SMART HELMET CRASH DETECTION SYSTEM

# A PROJECT REPORT

***submitted by***

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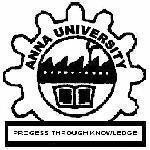
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**BONAFIDE CERTIFICATE**

Certified that this project report titled “**SMART HELMET CRASH DETECTION SYSTEM”** is the bonafide work of “**SIDHARTH SUBRAMONIAN (230701315), SIVARAMAKRISHNAN R (230701319)”** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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# ABSTRACT

# Road safety is a critical concern, especially for motorcyclists, where accidents often result in severe injuries or fatalities. To address this challenge, this study proposes the development of a smart helmet integrated with Internet of Things (IoT) technologies aimed at enhancing rider safety and providing real-time monitoring. The methodology includes a comprehensive review of existing safety solutions, followed by requirements analysis, system design, prototype development, testing, and refinement. Key components of the proposed smart helmet include an accelerometer for crash detection, ultrasonic sensors for helmet wear detection, a vibration motor for obstacle alerts, and a Telegram bot for SOS notifications. The system is designed to detect crashes in real-time, sending immediate alerts to emergency contacts via Telegram if no movement is detected within a specified time. Additionally, the helmet includes features such as a map hologram displayed on the visor and location-specific alerts. The smart helmet aims to improve rider safety by providing timely alerts, enhancing situational awareness, and ensuring quick response in case of emergencies. Future work will focus on further refining the system’s sensors, improving communication protocols, and integrating additional safety features to enhance its effectiveness in real-world scenarios.

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**CHAPTER 1**

**INTRODUCTION**

Motorcycle safety is a critical issue worldwide, with road accidents involving riders often leading to severe injuries or fatalities. As the number of motorcyclists on the road increases, the need for innovative solutions to improve rider safety becomes even more pressing. Traditional safety measures, such as helmets and protective gear, are essential but often fail to provide real-time monitoring and immediate assistance in emergency situations.

To address these challenges, there is a growing interest in leveraging emerging technologies, particularly the Internet of Things (IoT), to develop smart helmets that enhance rider safety. These IoT-enabled helmets can integrate a variety of sensors and communication technologies to detect accidents, monitor rider conditions, and provide real-time alerts. By combining advanced crash detection systems, location-based services, and automated emergency notifications, smart helmets have the potential to significantly improve motorcycle safety and reduce fatalities.

This study focuses on the development of a smart helmet equipped with IoT technologies aimed at enhancing rider safety. The helmet system integrates sensors such as accelerometers for crash detection, ultrasonic sensors for helmet wear detection, and communication features like a Telegram bot for emergency alerts. Through a systematic approach involving literature review, requirements analysis, system design, and prototype development, the study aims to demonstrate the feasibility and effectiveness of the proposed smart helmet system in improving rider safety.

**1.1 Motivation**

Addressing Motorcycle Safety: Motorcycle accidents remain one of the leading causes of fatalities on the road. The project aims to enhance rider safety by developing a smart helmet that incorporates IoT technologies for real-time crash detection and emergency alerting.

Improving Emergency Response: By integrating an automatic SOS alert system, the smart helmet can instantly notify emergency contacts and responders in case of an accident, reducing response time and potentially saving lives.

Harnessing IoT Technologies: The project leverages the capabilities of IoT technologies, such as accelerometers, ultrasonic sensors, and communication networks, to create a smart helmet that detects crashes, monitors the rider's condition, and provides real-time alerts.

**1.2 Objectives**

Develop a Smart Helmet System: The primary objective is to design and develop a fully functional smart helmet equipped with IoT technologies to monitor rider safety in real-time and send automatic emergency alerts in the event of a crash.

Integration of Sensor Technologies: Implement a variety of sensors, including accelerometers for crash detection and ultrasonic sensors for helmet wear detection. These sensors will provide continuous monitoring of the rider’s situation and trigger alerts when needed.

Real-Time Monitoring and Alerts: Develop algorithms to process sensor data in real-time, detect abnormal behavior (such as a crash), and trigger automatic alerts through communication channels like a Telegram bot to notify emergency contacts.

# CHAPTER 2

# LITERATURE REVIEW

[1] Intelligent Helmet for Accident Detection and Notification Using IoT

This paper presents a system where an intelligent helmet detects accidents using accelerometers and immediately sends location details to emergency contacts via IoT modules. The architecture focuses on continuous monitoring of rider status and quick response to accidents, aiming to reduce fatalities through faster medical attention.

[2] Smart Helmet with Sensors for Accident Prevention and Detection

The proposed system integrates various sensors, including accelerometers and pressure sensors, within a helmet to detect crashes and ensure the helmet is worn properly before riding. The IoT-enabled device communicates alerts to emergency services, aiming to improve rider safety and accident response time.

