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Smart Emergency Helmet for Accident Detection and Alert System Using GPS and GSM

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Abstract: ***Road accidents are a major cause of fatalities, particularly among two-wheeler riders, where delays in emergency response significantly increase the risk of death. This paper presents the design and development of a Smart Emergency Helmet aimed at reducing such delays through automatic accident detection and alert generation. The proposed system integrates an Atmega8 microcontroller with motion sensors, including MPU6050 and ADXL335, to continuously monitor rider movement and detect sudden impacts. Upon detection of an accident, a Neo-6M GPS module retrieves the real-time location, which is then transmitted via a SIM800L GSM module to predefined emergency contacts. The system was tested under multiple drop and impact conditions, achieving an accuracy of approximately 83.33% in detecting accident scenarios. The use of dual sensors enhances reliability and reduces false alerts. The proposed solution demonstrates the potential to significantly improve emergency response time and increase survival chances. Future enhancements may include the integration of artificial intelligence and health monitoring features to further improve system capabilities.***

Keywords: ***Smart Helmet, Accident Detection, GSM Module, GPS Tracking, Road Safety, IoT, Emergency Alert System***

I. INTRODUCTION

Road accidents are a major concern in India, leading to a significant number of fatalities every year. According to reports, the number of people who die due to road accidents in India is estimated to be between 1.68 to 1.73 lakh annually. Data from the SaveLIFE Foundation highlights the seriousness of this issue, while reports from Drishti IAS indicate that approximately 474 people lose their lives every day, which translates to nearly one death every three minutes. Furthermore, data from the Ministry of Road Transport and Highways shows that around 70,000 to 75,000 of these deaths involve two-wheeler riders. Nearly 40% to 45% of total road accidents are related to motorcycles, which accounts for approximately 190 to 200 accidents per day. This clearly indicates that two-wheeler riders are among the most vulnerable groups on the road. One of the major reasons for these fatalities is the delay in providing medical assistance. Reports suggest that nearly 50% of accident casualties occur due to delayed help reaching the victims. Additionally, around 30% of victims lose their lives before reaching the hospital, and only about 20% receive medical treatment within the critical “golden hour,” which is crucial for survival. The major reasons for these delays include the inability to determine the exact location of the accident, lack of timely communication with emergency authorities, and poor transportation and road conditions. In many situations, authorities are not informed quickly, which significantly increases response time and reduces the chances of saving lives.

A. Existing Solutions

There are several existing solutions aimed at improving road safety and reducing accident-related fatalities. Traditional helmets are widely used to provide physical protection to riders; however, they lack any smart or automated features for emergency response. Mobile-based emergency applications, such as accident detection apps and SOS services, can send alerts and share location details, but their effectiveness depends on user interaction or the proper functioning of the smartphone during an accident.

Additionally, modern motorcycles are equipped with safety features such as Anti-lock Braking Systems (ABS), which help in preventing accidents but do not provide any assistance after an accident has occurred. Manual reporting systems, where bystanders inform authorities, are still commonly relied upon, but they often lead to delays. GPS tracking devices are also used to monitor location, but they are limited to tracking and do not detect accidents or initiate emergency alerts automatically.

Despite the availability of these solutions, there are several limitations that reduce their effectiveness in real-world scenarios. Traditional helmets, although essential for safety, do not include any smart features or automated alert systems. Mobile-based emergency applications rely heavily on user interaction or the proper functioning of the smartphone, and they may fail in situations where the device is damaged or lacks network connectivity. Furthermore, manual reporting methods are not reliable, as they depend on the presence and responsiveness of nearby individuals, which can lead to significant delays in emergency response.

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B. Objectives

The objective of this project is to design and develop a smart emergency helmet system that can operate independently without requiring any external intervention from the victim or a third person. The system aims to automatically detect accidents and send alert messages, along with location details, to family members and emergency authorities. By enabling immediate communication, the proposed system seeks to reduce delays in providing medical assistance and improve the chances of saving lives.

