epilepsy: focal, generalized, combined generalized and focal, and unknown onset epilepsy, outlining the characteristics of seizures within each type. Furthermore, the article introduces various epilepsy syndromes, which are defined by a collection of medical features, and discusses diagnostic methods such as physical exams, blood tests, EEGs, and imaging. Treatment approaches, including antiepileptic drugs, surgical interventions, specific diets, and vagus nerve stimulation, are also covered.

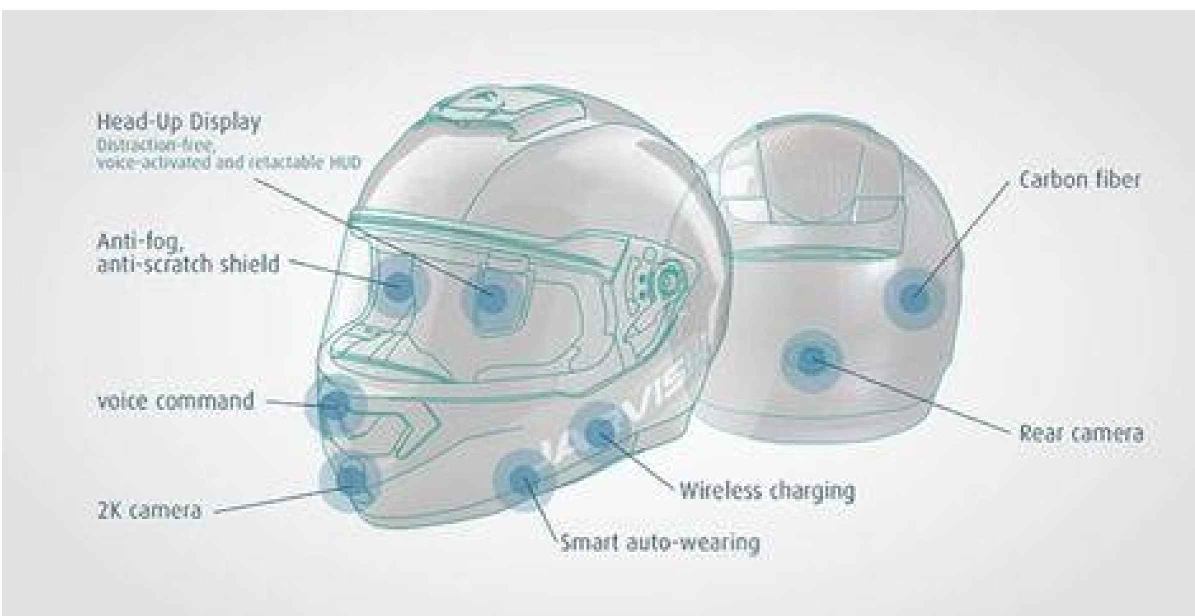


Fig 8:Implementation of Alcohol and Collision Sensors in a Smart Helmet

Rao,et.al(2022): Internet of Things (IoT) consists of smart devices which can sense the environment and performs the data interaction with the users by handling the large volume of data and also provide the numerous services to the users. In ITS, driving under the influence (DUI) which is represented as the Drunk and Drive that involves to operating the vehicle with consumption of alcohol is considered as the punishable offense. To identify and prevent the driving with alcohol consumption, the ITS system is designed with IoT based smart helmet system.

This automatically checks whether the person is wearing the helmet and has non- alcoholic breath while driving. Upon successful validations, the provision is made to operate the vehicle. The system I collaborated with the Bayesian learning model which is used to reduce computation complexity and improves the alcohol detection process.

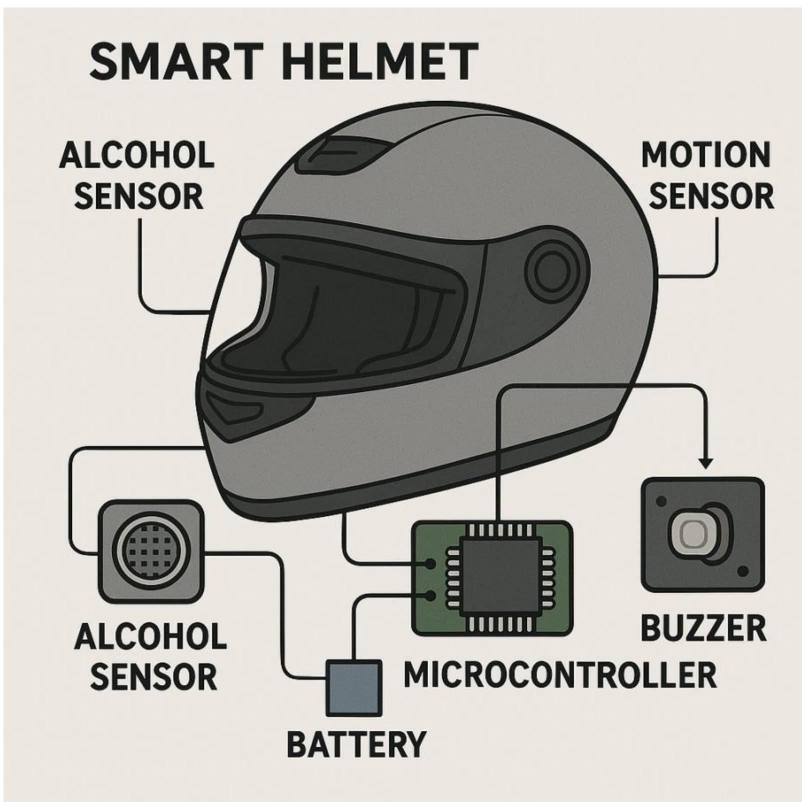


Fig 9:Alcohol Consumption Detection Using Smart Helmet System

3.PROPOSED WORK AND ANALYSIS

The project aims to develop an IoT-based alcohol detection and motion sensing system that ensures safety by monitoring the driver's alcohol consumption and detecting abnormal motion or accidents. The system integrates various sensors and communication modules to automatically alert concerned authorities in critical situations.

3.1 Proposed System

The proposed IoT-based Alcohol Detection and Motion Sensor System is designed to enhance road safety by detecting whether the driver has consumed alcohol and by monitoring the vehicle's motion for any abnormal activities such as accidents or collisions.

An MQ-3 alcohol sensor is used to detect the presence of alcohol in the driver's breath. If alcohol concentration exceeds a predefined threshold, the system immediately sends an alert and disables the vehicle ignition.A vibration or accelerometer sensor monitors the vehicle's motion to detect accidents or sudden impacts. If an accident occurs, the system automatically transmits an alert message containing the GPS location of the vehicle to the registered emergency contact using a GSM module.

The system is powered by a microcontroller (e.g., Arduino or NodeMCU) that processes sensor data and manages communication between modules through an IoT platform. The IoT connectivity ensures real-time monitoring and data storage on the cloud for further analysis.

Main Components Used:

- MQ-3 Alcohol Sensor
- Vibration/Accelerometer Sensor
- Arduino or NodeMCU Microcontroller
- GSM Module (SIM800L or similar)
- GPS Module
- Power Supply and IoT Cloud Platform

Working Process:

1. The system continuously monitors alcohol concentration and vehicle movement.
2. If alcohol is detected above the limit, the engine ignition is disabled, and an alert is sent.
3. If a sudden impact is detected by the motion sensor, it triggers the accident detection module.
4. The GPS module retrieves the current location.
5. The GSM module sends an emergency SMS containing the location details to predefined contacts or authorities.

3.2 Feasibility Study

The feasibility study evaluates the practicality of implementing the proposed IoT-based alcohol and motion detection system from technical, economic, operational, and social perspectives.

1. Technical Feasibility

The proposed system is technically feasible since it utilizes widely available and low-cost components such as sensors, microcontrollers, and GSM/GPS modules. The programming can be done using Arduino IDE, and IoT connectivity can be established using open-source cloud platforms like Blynk or ThingSpeak. Integration of sensors with the microcontroller is straightforward and reliable.

2. Economic Feasibility

The cost of components is minimal, making the system economically viable for large-scale deployment. Maintenance costs are also low since it uses durable hardware and open-source software tools. The benefits in terms of accident prevention and safety outweigh the initial setup cost.

3. Operational Feasibility

The system operates automatically without requiring user intervention. Once installed, it continuously monitors driver behavior and vehicle movement. The alerts and notifications are generated automatically, making it simple and user-friendly. Therefore, it is operationally feasible.

4. Social Feasibility

The system supports social welfare by preventing accidents caused by drunk driving and improving emergency response times. It encourages responsible driving and contributes to reducing road fatalities.

Hence, it is socially acceptable and beneficial.

- Prevent a motorcycle from starting unless the rider is wearing the helmet.
- Detect if the rider is under the influence of alcohol.
- Detect sudden falls or accidents using motion sensors.
- Send emergency alerts with GPS location via GSM or Wi-Fi.
- Provide a cost-effective, real-time solution using IoT technology

4.System Design/Materials and Methods

4.1 System Design

The system is designed to enhance rider safety by continuously monitoring alcohol intoxication and helmet usage, detecting motion or crash events, and sending real-time alerts to emergency contacts via IoT communication.