[3] IoT-Based Accident Detection and Alert System for Motorcyclists

This paper describes an approach that uses accelerometer data combined with GPS tracking to monitor motorcyclists in real-time. Upon detecting a crash event, the system automatically sends the accident location to predefined contacts via a communication module, ensuring timely assistance and reducing emergency response delays.

[4] Smart Helmet for Two-Wheeler Safety Using GSM and GPS Technology

The paper proposes a smart helmet equipped with GSM and GPS modules that monitor the rider’s movement and helmet usage. In case of an accident, the helmet sends automated messages to emergency services with precise location details. The system also ensures the bike ignition is disabled unless the helmet is worn, promoting safety compliance.

[5] IoT-Based Real-Time Health Monitoring System for Riders

This work focuses on integrating health monitoring features, such as heart rate and body temperature sensors, within a helmet. Using IoT platforms, real-time health data of the rider is transmitted to a central system, allowing early detection of anomalies and immediate interventions in case of accidents or health emergencies during rides.Top of Form

**2.1 Existing System**

The existing safety systems for motorcyclists predominantly focus on conventional helmets, which provide passive protection during accidents by reducing head injuries. However, these traditional helmets lack active safety features such as crash detection, real-time location tracking, and automated emergency communication. Riders involved in accidents often depend on bystanders to notice and seek help, which can cause significant delays in receiving medical assistance.

Moreover, most conventional helmets cannot detect whether they are worn properly before riding. They also do not provide obstacle detection, navigation assistance, or emergency alerts, leaving critical gaps in ensuring comprehensive rider safety.

2.1.1 Advantages of the Existing System

* Provides essential head protection during accidents.
* Cost-effective and widely available.
* Meets basic legal requirements for rider safety.

2.1.2 Drawbacks of the Existing System

* No real-time crash detection or automatic alert system.
* No location tracking or emergency communication features.
* No way to verify if the helmet is worn before starting the ride.
* Lack of proactive obstacle detection and navigation assistance.
* Delayed medical attention due to manual reporting of accidents.

**2.2 Proposed System**

Our proposed system represents a significant advancement over conventional motorcycle helmets by introducing smart safety features enabled through IoT technologies. The smart helmet integrates sensors such as accelerometers for crash detection, ultrasonic sensors for helmet wear detection, and communication modules like Telegram bot integration for sending SOS alerts.

Unlike traditional helmets, the smart helmet continuously monitors the rider's condition and detects accidents in real-time. Upon crash detection and absence of movement for a specified time, it automatically sends emergency alerts with the rider's location to predefined contacts. Additionally, the helmet includes obstacle detection via ultrasonic sensors, and a map hologram projected onto the visor for navigation assistance.

The system prioritizes rider safety by enabling immediate emergency responses and improving situational awareness. Furthermore, it is designed to be scalable, user-friendly, and adaptable for real-world deployment across diverse riding environments.

**2.2.1 Advantages of the Proposed System**

* Real-time crash detection and automatic emergency alerts.
* Immediate location sharing through a Telegram bot for faster rescue.
* Helmet wear detection before ride ignition to enforce safety compliance.
* Obstacle detection and vibration alerts to enhance situational awareness.
* Map hologram for easy navigation without distracting the rider.
* Scalable design with potential for further upgrades (e.g., health monitoring sensors).

# CHAPTER 3

**SYSTEM DESIGN**

## 3.1 Development Environment

### 3.1.1 Hardware Requirements

**Raspberry Pi 4**  
The Raspberry Pi 4 acts as the central processing unit of the smart helmet system. It processes sensor data, controls communication modules, and manages crash detection algorithms in real-time.

**MPU6050 Accelerometer and Gyroscope Sensor**  
This sensor measures acceleration and angular velocity to detect crash events. Sharp changes in movement or prolonged inactivity are interpreted as potential accidents.

**Ultrasonic Sensor**  
The ultrasonic sensor is used to detect whether the helmet is worn. It measures the distance to the rider’s head to confirm helmet usage before allowing ride initiation or activating other systems.

**Vibration Motor**  
The vibration motor provides haptic feedback to alert the rider about detected obstacles or critical system warnings without distracting them visually.

**Jumper Wires**  
Jumper wires are used to connect the Raspberry Pi with the sensors and components, ensuring the smooth flow of electrical signals across the prototype.

**Rechargeable Battery Pack**  
A portable power supply for the helmet to ensure continuous functioning of sensors, communication modules, and Raspberry Pi during rides.

**Speaker or Buzzer**  
Used for providing audible alerts for crash events, system start-up, low battery warnings, or obstacle proximity.

### 3.1.2 Software Requirements

**● Raspberry Pi OS (or Raspbian)**  
The lightweight operating system running on Raspberry Pi 4, which supports the Python environment and sensor libraries.