C. Proposed System

To overcome the limitations of existing systems, this paper proposes a "Smart Emergency Helmet" designed to provide immediate assistance in case of accidents. The proposed system integrates sensors for automatic accident detection, along with a GPS module to accurately determine the location of the incident. A GSM module is used to send alert messages to predefined emergency contacts, ensuring timely communication. The system operates automatically without requiring any human intervention, thereby reducing delays and improving the chances of providing quick medical assistance to accident victims.

D. Comparative Analysis of the Proposed System

To understand the effectiveness of the proposed system, a comparison is made with existing solutions such as traditional helmets, mobile-based applications, and GPS tracking devices. The comparison is based on key parameters like accident detection, dependency on user action, response time, and reliability.

Feature	Traditional Helmet	Mobile-Based Apps	GPS Tracking Devices	Proposed Smart Emergency Helmet
Accident Detection	NO	Partial	NO	YES
Human Dependency	HIGH	MEDIUM	MEDIUM	NONE
Real-time Alert	NO	Depends on User/App	LIMITED	YES
Works After Crash	NO	NOT RELIABLE	NO	YES
Location Sharing	NO	YES	YES	YES
Response Time	SLOW	MODERATE	MODERATE	FAST
Reliability	LOW	MEDIUM	MEDIUM	HIGH

From the comparison, it can be observed that the proposed Smart Emergency Helmet overcomes many limitations of existing solutions. It provides automatic accident detection, reduces dependency on external factors, and ensures faster communication during emergency situations.

For better comparison, each system is evaluated based on the number of important features it supports, such as accident detection, real-time alert, location sharing, reliability, and reduced human dependency. The values shown in the graph represent the total number of these features available in each system.