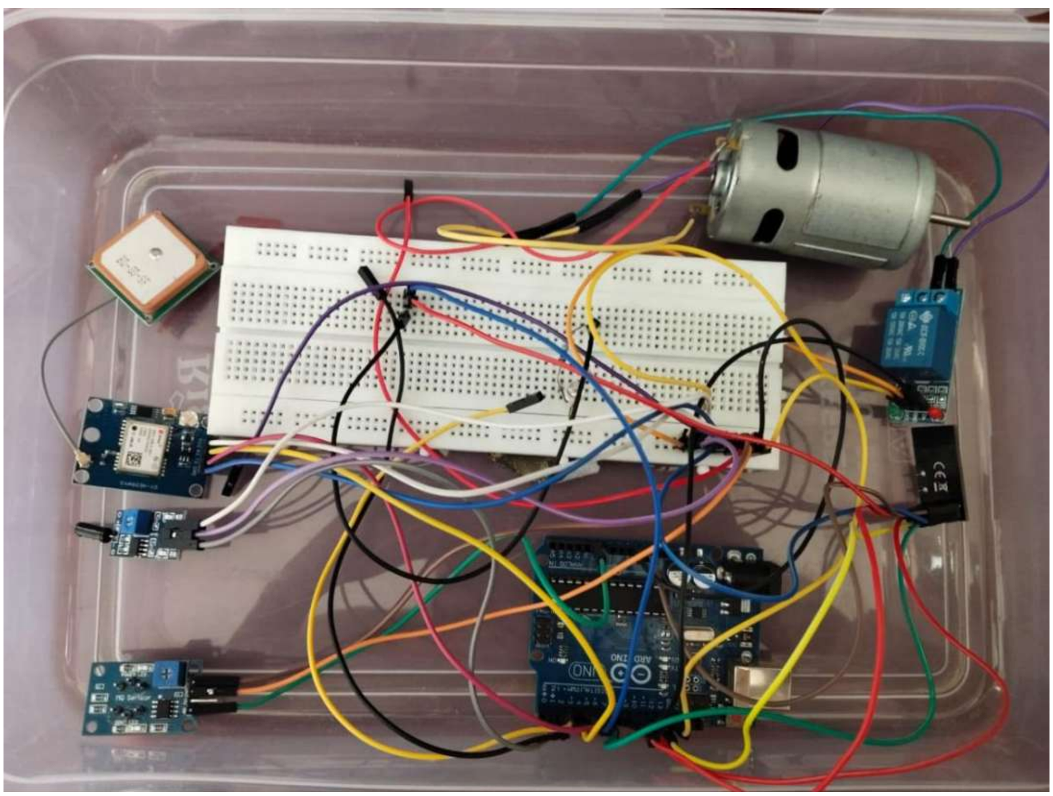


Fig 10: System design IOT based smart helmet

In the proposed IoT-based smart helmet system, all components are connected to a central microcontroller such a Arduino, which serves as the brain of the system. The MQ-3 alcohol sensor is connected to an analog input pin of the microcontroller to monitor the rider's breath for alcohol. An IR sensor or pressure sensor, placed inside the helmet, is connected to a digital input pin and checks whether the helmet is worn properly. The MPU6050 motion sensor (which includes an accelerometer and gyroscope) is connected via I2C communication lines (SDA and SCL) to detect sudden movements, impacts, or falls, indicating a potential accident. A relay module is connected to a digital output pin and linked to the vehicle's ignition circuit; it allows or blocks the engine start based on safety conditions. A GSM module (like SIM800L) is connected via serial communication (TX and RX pins) to send SMS alerts during emergencies. Alternatively, NodeMCU's built-in Wi-Fi can be used to send notifications over the internet. A GPS module can also be connected through serial pins to provide real-time location data, especially during accident detection. Buzzers and LEDs are connected to output pins to alert the rider in case of violations like alcohol detection or helmet absence. All these components are powered by a rechargeable battery connected to the microcontroller's power input pins, with voltage regulation as needed. Together, these connections ensure that the system enforces safety rules, detects accidents, and communicates alerts efficiently.

The System's Functional Layout Consists of Several Units:

1. Input Unit

- **Sensors Used:**
  - Alcohol Sensor (MQ-3): Detects the presence of alcohol in the rider's breath.
  - Motion/Crash Detection Sensor (Accelerometer): Detects sudden impacts or falls, indicating an accident.

  Continuously monitors the rider's condition and helmet usage to ensure safety compliance before and during the ride.

2. Power Supply Unit

- **Components:** Rechargeable lithium-ion battery + Voltage regulator (e.g., 7805 or onboard regulator).
- Supplies stable power to all the sensors and modules in the system, ensuring smooth and uninterrupted operation.

3. Processing Unit

- **Component:** Microcontroller (e.g., **Arduino Uno**, **ESP32**).
  Collects input from the alcohol, helmet, and motion sensors.
  - Controls outputs such as the ignition relay, buzzer, and communication modules.

4. **Communication Unit**

- **Components:**
  - **GPS Module (NEO-6M):** Captures the real-time geographical location of the helmet/rider.
  - **GSM Module (SIM800L):** Sends emergency SMS alerts containing GPS coordinates to pre-configured contacts.
- Enables wireless communication for emergency notifications in case of accidents or alcohol detection.

5. **Output Unit**

- **Outputs:**
  - **Ignition Relay Control:** The system prevents vehicle startup if the rider is intoxicated or not wearing a helmet.
  - **SMS Alerts:** Sends an **SOS message** with a **live location link** via GSM to emergency contacts.
  - **Buzzer Sound:** Notifies the rider or surrounding people in real-time.

4.2 BLOCK DIAGRAM

Sensors (Alcohol, Helmet Detection, Motion) feed real-time data into the **Microcontroller**. The **Microcontroller** processes this data and decides:

- Whether to allow ignition (via **Relay Module**).
- When to send SMS alerts through the **GSM Module**.
- **GPS Module** provides the current location in case of an emergency.

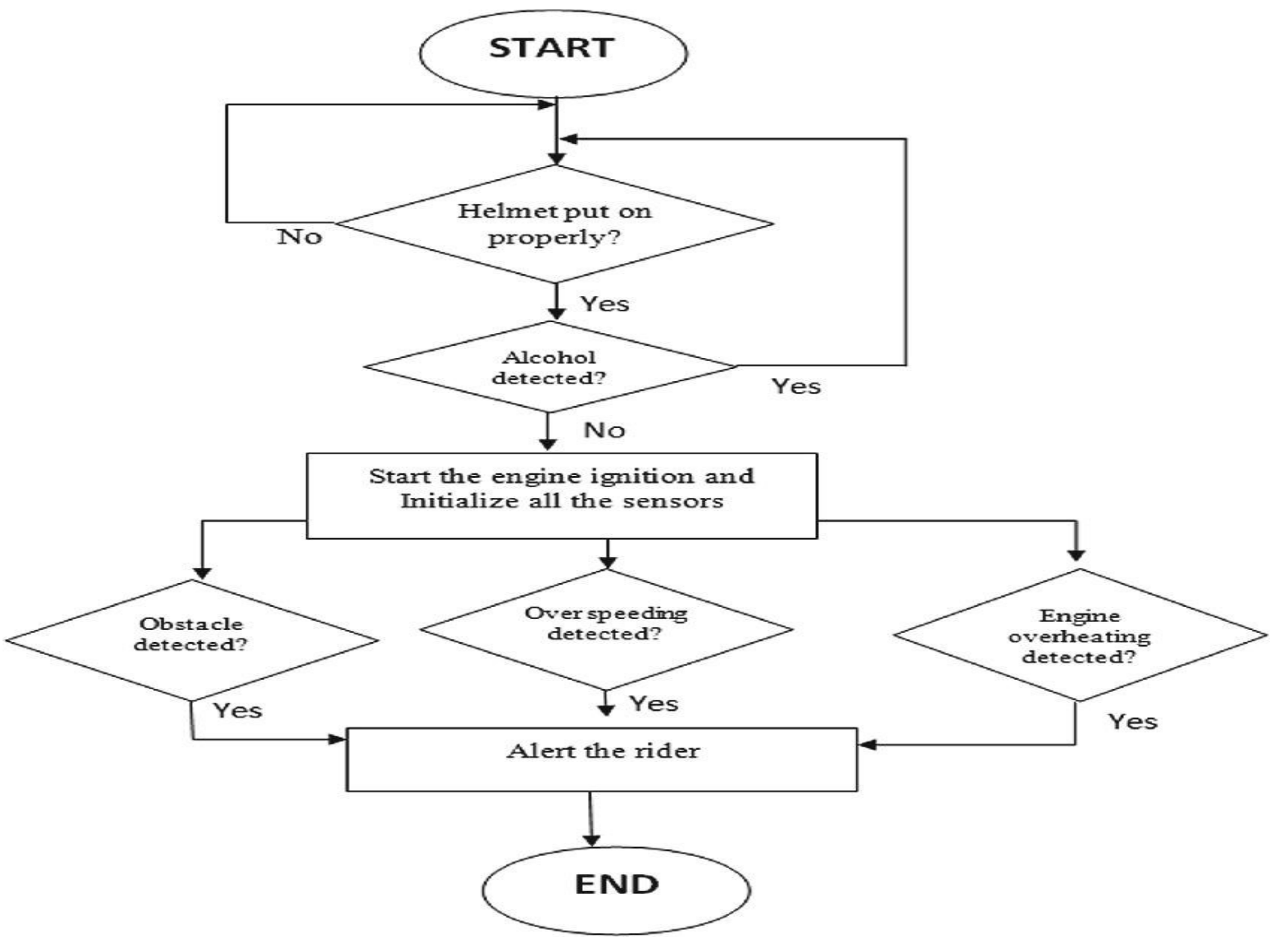


Fig 11 : Block Diagram

Power Supply Block:

The power supply is the starting point of the system. It provides necessary electrical energy to all components, including sensors and the microcontroller. Usually, this comes from a rechargeable battery or a standard 9V battery. The power may pass through a voltage regulator to ensure stable and safe operation.