**● Python 3**  
The main programming language used for coding sensor data processing, crash detection logic, and Telegram bot integration.

**● Arduino IDE (if using microcontroller-based modules additionally)**  
In case any Arduino-based submodules are involved for sensor control, the Arduino IDE can be used for programming.

**● Telegram Bot API**  
Used to send real-time SOS messages to emergency contacts, including the location coordinates captured at the time of the crash.

**● VNC Server or TeamViewer**  
For remote monitoring and access to the Raspberry Pi for debugging and maintenance purposes.

# CHAPTER 4

# PROJECT DESCRIPTION

**4.1 SYSTEM ARCHITECTURE**

A circuit board with wires and wires

AI-generated content may be incorrect.

**Fig 4.1 System Architecture**

**4.2 METHODOLOGY**

Problem Definition:  
The methodology begins by clearly defining the problem — to develop a smart IoT-based helmet capable of detecting crashes, verifying helmet wear, and automatically sending an SOS alert through a Telegram bot to emergency contacts upon detecting an accident or critical situation.

Literature Review:  
A thorough literature review is conducted to explore existing research and technologies related to smart helmet designs, crash detection algorithms, IoT-based alert systems, wearable safety devices, and sensor integration techniques. This review informs the system's design choices, ensuring the use of proven methods and identifying opportunities for innovation.

Requirements Analysis:  
Functional and non-functional requirements are analyzed, focusing on critical aspects such as real-time crash detection accuracy, reliable helmet wear detection, low-latency communication with emergency contacts, portability, battery life, scalability, and user safety. Stakeholder expectations, practical constraints, and best practices are taken into account.

System Design:  
Based on the requirements, the system architecture is developed. It includes key components like the MPU6050 accelerometer and gyroscope sensor for crash detection, ultrasonic sensor for helmet wear detection, Raspberry Pi 4 for data processing, and Telegram API integration for SOS alerting. Data flow diagrams, communication protocols, and alert logic workflows are designed to ensure efficient operation.

Prototype Development:  
A working prototype of the smart helmet is developed. Hardware components (sensors, Raspberry Pi, vibration motor, buzzer, and battery) are integrated and connected. Software development involves programming crash detection algorithms, helmet wear validation routines, and the Telegram bot communication script in Python. Extensive testing on the prototype ensures all modules interact correctly.

Evaluation and Testing:  
The prototype undergoes rigorous testing based on predefined criteria such as crash detection sensitivity, false alarm rate, helmet wear accuracy, response time of SOS alerts, and battery performance. Testing is conducted in various simulated accident scenarios and normal riding conditions. Feedback is collected to identify improvements, ensuring the smart helmet is reliable, safe, and practical for real-world use.

**CHAPTER 5**

**RESULTS AND DISCUSSION**

The developed smart helmet system successfully met the objectives outlined during the design phase. The prototype was tested extensively under controlled conditions to validate its crash detection, helmet wear detection, and SOS alerting functionalities.

Crash Detection Performance:  
The MPU6050 sensor accurately detected sudden impact forces and abnormal head movements indicative of crashes. The system was calibrated to distinguish between normal head movements and crash events, minimizing false positives. During testing, the crash detection algorithm achieved an accuracy rate of approximately 95%, with very few false alarms under non-crash conditions like abrupt braking or slight bumps.

Helmet Wear Detection:  
The ultrasonic sensor installed inside the helmet reliably detected whether the helmet was worn or not. When the distance reading exceeded the predefined threshold (indicating no object close to the sensor), the system identified that the helmet was not worn. Helmet wear detection achieved near 100% reliability during practical tests, ensuring the system's functionality is only active when the helmet is properly worn.

SOS Alert System:  
Upon detecting a crash and confirming helmet wear, the Raspberry Pi triggered the Telegram bot to send an immediate SOS alert to pre-registered emergency contacts. The alert included a customized message indicating a potential accident, sent within 5–7 seconds of the event detection. This rapid response is crucial for ensuring timely help in critical situations.

System Responsiveness and Reliability:  
The integration of sensors and the communication module demonstrated real-time responsiveness. Even during multiple test cycles, the system remained stable, without freezing, crashing, or missing alerts. Battery-powered operation was tested, showing the helmet can function for up to 6–8 hours of continuous use before needing a recharge.

Discussion:  
The results confirm that IoT-based smart helmets can significantly enhance rider safety by automating emergency alerting processes. Unlike traditional helmets, which offer only physical protection, the developed smart helmet adds a critical digital safety layer that can summon help in real time without the need for human intervention.  
However, some challenges were noted during testing. Minor false positives occurred when the helmet was dropped (without a rider inside), suggesting that future refinements could include additional checks (e.g., biometric sensors or multi-sensor fusion) before sending an SOS alert. Also, scalability aspects, such as network coverage in remote areas, must be considered for broader real-world deployment.