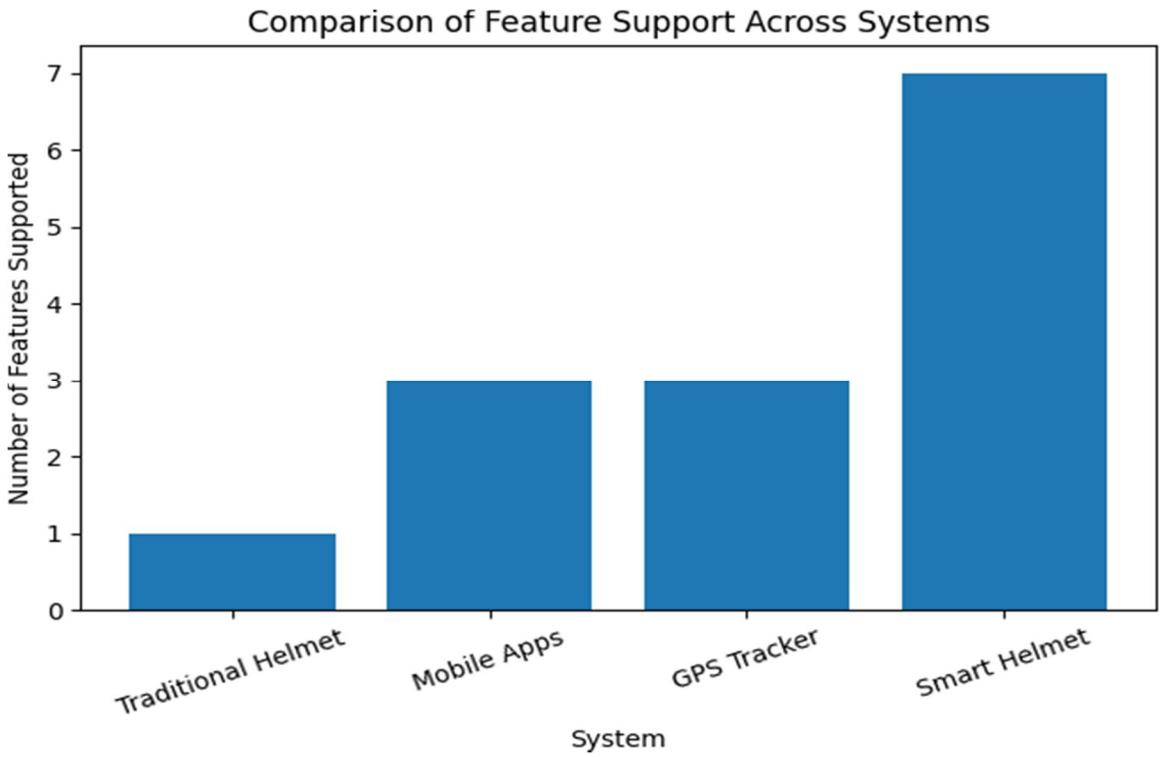


Figure 1: Comparison of Feature Support Across Different Systems

The graphical representation shows that the proposed Smart Emergency Helmet supports more important features compared to existing solutions, making it more effective and reliable in emergency situations.

II. WORKING PRINCIPLE

The proposed system consists of several hardware components that work together, including a microcontroller, sensors, communication modules, and a power supply unit, all integrated into the helmet design.

A. Component's Used:

The components used in the proposed system are as follows:

1) Atmega8 Microcontroller: The Atmega8 microcontroller acts as the central processing unit of the system. It is an 8-bit AVR processor operating at 5V with a clock frequency of 16 MHz. The microcontroller processes data received from various sensors and manages the operation of the GPS and GSM modules. It continuously collects and analyzes motion data from the MPU6050 and ADXL335 sensors to detect sudden impacts that may indicate an accident. Upon detecting such an event, it activates the GPS module to obtain the real-time location of the rider and communicates this information to predefined contacts through the GSM module.

2) MPU6050: The MPU6050 is a 6-axis motion sensing device that combines a 3-axis accelerometer and a 3-axis gyroscope. It is capable of measuring both linear acceleration and angular velocity, enabling precise motion detection. In the proposed system, the sensor continuously monitors the movement of the rider. When the sensor readings exceed predefined threshold values, it indicates a potential accident. The microcontroller then verifies this event and triggers the GPS module to obtain the real-time location for further communication.

3) ADXL: The ADXL335 is a compact and low-power 3-axis analog accelerometer that measures both static and dynamic acceleration along the X, Y, and Z axes. In the proposed system, it is used to detect sudden impacts, shocks, or abrupt changes in velocity that may occur during an accident. When the measured acceleration exceeds a predefined threshold, it sends a signal to the microcontroller to assist in confirming the accident event. Additionally, the use of this sensor alongside the MPU6050 improves system reliability and helps reduce false alerts.

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4) Sim800L: The SIM800L GSM module enables wireless communication using SMS or call services over a standard 2G mobile network. It is capable of both transmitting and receiving data, making it suitable for emergency alert systems. In the proposed system, once an accident is confirmed, the microcontroller sends commands to the GSM module, which immediately transmits an alert message to predefined contacts. The message typically includes a notification such as "Accident detected" along with the real-time GPS coordinates obtained from the Neo-6M module, ensuring timely communication for emergency assistance.

5) NEO6: The Neo-6M GPS module is a highly sensitive and efficient device used to determine real-time geographic location through satellite communication. It operates within a voltage range of 3V to 5V and provides accurate positioning data in the form of latitude and longitude coordinates. In the proposed system, the GPS module is activated by the microcontroller immediately after an accident is detected. It retrieves the current location of the rider, which is then transmitted to predefined contacts through the GSM module for quick emergency response.

6) Li-ion Battery: The Li-ion battery is a lightweight and high energy density power source widely used in portable electronic devices. In the proposed system, it serves as the main power supply for all the components integrated into the helmet. The battery provides energy to the voltage regulator, which then ensures a stable and appropriate power distribution to all system components.

7) Voltage regulator: A voltage regulator is used to ensure a stable and safe power supply to all electronic components in the system. Common regulator ICs such as LM7805 or AMS1117 are utilized for this purpose. It converts the varying output voltage from the battery into a constant and regulated voltage suitable for the components. This helps maintain consistent system performance and protects sensitive devices such as sensors, the microcontroller, and communication modules from potential overvoltage damage.