Helmet Module:

This block includes sensors to detect whether the rider is wearing the helmet. An IR sensor (infrared) or pressure sensor is placed inside the helmet to check for head presence. If the sensor does not detect that the helmet is worn, it sends a signal to the microcontroller, which can block the vehicle from starting. This ensures helmet compliance before riding.

Alcohol Detection Block:

The alcohol detection block uses an MQ-3 gas sensor, which can sense alcohol vapors in the rider's breath. The sensor is placed close to the rider's mouth inside the helmet. If the detected alcohol level is above a predefined threshold, the system identifies the rider as intoxicated. The microcontroller then prevents the ignition system from being activated and may trigger alerts (like a buzzer or message).

Motion and Accident Detection Block:

This block includes a motion sensor, such as an accelerometer or gyroscope (e.g., MPU6050), which detects sudden movement, tilting, or impact. If the helmet experiences a rapid jerk, fall, or unusual movement that suggests an accident, the sensor sends data to the microcontroller. The system then recognizes it as a possible accident.

Microcontroller Block:

The microcontroller (e.g.**Arduino**) is the brain of the system. It receives input signals from the alcohol sensor, motion sensor, and helmet wear detector. It processes this data and makes decisions, such as:

Whether to allow the bike to start,

Whether to send an alert if an accident is detected,

Whether to sound a buzzer or turn on indicator LEDs

It also controls communication with external devices like GPS or GSM modules.

GPS Module:

The GPS module tracks the real-time location of the helmet (and therefore the rider). When an accident is detected, the GPS module sends the exact coordinates to the microcontroller, which includes them in the alert message. This helps emergency contacts find the rider quickly.

GSM / Wi-Fi Communication Block:

This block is responsible for sending alert messages. If an accident or alcohol detection occurs, the microcontroller communicates with a GSM module (like SIM800L) or a Wi-Fi module (inbuilt in NodeMCU) to send SMS or push notifications. The alert may include a custom message and GPS location.

Ignition Control Block:

This block contains a relay module that acts as a switch between the bike's ignition system and the microcontroller. If the helmet is not worn or alcohol is detected, the microcontroller sends a signal to the relay to block the engine start. Only when safety conditions are met (helmet worn, no alcohol) will the relay allow the bike to start.

Helmet is powered ON.

Helmet sensor checks if the rider is wearing it.

Alcohol sensor tests the rider's breath.

If helmet is worn and alcohol is not detected.

Microcontroller allows ignition via relay.

If alcohol is detected or helmet is not worn:

Microcontroller blocks ignition.

If an accident is detected, GPS location is collected.

4.3 Modules

MQ3 sensor (Alcohol Sensor):

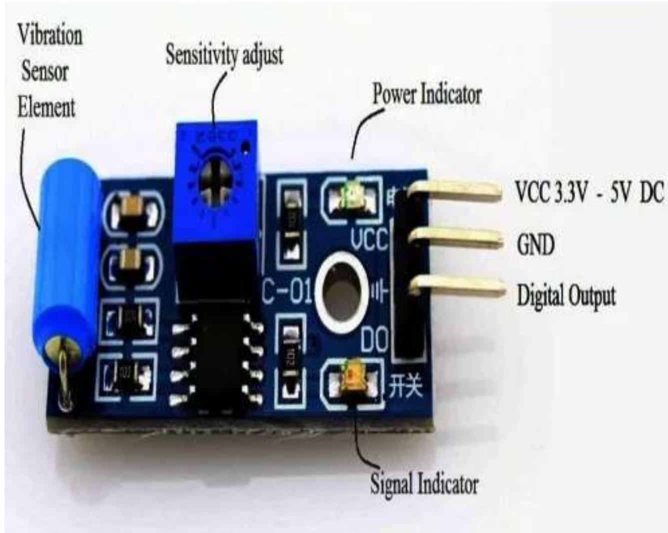
MQ3 sensor is a special kind of sensor that can only sense the alcohol from the moisture in the air. the moisture content of alcohol can be detected by the sensor. inside the sensor, there is a metal electrode that can be activated when comes into contact with the alcohol.

there is electron flow between the electrode used inside the mq3 sensor. when the sensor comes in contact with alcohol the conductivity of the same electrode will be high.this sensor wil help in this smart helmet project using arduino that can be detected at the output pin. so, we can connect this mq3 sensor with Arduino or whatever controller we are suing here.

MQ3 sensor input voltage is 5V which can be given by the Vcc pin of the sensor. mq3 sensor may be malfunction when we use it for hours.

vibration Sensor SW-420:

The other important sensor is Vibration sensor. the model number is SW-420 for the given vibration sensor. the working of the vibration sensor is very simple.



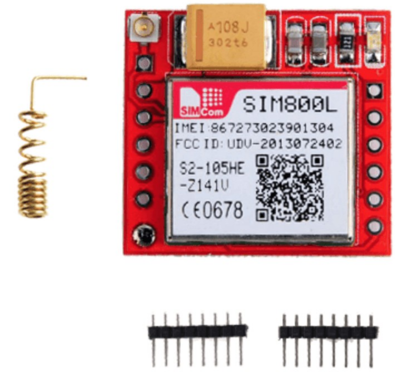
there is a lot small metal balls inside the cylindrical shape enclosed. inside the sensor there is many metal line. each of the two line connected to the ground and signal wire. when there is vibration occours the ball touches both the lines and conduct the electricity and give the signal at output pin.

this vibration sensor will be used to trigger the gsm module. vibration sensor continuously send the signal to the arduino. Arduino is our microcontroller in this smart helmet project. if any rise in the signal it the arduino will take the action according to the signal.

GSM SIM800L Module:

We use GSM SIM800L Module in this smart helmet project to navigate the location. it will be triggered with the vibration sensor.GSM SIM800L is a low power module which support 2g 3g sim for communication.

GSM SIM800L module is small in size and low cost GSM module that allows you to connect your device to the gsm network. it have the ability to communicate with other devices via SMS, voice calls, or GPRS. there are quad bands given that can be supports 850/900/1800/1900 MHz frequency bands.



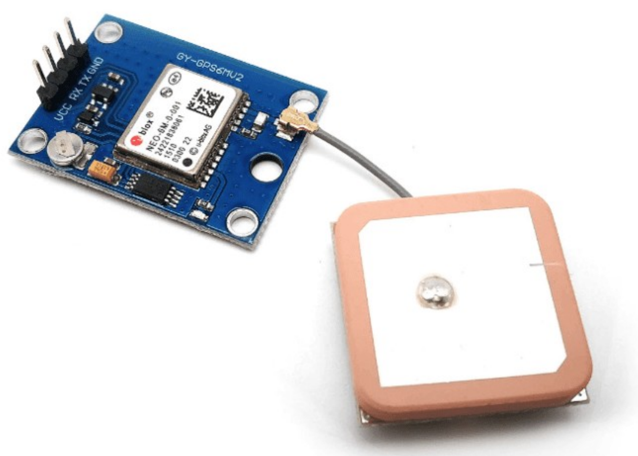
Sim800l module can be run over the 2g and 3g band. The module support the UART protocol. to enable the protocol there is two pin Rx and Tx. by these pin the module transfer and receive the data.

It runs from 3.3 volts to 5v but need at least 2 amp power. i suggest give 5v 2amp external power supply. to power the mmodule.

GPS Module neo 6m module:

Neo 6M module is use for sending the current location in this arduino based _helmet project.

The NEO-6M GPS module is a low cost and small size module which can receive the gps signal and can be provide position with lattitude and longitude with time. it work with the global positioning system also it supports global navigation satelite system.



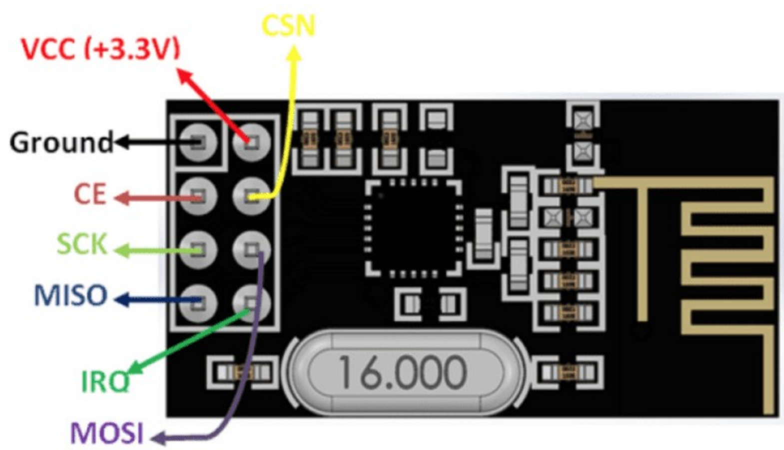
The gps neo 6m module can be communicate with any microcontroller with the UART protocol in this project this module will be connect to the arduino with the UART protocol and use rx and tx pin to connect the system.

There is a library which can help to callibrate the sensor with the coding.

Some common applications for the NEO-6M GPS module include navigation systems, geotagging, tracking devices, and unmanned aerial vehicles (UAVs). It is important to note that the module requires a clear view of the sky to receive GPS signals, and may not work well indoors or in areas with poor satellite coverage.