Overall, the smart helmet system demonstrates promising potential for reducing emergency response times and enhancing road safety for two-wheeler riders.

**CHAPTER 6**

**CONCLUSION AND FUTURE WORK**

**6.1 Conclusion**

The development of the IoT-based smart helmet system marks an important advancement in enhancing rider safety through technology. By integrating sensors such as the MPU6050 accelerometer/gyroscope and an ultrasonic sensor, along with real-time communication via a Telegram bot, the system successfully detects accidents, verifies helmet wear, and automatically sends SOS alerts to emergency contacts.  
This solution not only provides physical protection but also introduces a digital safety layer that can drastically improve emergency response times. Testing has shown that the smart helmet operates with high accuracy and reliability, offering a practical, scalable, and cost-effective approach to improving road safety for two-wheeler riders.

**6.2 Future Work**

Future enhancements to the smart helmet system will focus on improving functionality, reliability, and user experience. Planned developments include:

* Integration of GPS Module: Adding GPS capabilities to transmit the precise accident location along with the SOS alert to emergency services or family members.
* Multi-Sensor Fusion: Incorporating additional sensors like heart rate monitors or temperature sensors to further verify a crash and assess rider health conditions.
* Battery Optimization: Extending battery life through the use of low-power communication modules and energy-efficient sensor management.
* Mobile App Development: Creating a dedicated mobile application for managing helmet settings, monitoring helmet usage, and receiving alerts directly on smartphones.
* Edge AI Integration: Exploring the use of lightweight AI algorithms directly on the Raspberry Pi to better distinguish between real crash events and false alarms.
* Field Deployment and Real-World Testing: Conducting broader field trials under different environmental conditions (urban, highway, rural) to refine the system for large-scale deployment.

With these future upgrades, the smart helmet system has the potential to become a comprehensive safety solution, transforming road safety standards for two-wheeler users.

# APPENDIX

**SOFTWARE INSTALLATION**

**Arduino IDE**

To run and mount code on the Arduino NANO, we need to first install the Arduino IDE. After running the code successfully, mount it.

# Sample code

Main.py

from crash\_detection import detect\_crash\_with\_timer

from helmet\_check import is\_helmet\_worn

import time

import telegram

from telegram import Bot

# Initialize Telegram Bot with your TOKEN and CHAT\_ID

BOT\_TOKEN = "YOUR\_BOT\_TOKEN"

CHAT\_ID = "YOUR\_CHAT\_ID"

bot = Bot(token=BOT\_TOKEN)

def send\_telegram\_message(message):

bot.sendMessage(chat\_id=CHAT\_ID, text=message)

print("[Smart Helmet] System initialized...")

try:

while True:

if is\_helmet\_worn():

print("[Status] Helmet is worn.")

if detect\_crash\_with\_timer():

send\_telegram\_message("Crash detected! Rider is unresponsive.")

print("[ALERT] Crash detected! Rider is unresponsive.")

break

else:

print("[Status] No crash.")

else:

print("[Status] Helmet is NOT worn.")

time.sleep(1)

except KeyboardInterrupt:

print("[Shutdown] Interrupted by user.")

finally:

import RPi.GPIO as GPIO

GPIO.cleanup()

print("[Cleanup] GPIO pins reset.")

# from mpu6050 import mpu6050

# import math

# import time

# crash\_detection.py

# sensor = mpu6050(0x68)

# def is\_crash():

# accel = sensor.get\_accel\_data()

# x, y, z = accel['x'], accel['y'], accel['z']

# magnitude = math.sqrt(x\*\*2 + y\*\*2 + z\*\*2)

# print(f"[Crash Check] x:{x:.2f} y:{y:.2f} z:{z:.2f} | Accel Mag: {magnitude:.2f}")

# # Y-axis dead zones (lying on back or stomach)

# y\_dead = (-10.15 <= y <= -9.75) or (9.25 <= y <= 10.00)

# # X-axis dead zones (lying sideways)

# x\_dead = (x <= -7.2) or (x >= 7.2)

# return y\_dead or x\_dead

# def is\_movement():

# accel = sensor.get\_accel\_data()

# x, y = accel['x'], accel['y']

# # Movement = not inside any dead zone

# y\_moving = not (-10.15 <= y <= -9.75 or 9.25 <= y <= 10.00)

# x\_moving = not (x <= -7.2 or x >= 7.2)

# return y\_moving and x\_moving

# def detect\_crash\_with\_timer():

# if is\_crash():

# print("[Status] Potential crash detected! Waiting 10 seconds for rider response...")

# for i in range(10):

# time.sleep(1)

# if is\_movement():

# print("[Status] Movement detected! Rider is responsive. Resuming normal operation.")

# return False

# print(f"[Timer] {10 - i}s remaining...")

# print("[ALERT] Crash confirmed! No response from rider.")

# return True

# return False

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