B. Working Principle:

The proposed Smart Emergency Helmet is designed to detect accidents using impact sensing technology. The system utilizes the MPU6050 sensor (accelerometer and gyroscope) along with the ADXL335 analog accelerometer to continuously monitor the motion and impact experienced by the rider. The collected data is processed by the Atmega8 microcontroller, which analyses the sensor readings in real time. When the system detects sudden or abnormal changes in motion that exceed predefined threshold values, it identifies the occurrence of a potential accident.

Once an accident is detected, the Atmega8 microcontroller immediately communicates with the Neo-6M GPS module to obtain the current location of the rider. The retrieved location details, including latitude and longitude, are then transmitted along with an automated emergency message through the SIM800L GSM module to predefined contact numbers.

All components in the system are powered by a Li-ion battery, with the voltage being regulated by a voltage regulator to ensure stable operation. This integrated system provides real-time accident alerts, enabling faster response from emergency services and family members, thereby increasing the chances of saving lives.

C. Circuit Diagram:

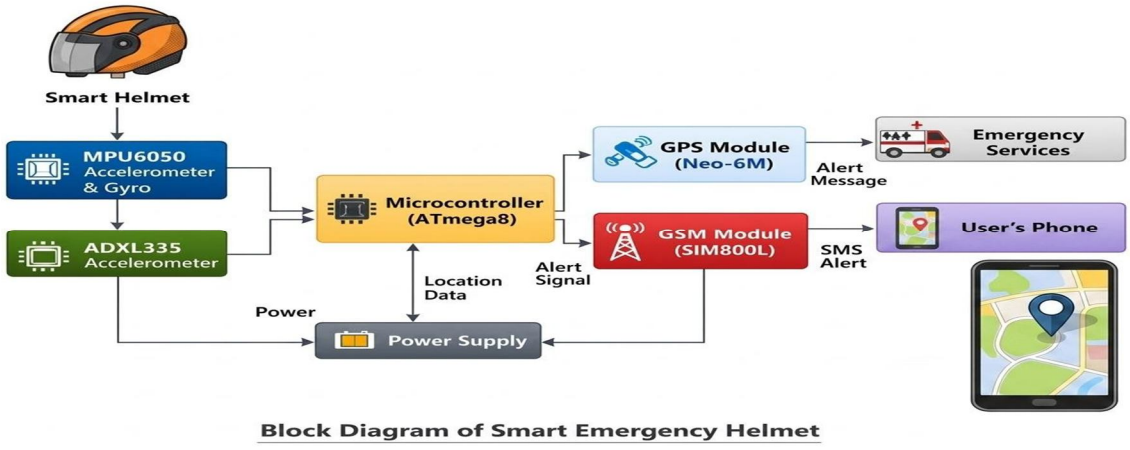


Figure 2: Circuit Diagram

III. RESULTS AND DISCUSSION

To evaluate the performance of the proposed system, a series of drop and impact tests were conducted under different conditions. A total of 18 test cases were performed to simulate real-world accident scenarios. Out of these, the system successfully detected accidents and generated alerts in 15 cases. Based on these observations, the system achieved an accuracy of approximately 83.33%.
The use of dual sensors, namely MPU6050 and ADXL335, enhanced detection reliability by reducing false positives and enabling better validation of accident events. However, in a few cases, the system failed to detect impacts accurately, which may be attributed to variations in threshold settings or sensor sensitivity. Furthercalibration and optimization of these parameters can improve the overall performance and accuracy of the system.

IV. CONCLUSION

1) The Smart Emergency Helmet project is developed to address the increasing number of casualties caused by rising motorcycle accident rates. This system effectively integrates safety and technology into a practical solution aimed at improving emergency response. It is capable of automatically detecting accidents using motion sensors and communicating the incident details to healthcare authorities and predefined contacts through a microcontroller-based system.

2) The developed prototype demonstrates good accuracy and operational efficiency, significantly reducing response time and increasing the chances of saving lives. The results indicate that such a system can play a vital role in enhancing road safety for two-wheeler riders.