NRF module NRF24L01:

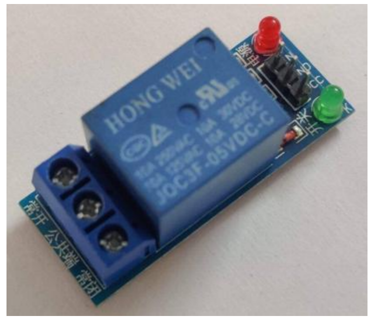
There are two device in this smart helmet project one is transmitter and other is receiver in both of them we need to transmit the data. so we are using NRF module to bidirectional communication.



NRF module are the small size low cost ultra power module that works 2.4 GHZ wireless transreceiver. that can be use in wireless communication project. you can also connect many nrf module together and make commuincation between all the NRF Module.

NRF module use the SPI (serial peripheral interface) protocol to make the communication between all the device we have two nrf moduel one will be connect to the transmitter and other will be connect to the receiver module.

Single channel Relay module:
Here in the receiver section we are using a relay which will be trigger the motor which is to be pretend the bike engine.

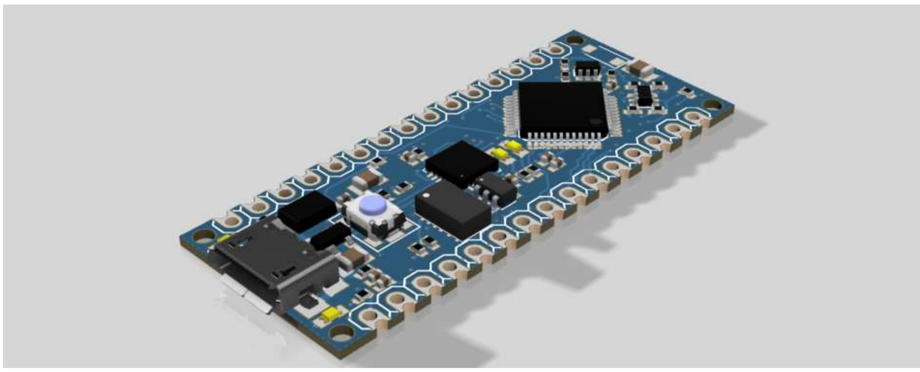


when it receive the data from the tranmitter and start the motor it need to be trigger by the relay module. relay module will be use to operate the 12v DC motor.

DC motor 12v:
We are using here 12v dc motor with gears . If the driver is drung the motor will be turn off. it means the bike engine will be turn off.

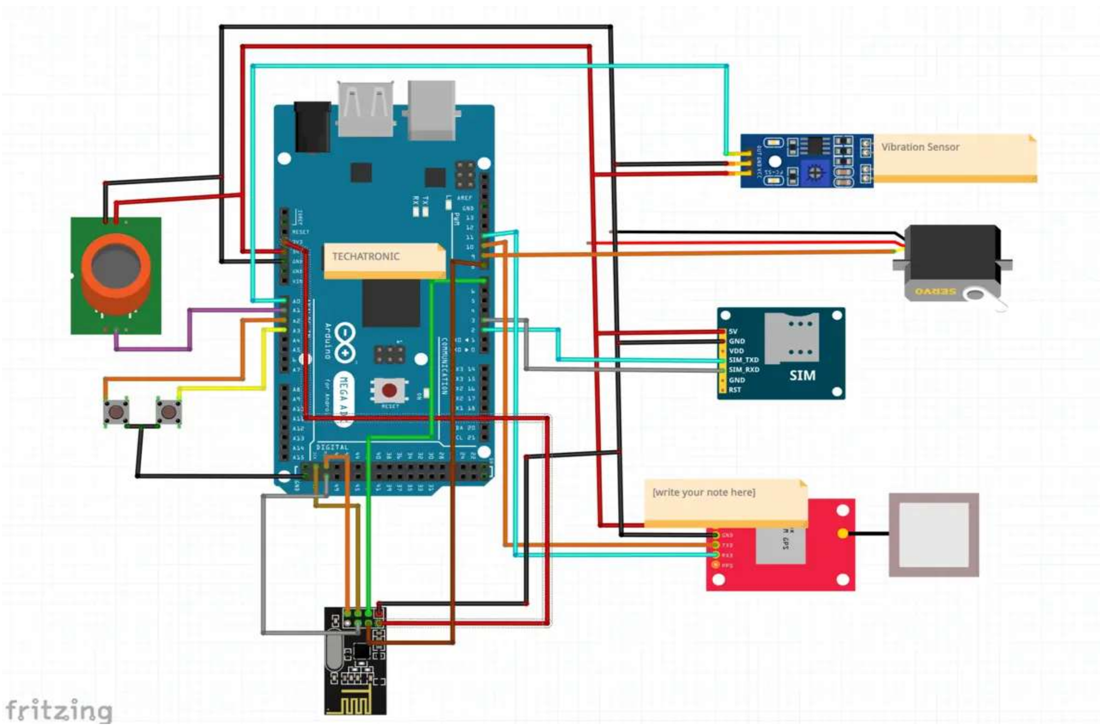
12v dc motor connected via 12v external poswer supply. which is connected through the relay which always will be triggered from the relay. Arduino can’t run a dc motor due to back emf and low current at the pins.

Arduino nano:



The Arduino Nano 33 BLE Sense Rev 2 is a compact and versatile development board designed for embedded electronics projects. It is an upgraded version of the Nano 33 BLE Sense, integrating a variety of sensors and communication capabilities. The board is based on the Nordic Semiconductor nRF52840 chip, offering Bluetooth Low Energy (BLE) connectivity for wireless communication. What sets the Nano 33 BLE Sense Rev 2 apart is its rich sensor suite, making it ideal for projects involving IoT, wearables, and edge computing. It includes a 9-axis IMU (Inertial Measurement Unit) for motion sensing, environmental sensors for temperature, humidity, and pressure, and a microphone for sound detection. These sensors enable developers to create applications that involve motion tracking, environmental monitoring, and audio processing. Additionally, the board features a user-friendly design with a compact form factor, making it suitable for projects with space constraints. It can be programmed using the Arduino IDE, which simplifies the development process for both beginners and experienced users. Overall, the Arduino Nano 33 BLE Sense Rev 2 is a powerful and feature-packed development board, combining wireless connectivity and a diverse range of sensors to facilitate the creation of innovative and interactive projects.

3D-Circuit diagram:



The circuit diagram of the IoT-based smart helmet consists of several sensors and modules connected to a central microcontroller, such as **NodeMCU (ESP8266)** or **Arduino UNO**. The **MQ-3 alcohol sensor** is connected to the analog input pin (A0) of the microcontroller. It detects the presence of alcohol from the rider's breath and sends an analog voltage based on the concentration. An **IR sensor** (or pressure sensor), used to detect if the helmet is being worn, is connected to a digital input pin (e.g., D2) and provides a HIGH or LOW signal based on the presence of the rider's head.

The **MPU6050 motion sensor**, which contains both an accelerometer and gyroscope, is connected to the microcontroller through **I2C communication** — SDA (data line) to the D2 pin and SCL (clock line) to the D1 pin. This sensor detects sudden movement or impact, which can indicate an accident. A **relay module** is connected to a digital output pin (e.g., D4). The relay acts as a switch to control the vehicle's ignition system. When the rider is safe (helmet worn and no alcohol detected), the relay closes the circuit to allow engine start; otherwise, it remains open to block ignition.

If a **GSM module** (like SIM800L) is used, it is connected via serial communication — TX of the GSM to RX of the microcontroller and RX of the GSM to TX of the microcontroller. This module is responsible for sending SMS alerts to emergency contacts in case of an accident or violation. Optionally, a **GPS module** can be connected via separate serial pins to provide real-time location tracking, which is included in the alert messages. A **buzzer and LED** are connected to output pins to provide immediate audio and visual alerts to the rider if safety rules are violated.

The entire circuit is powered using a **battery pack** (like a 9V or 3.7V Li-ion battery), connected to the VIN and GND pins of the microcontroller. If needed, a voltage regulator is used to step down or stabilize the voltage supply. All grounds (GND) from sensors and modules are connected to the common ground of the microcontroller to complete the circuit.

A GSM module (like SIM800L) is connected via serial communication (TX and RX pins) to send SMS alerts during emergencies. Alternatively, NodeMCU's built-in Wi-Fi can be used to send notifications over the internet. A GPS module can also be connected through serial pins to provide real-time location data, especially during accident detection. Buzzers and LEDs are connected to output pins to alert the rider in case of violations like alcohol detection or helmet absence. All these components are powered by a rechargeable battery connected to the microcontroller's power input pins, with voltage regulation as needed. Together, these connections ensure that the system enforces safety rules, detects accidents, and communicates alerts efficiently.

4.4 UML Diagram

The UML (Unified Modeling Language) diagram for the smart helmet system helps to visually represent the structure and behavior of the project components, their interactions, and the flow of control. Typically, for this kind of embedded IoT project, the most relevant UML diagrams are the Use Case Diagram and the Class or Activity Diagram.

4.4.1. Component Diagram

In the Use Case Diagram, the main actor is the Rider, who interacts with the system by wearing the helmet and attempting to start the motorcycle. The system itself is represented as a single entity that provides multiple use cases or functions. These use cases include “Check Helmet Worn Status”, “Detect Alcohol Presence”, “Detect Accident or Fall”, “Control Ignition”, and “Send Emergency Alert”. There can also be a secondary actor, such as Emergency Contact, who receives alerts via SMS or app notifications.

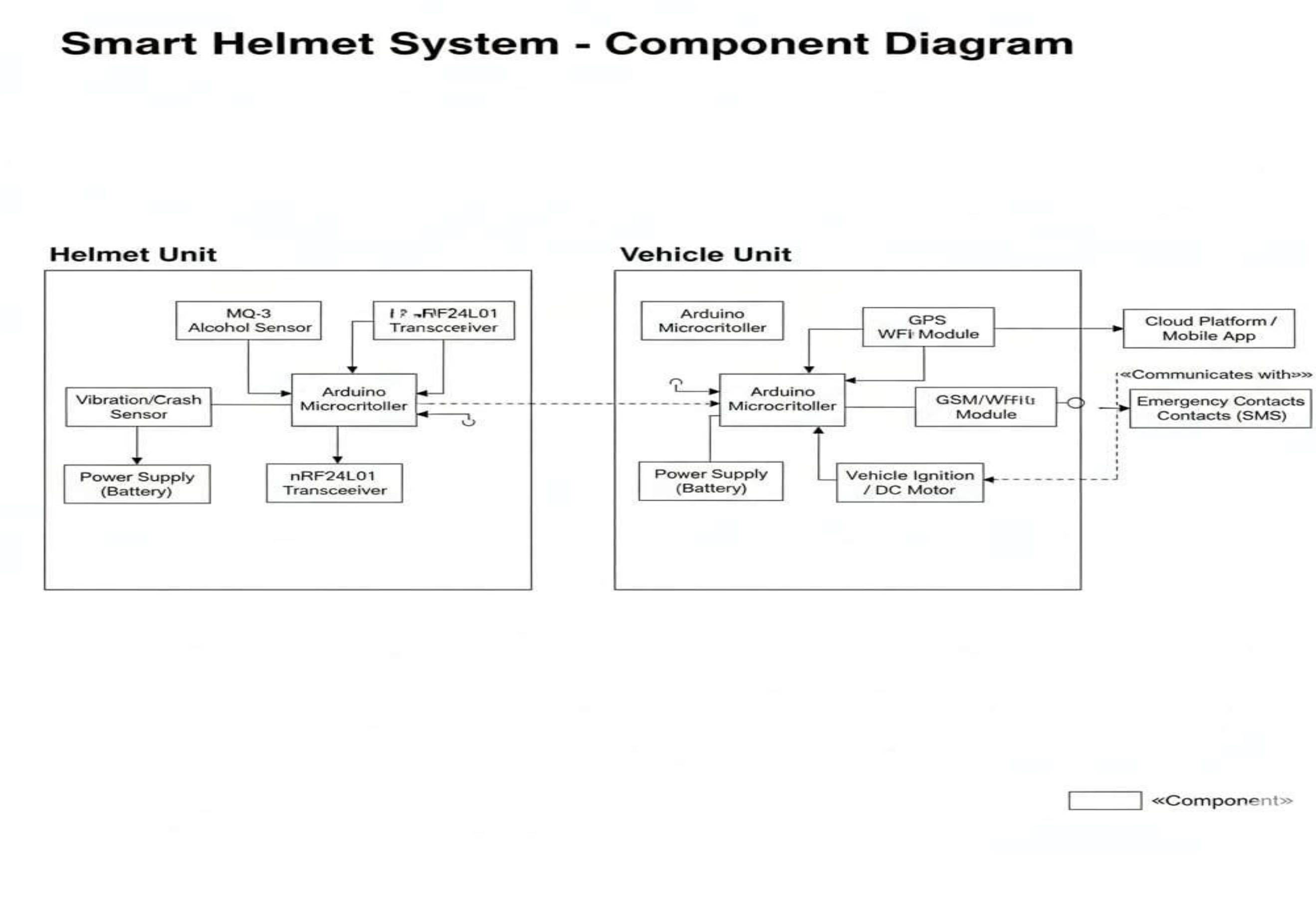


Fig 12:Component Diagram

4.4.2 Activity Diagram

In the Activity Diagram, the flow begins with the Helmet Power On. The system first checks the helmet status using an IR or pressure sensor. If the helmet is not worn, it goes to the "Block Ignition" activity and ends the process. If the helmet is worn, it continues to check alcohol level. If alcohol is detected, it also blocks the ignition and triggers a buzzer. If both checks pass, the system enables the “Start Vehicle” activity. Parallelly, the system monitors the MPU6050 sensor for motion or fall detection. If an accident is detected, the GPS module is triggered to get location data, and the GSM module sends an alert to predefined contacts. The activity ends with alert confirmation and logs data .

The IoT-based Smart Helmet is an innovative safety system designed to protect two-wheeler riders by ensuring that the helmet is worn properly and that the rider is not under the influence of alcohol before starting the vehicle. The system integrates several sensors and IoT components, such as an alcohol sensor, motion sensor, GPS module, microcontroller, and wireless communication module. These components work together to monitor the rider’s safety conditions and communicate data to a connected mobile application and cloud server.

When the helmet is powered on, it first checks whether it is being worn correctly using a wear detection sensor. It then activates the alcohol sensor to measure the rider’s breath alcohol concentration. If alcohol is

detected above the permissible level or if the helmet is not worn, the helmet’s controller unit sends a signal to the vehicle interface to block the ignition system, thereby preventing the rider from starting the vehicle. If both conditions are satisfied—helmet worn and alcohol level normal—the helmet allows the engine to start and continuously monitors the rider’s motion through the built-in accelerometer and gyroscope sensors.

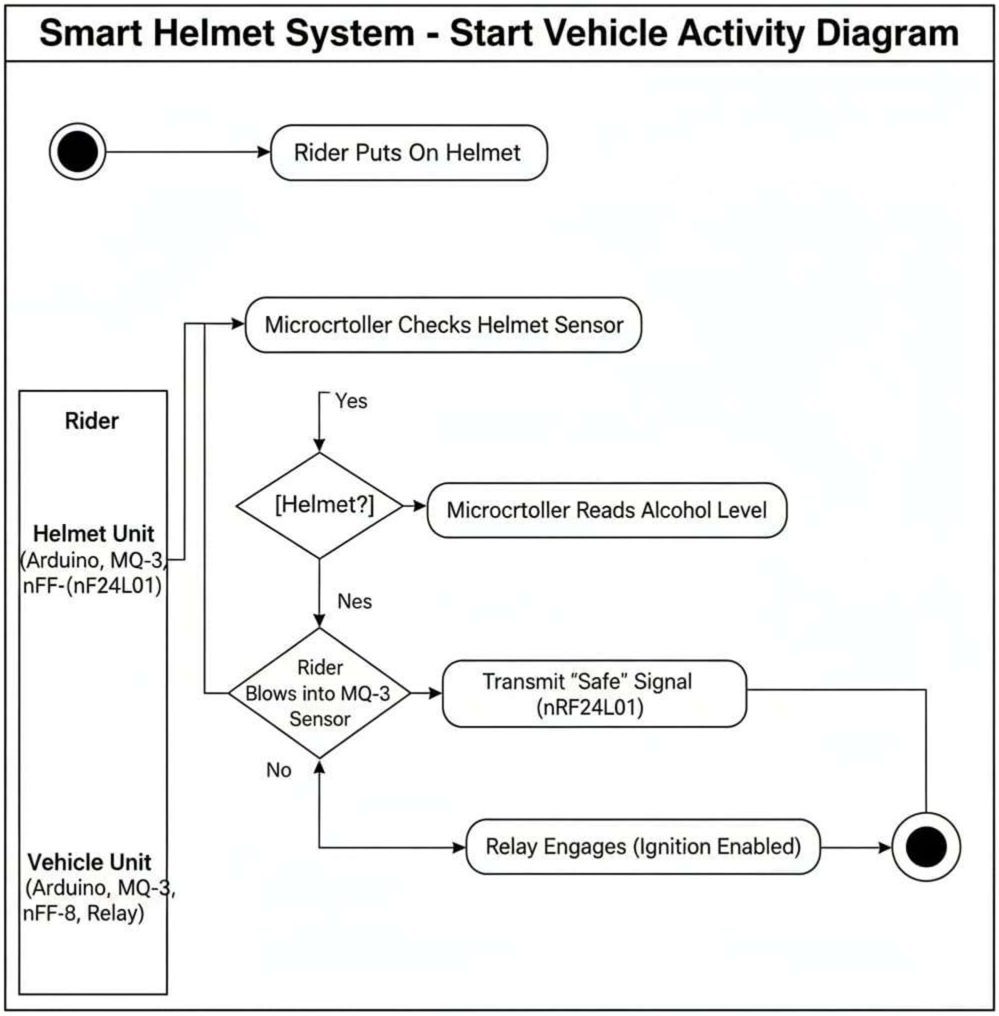


Fig 13: Activty Diagram

These UML diagrams help in understanding how different components and users interact with the system, the logical flow of events, and the decision-making structure behind the features. It makes the design of the system more organized, especially during development and debugging.

Rider → HelmetSensor: Check Helmet Status

HelmetSensor → Microcontroller: Send Status

Microcontroller → AlcoholSensor: Read Alcohol Level

AlcoholSensor → Microcontroller: Send Value

Microcontroller → Relay: Control Ignition

Microcontroller → MPU6050: Monitor Motion

MPU6050 → Microcontroller: Accident Detected

Microcontroller → GPS Module: Get Location

GPS Module → Microcontroller: Location Data

Microcontroller → GSM Module: Send Alert

The Sequence Diagram helps to describe the order in which each component communicates with the microcontroller. For example, the rider triggers the process by wearing the helmet. The IR sensor sends a signal to the microcontroller. Then the alcohol sensor sends its data. The microcontroller evaluates both inputs and decides whether to activate the relay for ignition. Simultaneously, the motion sensor sends real-time data. In case of an accident, the GPS and GSM modules are triggered in sequence to send an emergency alert.