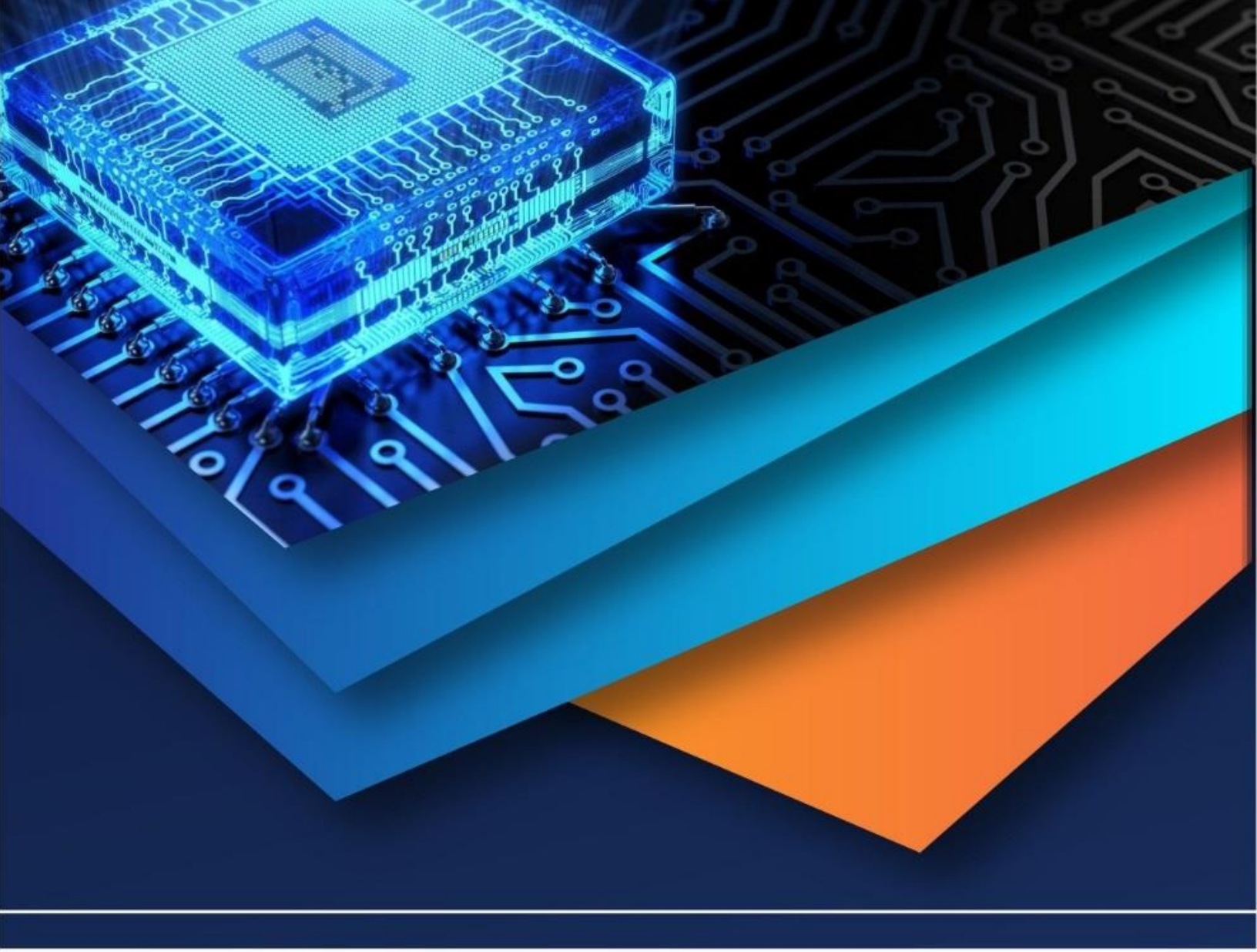
3) In the future, the system can be further enhanced by integrating artificial intelligence to detect risky riding patterns and predict potential accidents. Additionally, incorporating health monitoring features within the helmet could provide early warnings for medical emergencies. These advancements can transform the helmet into an intelligent personal safety device with broader applications.

V. ACKNOWLEDGEMENT

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