4.4.3 Use Case Diagram

Lastly, the Use case Diagram can be imagined to show how the system is structured logically. There could be classes like “HelmetSystem,” “SensorModule,” “CommunicationModule,” and “PowerModule,” each with their own attributes and functions. For example, the HelmetSystem class may include attributes like helmetStatus, alcoholLevel, and functions like checkHelmet() or blockIgnition().

The cloud system then forwards this alert, along with the location details, to the rider’s emergency contacts or nearby authorities for quick assistance. The mobile application displays the helmet’s status, alcohol level, and live location, ensuring that both the rider and family members stay informed in real time.

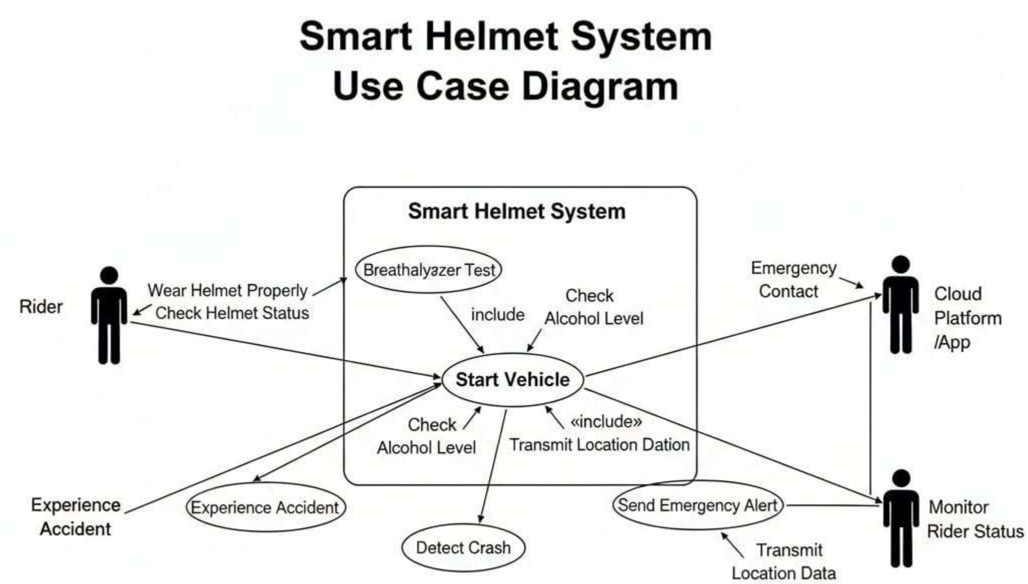


Fig 14: Use Case Diagram

During the ride, the motion sensor actively detects any abnormal movements or sudden impacts that may indicate an accident. If a crash is detected, the helmet automatically retrieves the rider's location using the GPS module and sends an emergency alert to the connected mobile application and cloud server. The cloud system then forwards this alert, along with the location details, to the rider's emergency contacts or nearby authorities for quick assistance. The mobile application displays the helmet's status, alcohol level, and live location, ensuring that both the rider and family members stay informed in real time.

In UML terms, the system involves multiple actors, including the rider, vehicle system, mobile application, cloud server, and emergency contacts. The use cases describe actions such as wearing the helmet, detecting alcohol, preventing or allowing vehicle start, detecting accidents, and sending alerts. The class diagram includes components like HelmetController, AlcoholSensor, MotionSensor, GPSModule, MobileApp, CloudServer, and VehicleInterface, each responsible for specific functions. The sequence diagram shows how these components interact step-by-step — from helmet activation and alcohol detection to vehicle control and emergency alert transmission. The activity and state diagrams represent how the system transitions through different states, such as idle, authorized, riding, and crashed, based on the sensor inputs

Overall, the IoT-based Smart Helmet is an intelligent and connected safety device that enhances road safety by combining hardware sensors, wireless communication, and cloud-based monitoring. It prevents drunk driving, ensures helmet usage, and provides rapid emergency response in the event of accidents, making it an essential innovation for modern transportation safety.

5.IMPLEMENTATION/RESULTS AND DISCUSSION

5.1 Software Requirements

Software Technologies

- **Arduino IDE:** Used for writing and uploading code to the microcontroller.
- **Embedded C / C++ Programming:** Used to control sensor operations and logic.
- **IoT Dashboard / Mobile App:** Displays sensor readings and alert notifications.

Power Supply Technology

A regulated 5V DC power supply is used to operate sensors and modules. Rechargeable batteries or vehicle power systems can also be used for portability and reliability.

The IoT-based smart helmet project integrates a combination of embedded systems, sensor technologies, wireless communication, and Internet of Things (IoT) concepts to enhance rider safety and accident response. The primary technology used is embedded systems programming, where a microcontroller such as Arduino Uno or NodeMCU (ESP8266) is used to interface with multiple hardware components like sensors, relays, and communication modules. The system is programmed using C/C++ in the Arduino IDE, which enables the reading of sensor data, decision-making, and control of output devices like relays and buzzers.

5.2 Hardware Requirements

1. MQ-3 Alcohol Sensor
   - Detects alcohol in the rider's breath.
   - Sends analog signals based on alcohol concentration.
2. Motion Sensor Accelerometer (MPU6050)
   - Detects motion, vibrations, or falls during a crash.
   - Sends signal to trigger an emergency response.
3. Microcontroller (Arduino Uno)
   - Acts as the brain of the system.

- Collects sensor data, processes logic, and manages communication.

4. GPS Module (NEO-6M)
   - Fetches real-time location coordinates of the user.
   - Useful for sending location in emergency alerts.
5. GSM Module (SIM800L)

Sends SMS alerts with live GPS coordinates to pre-configured emergency contacts.

Works without internet.

6. Relay Module o

Controls ignition system based on safety checks (helmet and alcohol).

- Disables ignition if unsafe conditions are detected.

5.3 Technologies used

The proposed **IoT-Based Alcohol Detection and Motion Sensor System** integrates several hardware and software technologies to ensure efficient detection, monitoring, and communication. The system makes use of embedded electronics, IoT communication, and cloud technologies for real-time operation and data analysis.

Internet of Things (IoT)

The Internet of Things enables the connection of physical devices such as sensors, microcontrollers, and communication modules to the internet for real-time data exchange. In this project, IoT allows remote monitoring of the driver's condition and vehicle motion. Sensor data (alcohol level, vibration, GPS location) can be sent to a cloud platform or mobile application for continuous tracking and emergency alerts.

Microcontroller Technology (Arduino / NodeMCU)

A microcontroller acts as the brain of the system.

Arduino Uno or **NodeMCU (ESP8266/ESP32)** is used to interface all sensors and modules.

- It processes the input from the alcohol and motion sensors and triggers appropriate actions like disabling the ignition or sending alerts.
- NodeMCU provides built-in Wi-Fi capability, making it easier to connect to IoT platforms.

Sensor Technology

(a) MQ-3 Alcohol Sensor

- Detects alcohol concentration in the driver's breath.
- Works on the principle of change in resistance when exposed to alcohol vapors.
- Provides an analog signal proportional to the amount of alcohol detected.

(b) Vibration/Accelerometer Sensor (e.g., ADXL335 or SW-420)

- Detects sudden motion, vibration, or impact.
- Helps identify accidents or unusual vehicle movement.

Sends a digital or analog signal to the microcontroller for processing

GPS (Global Positioning System) Technology

- Provides the real-time geographical location of the vehicle.
- Used for tracking the vehicle's position during accidents.
- The GPS module sends latitude and longitude data to the microcontroller, which can be shared through SMS or IoT platforms.

GSM (Global System for Mobile Communication) Technology

- The GSM module (e.g., SIM800L or SIM900A) is used to send SMS alerts to emergency contacts or authorities.

When an accident or alcohol detection event occurs, the module transmits a message containing the GPS coordinates of the vehicle.

2. IoT Cloud Platforms

Cloud platforms such as Blynk, ThingSpeak, or Firebase are used to store and visualize sensor data online.
These platforms enable:

- Real-time monitoring through mobile apps or dashboards
- Data logging for future analysis
- Remote alert notifications

3.Safety & Alert Systems

Buzzer / LED Indicators

Alerts the rider if helmet is not worn or alcohol detected.

Emergency Alert System

Sends SMS or push notifications to family or emergency services in case of accidents.

In short, the IoT smart helmet combines sensors, communication modules, microcontrollers, and cloud/mobile integration to monitor rider safety, prevent accidents, and provide emergency alerts.

5.4 Coding

```
#include <SoftwareSerial.h>

// Define pins
const int alcoholPin = A0;     // MQ-3 analog pin
const int relayPin = 9;        // Relay control pin

// Alcohol detection threshold (adjust as needed)

const int alcoholThreshold = 300;  // Higher = more alcohol vapo
// GSM Serial on D7 (RX), D8 (TX) SoftwareSerial
gsmSerial(8, 7); // TX, RX

bool alertSent = false;

void setup()
  { Serial.begin(9600);
  gsmSerial.begin(9600);

  pinMode(alcoholPin, INPUT);
  pinMode(relayPin, OUTPUT);

  // Turn motor ON initially
  digitalWrite(relayPin, HIGH); // Relay ON → Motor ON

  delay(1000);
  sendSMS("Helmet system ready. Motor enabled.");
}

void loop() {
  int alcoholValue = analogRead(alcoholPin);
  Serial.print("Alcohol Value: ");
```

```
  Serial.println(alcoholValue);

  if (alcoholValue > alcoholThreshold) {
    // Turn OFF motor
    digitalWrite(relayPin, LOW); // Relay OFF → Motor OFF

    // Send alert once
    if (!alertSent) {
      sendSMS("Alert! Alcohol detected. Motor ignition disabled.");
      alertSent = true;
    }
  } else {
    // Reset system when alcohol not detected
    digitalWrite(relayPin, HIGH); // Motor ON
    alertSent = false;
  }

  delay(1000); // Adjust delay as needed
}

void sendSMS(String message)
  { gsmSerial.println("AT");
  delay(500);
  gsmSerial.println("AT+CMGF=1"); // Text mode
  delay(500);
  gsmSerial.println("AT+CMGS=\"+91xxxxxxxxxx\""); // Replace with real number
  delay(500);
  gsmSerial.println(message);
  delay(500);
  gsmSerial.write(26); // ASCII for Ctrl+Z to send message
  delay(3000);
}
```

6.TESTING

6.1 Testing Objectives

To verify the functionality of individual components
Ensure that each module—alcohol sensor, motion/vibration sensor, GPS, GSM, microcontroller—operates correctly and provides accurate output signals.

To check system integration and communication
Confirm that all sensors and modules communicate effectively with the microcontroller and IoT platform without data loss or delay.

To validate accurate alcohol detection
Test whether the MQ-3 sensor correctly identifies alcohol presence and triggers the appropriate response (engine lock and alert generation).

To ensure reliable motion and accident detection
Verify that the vibration/accelerometer sensor accurately senses sudden impact or unusual motion and activates the emergency alert function.

To test real-time alert transmission
Check that the GSM module successfully sends SMS notifications containing GPS location details to emergency contacts without delay.

To measure performance and response time
Evaluate the speed of system response—from sensor detection to message delivery—to ensure timely alerts in critical situations.

To assess system stability and reliability
Confirm that the system operates continuously over time without false triggering, sensor drift, or communication failure.

6.2 Test Cases

A series of test cases were conducted to verify the proper functioning of the IoT-based alcohol detection and motion sensor system. Each test aimed to validate individual modules, system integration, and overall performance under real-time conditions.

In **Test Case TC01 (Power ON Test)**, the system was switched on to ensure that all modules initialized correctly. The expected result was that the system should enter a ready state after successful initialization, and the test passed as all modules functioned properly.

In **Test Case TC02 (Alcohol Detection without Alcohol)**, the sensor was exposed to normal air. The expected outcome was that the alcohol level would remain below the threshold, allowing ignition. The result confirmed that ignition was permitted and no alert message was generated, indicating a successful test.

In **Test Case TC03 (Alcohol Detection with Alcohol)**, the MQ-3 sensor was exposed to alcohol vapors. The system was expected to detect alcohol levels exceeding the threshold, disable ignition, and send an alert message. The system responded accurately by turning off ignition and sending an SMS alert, marking the test as a success.

Test Case TC04 (Vibration Detection) involved simulating sudden motion or a collision to check accident detection. The expected result was that the system would detect motion and send an accident alert with GPS location. The test passed as the system sent the correct alert message containing the coordinates.

In **Test Case TC05 (GPS Data Accuracy)**, the GPS module was tested to verify its ability to display the correct latitude and longitude. The readings were accurate within 5–10 meters, confirming successful GPS performance.

Test Case TC06 (GSM Message Transmission) verified the alert-sending capability. When an alert was triggered (due to alcohol or vibration), the system was expected to send an SMS to the registered contact. The SMS was received within 3–5 seconds, meeting expectations.

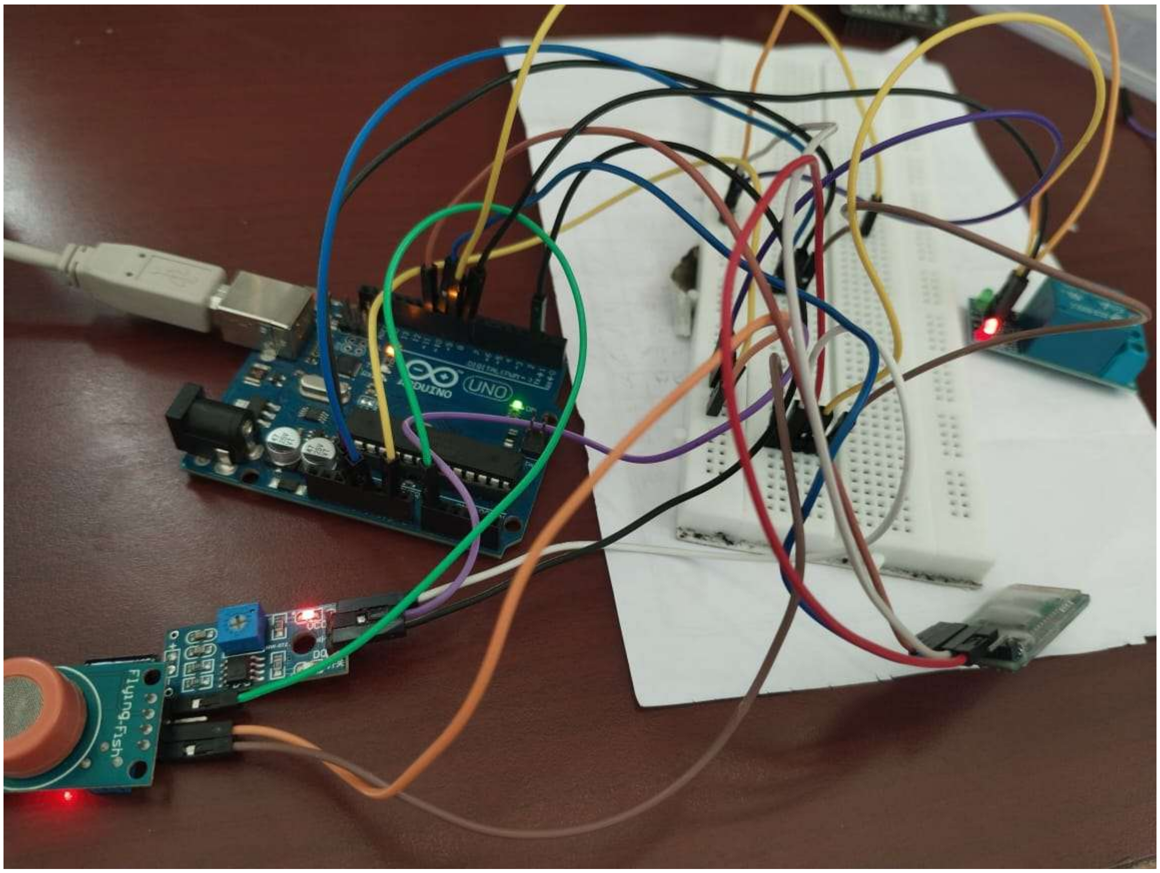
For **Test Case TC07 (IoT Data Upload)**, the system transmitted sensor data to the IoT platform. The expected result was that the data would appear on the IoT dashboard or mobile app, and the test was successful as all data were correctly uploaded and displayed.

In **Test Case TC08 (Continuous Monitoring)**, the system was run continuously for 2–3 hours to check its stability. The system remained stable throughout the test, maintaining consistent monitoring without any false alerts.

Test Case TC09 (Sensor Calibration Test) was conducted by varying alcohol concentrations manually to verify proportional sensor response. The system accurately detected and displayed corresponding alcohol levels, proving the sensor's precision and consistency.

Finally, **Test Case TC10 (System Integration Test)** was performed to evaluate the combined performance of all modules working together. The system exhibited smooth operation, with no communication delays or conflicts among modules, confirming full integration and coordination.

7.RESULTS/FUTURE SCOPE OF WORK

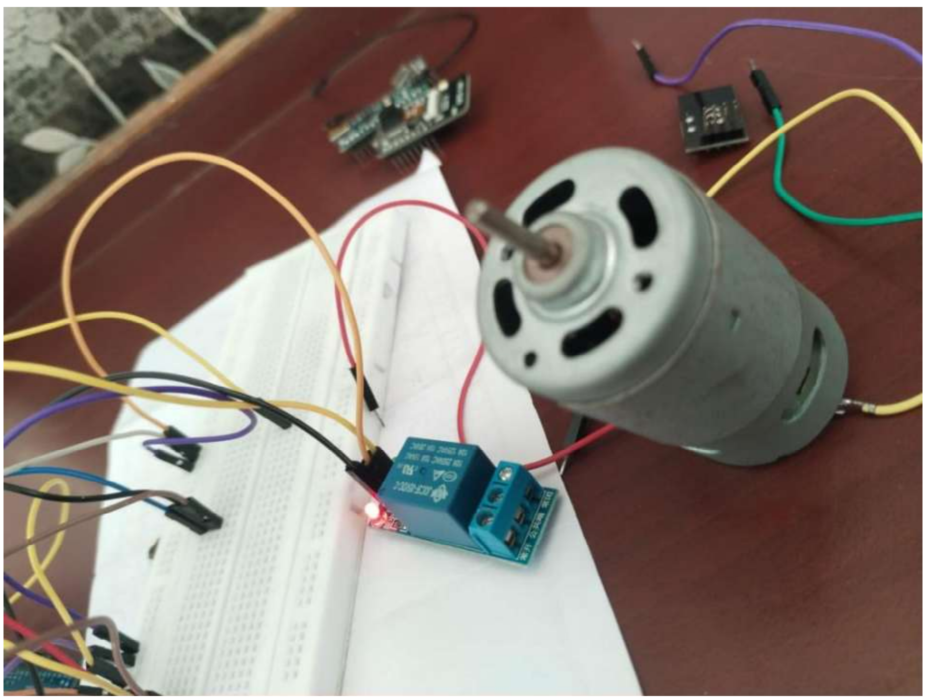


The proposed **IoT-Based Alcohol Detection and Motion Sensor System** was successfully designed, implemented, and tested. The system achieved all its intended objectives by detecting alcohol consumption, monitoring vehicle motion, and providing timely alerts through GSM and GPS technologies.

During testing, the **MQ-3 alcohol sensor** accurately detected alcohol levels and disabled the vehicle ignition when the concentration exceeded the set threshold. The **vibration sensor** responded effectively to sudden impacts or abnormal vehicle motion, automatically triggering accident alerts. The **GPS module** provided precise location information, while the **GSM module** transmitted emergency messages to the registered contact number within a few seconds.

The integration of these modules with the **IoT platform** allowed for real-time monitoring and data visualization, ensuring continuous tracking and quick emergency response. The system demonstrated high accuracy, reliability, and stability during continuous operation.

Although the system performed successfully, there are several areas where future improvements and enhancements can be made to make it more efficient, scalable, and user-friendly.



1. **Integration with Mobile Application:**
   Develop a dedicated Android or iOS app to monitor real-time data, receive notifications, and display accident history on an interactive dashboard.
2. **Cloud Data Analytics:**
   Store continuous data on cloud platforms and apply data analytics or machine learning algorithms to analyze driver behavior patterns and predict accident risks.

3. **Automatic Vehicle Control:**
   Integrate with vehicle control systems (ECU) for automatic braking or engine shutdown in emergency situations.
4. **Camera and Image Processing:**
   Add a camera module for visual monitoring and facial recognition to detect driver drowsiness or distraction.
5. **Advanced Communication Technologies:**
   Use 4G/5G or LoRa communication modules instead of GSM for faster, wider, and more reliable connectivity.

Table2: Range Descripiton About Different Sensors

Sensor Name	Actual Range	Threshold Used in Project
MQ-3 Alcohol Sensor	0.04 mg/L to 4 mg/L (alcohol vapor)	> 0.25 mg/L or analog value > 300
IR Sensor	2 – 30 cm (depends on module)	Object detected within 5–10 cm
Pressure Sensor	Varies (e.g., FSR: 0–10 kg)	Pressure ≥ 1 kg
MPU6050 (Accelerometer)	±2g to ±16g (adjustable range)	Sudden change ≥ ±3g
MPU6050 (Gyroscope)	±250 to ±2000°/s	Angular velocity > 300°/s
GPS Module	Global satellite range	No threshold (requires valid location fix)

8. CONCLUSION

The IoT-Based Smart Helmet with Alcohol Detection and Motion Sensor was developed to enhance rider safety through preventive and responsive technologies. The system successfully integrates key safety features such as alcohol detection, helmet usage verification, motion/crash detection, real-time location tracking, and emergency alerting. The results from testing confirm that the helmet effectively prevents vehicle ignition in unsafe conditions—such as when the rider is intoxicated or not wearing the helmet—thereby addressing two major causes of road accidents: drunk driving and helmet negligence.

The system's ability to detect crashes and automatically send an SOS message with GPS coordinates to emergency contacts further strengthens its value as a life-saving device. The integration of GSM and GPS modules ensures that emergency alerts are sent in real time, even without internet connectivity, making it suitable for use in remote or low-network areas. The entire system operates efficiently on battery power, making it portable, reliable, and user-friendly.

In conclusion, this smart helmet prototype demonstrates a meaningful step toward reducing road fatalities and promoting responsible riding behavior. However, future enhancements could include integrating IoT cloud platforms for remote monitoring, adding voice-based alerts, or using machine learning algorithms to better detect crash patterns. Additionally, efforts to reduce the size of the components and improve durability will make the device more suitable for commercial deployment. The project lays a strong foundation for next-generation smart wearables in the field of intelligent transportation systems.

9.FUTURE ENHANCEMENTS

The current implementation of the IoT-Based Smart Helmet demonstrates a practical and effective solution for enhancing two-wheeler rider safety. However, there is significant potential for improvement and expansion in the future. With the integration of advanced technologies and smarter systems, the helmet can evolve into a more intelligent, robust, and commercially viable product. Below are several key areas of future development:

1. **IoT Cloud Integration** □By connecting the helmet to IoT cloud platforms such as ThingSpeak, AWS IoT, or Google Firebase, data such as alcohol levels, crash reports, and GPS locations can be stored and monitored remotely.
2. **Machine Learning for Crash Detection** □Machine learning algorithms can be trained to recognize complex crash patterns and differentiate between normal vibrations (like speed bumps) and actual accidents.
3. **Voice Command and Alert System**

   □ Adding voice recognition could enable hands-free control, such as starting the system, triggering SOS alerts, or giving safety reminders.
4. **Solar-Powered Battery Charging** □ Integrating solar panels on the helmet can extend battery life and reduce the need for frequent charging, making the device more sustainable and user-friendly.
5. **Mobile App Integration**

   A dedicated smartphone app can be developed to:

   - Receive alert notifications. o Track ride history and safety scores.
   - Configure emergency contact numbers and sensitivity settings.
6. **Health Monitoring Features** □ Additional sensors can be included to track heart rate, body temperature, or even fatigue detection, providing health insights to the rider and enabling proactive medical responses.

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10. APPENDIX / APPENDICES

The appendices contain supplementary technical documentation essential for the replication, understanding, and empirical validation of the **"Guardian Band: Smart Safety for Women"** prototype. This documentation provides the granular detail supporting the hardware integration, software logic, and performance claims made in the body of the thesis.

APPENDIX A: Final Bill of Materials (BOM)

This appendix provides a comprehensive listing of all hardware and specialized components used in the construction of the final working prototype, including component specifications and unit cost estimates.

- **A.1 Hardware Component List:** A detailed table listing the specific quantity, full product name, and technical specification (e.g., *Arduino Nano V3*, *SIM800L GSM/GPS Module*, *KY-038 Microphone Sound Sensor*).
- **A.2 Power System Breakdown:** Documentation of the power components, including the specifications of the Li-ion battery (voltage and mAh capacity) and the details of the **TP4056 Battery Charging Module**.
- **A.3 Specialized Consumables:** Details on passive components, such as the value of pull-up/pull-down resistors used for the **Push Button** and the specific resistance (220Ω) used for current limiting the **LED**.

APPENDIX B: Detailed System Schematics and Pin Mapping

This section provides the full technical diagrams and wiring documentation necessary to understand the component-level connections of the prototype.

- **B.1 Circuit Schematic:** The detailed circuit diagram showing all components, their wiring, and essential safety features (e.g., the inclusion of the **AMS1117 3.3V Voltage Regulator** powering the SIM800L).
- **B.2 Hardware Pin Configuration:** A tabular map clearly detailing the specific digital and analog pins used on the **Arduino Nano** for each component (e.g., Push Button -> D7, SIM800L TX -> D3, Microphone DO -> D5).
- **B.3 Power Distribution Map:** A schematic showing the power lines (5V, 3.3V Regulated, and GND) originating from the battery and how they are distributed to each module (Arduino, GSM, GPS, Sensors).

APPENDIX C: Full System Firmware (Source Code)

This appendix includes the complete, runnable source code developed for the **Arduino Nano**.

- **C.1 Core Code Listing:** The complete, well-commented Arduino source code file (.ino).
- **C.2 Key Function Detail:** Code snippets highlighting the logic of critical functions, specifically the triggerEmergency() function and the polling logic within the void loop() that monitors both the **D7** and **D5** pins for activation signals.
- **C.3 Library Documentation:** A list and description of all external libraries utilized, including **SoftwareSerial** and **TinyGPS++**, and the specific pins assigned for serial communication.

APPENDIX D: UML and Architectural Diagrams

This section includes all visual models used to define and structure the system's architecture and operational flow.

- **D.1 Block Diagram:** The hierarchical diagram showing the major system units (Input, Processing, Communication, Output) and the physical connections between the components.
- **D.2 UML Sequence Diagram:** The diagram illustrating the chronological, step-by-step messaging and interaction sequence, from the **User** trigger to the **Emergency Contact** receiving the SMS alert.
- **D.3 UML Class Diagram:** The model defining the logical software components (classes) within the firmware, their attributes (data), methods (functions), and relationships (e.g., the Microcontroller managing the GPS Parser).

APPENDIX E: Testing and Validation Metrics

This section documents the quantitative results of the prototype's performance testing.

- **E.1 Alert Latency Results:** Quantitative data measuring the time interval (in seconds) between the emergency trigger (button press) and the actual message transmission confirmation from the GSM module.
- **E.2 GPS Accuracy Samples:** A comparison table showing the coordinates reported by the NEO-6M module against verified coordinates (e.g., taken from a reliable smartphone or map tool) across various outdoor test locations.
- **E.3 Microphone Sensitivity Test:** Data showing the decibel level required to reliably trigger the **Microphone Sensor** for voice activation, ensuring a balance between easy activation and resistance to false alarms.

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