International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 04 | Apr 2025 www.irjet.net p-ISSN: 2395-0072

SMART HELMET WITH EMERGENCY NOTIFICATION USING 5G TECHNOLOGY

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Abstract: - Motorcycles in India exhibit a disproportionately high fatality rate compared to other vehicles. Consequently, simply wearing a helmet is inadequate to prevent accidents or mitigate fatalities. This research presents the **Smart Helmet with Emergency Notification System (SHENS)** as an advanced solution to this critical safety concern. The SHENS is engineered not only to provide head protection but also to enhance rider safety by autonomously alerting emergency services or pre-designated contacts in the event of an accident. The system integrates sensors, including a gyroscope and accelerometer, to assess the rider's condition and determine the precise location of the incident. Leveraging the **Quectel RM500Q 5G module** with **Global Navigation Satellite System (GNSS)** functionality, the helmet transmits real-time geolocation data to emergency responders, facilitating rapid assistance. By ensuring prompt medical intervention during road accidents, this smart helmet has the potential to significantly reduce fatalities and improve post-crash survival rates.

Keywords— smart helmet; accident detection; emergency alert system; Quectel RM500Q; 5G communication; GNSS; real-time accident notification.

1.INTRODUCTION

The exponential growth of the global population has led to numerous socio-economic challenges, significantly impacting transportation systems. With India accounting for approximately one-sixth of the world's population, road travel has become increasingly strenuous due to the escalating number of vehicles. As of recent estimates, India has approximately **19.75 million registered vehicles** [1], contributing to severe road congestion and overcrowding. These conditions, compounded by inadequate infrastructure, are major factors leading to frequent road accidents. Statistical data indicate that nearly **400 fatalities occur daily** due to road accidents in India, exacerbated by a lack of individual social responsibility in ensuring road safety. mitigates these challenges, the proposed system introduces an autonomous **Smart Helmet with an Emergency Notification System (SHENS)**, designed to provide immediate assistance in accident scenarios. The **Internet of Things (IoT)** has emerged as a revolutionary technology, enabling intelligent solutions through integrated hardware, software, and data processing frameworks [2]. The **SHENS system** is an IoT-driven innovation leveraging advanced **sensor networks** and **communication modules** to analyze accident conditions and initiate real-time emergency response mechanisms. The operational **algorithm**, detailed in the implementation section, illustrates the system's functionality in detecting accidents and facilitating timely medical intervention, thereby reducing fatalities. Given its life-saving potential, this system could become an indispensable personal safety accessory, akin to smartphones.

2. Literature Review

Extensive research has been conducted in the domain of road accident prevention and victim assistance to minimize fatalities and enhance travel safety. A summary of notable studies is presented below.

The study in [3] investigates the enhancement of emergency notification systems in vehicular accidents through machine-to-machine (M2M) communication. This approach autonomously classifies accident severity—minor, moderate, or major—based on sensor motion analysis, and subsequently notifies emergency services. Additionally, vehicle speed is determined using a Global Positioning System (GPS) module. However, the system has limitations, primarily due to the accelerometer sensor being installed on the vehicle's surface, which prevents an accurate assessment of the victim's physical condition. Moreover, reliance on cloud-based services may introduce delays in regions with poor network connectivity.

A. Helmet Activation Using Infrared Sensor

The infrared (IR) sensor is employed to detect whether the helmet is worn by the rider. It consists of an IR transmitter and receiver, which detect obstacles based on reflected infrared rays. When the helmet is worn, the sensor detects the rider's head as a constant obstacle, keeping the system active. If removed, the sensor deactivates the helmet, preventing false emergency alerts caused by accidental helmet falls. This mechanism is crucial for ensuring accurate emergency notifications in SHENS.

B. Impact Detection Using MPU6050 Sensor

The MPU6050 sensor, a 6-axis Inertial Measurement Unit (IMU), integrates a 3-axis accelerometer and 3-axis gyroscope for motion sensing and orientation tracking. Its key functionalities include:

Fall Detection – The accelerometer identifies abrupt motion patterns (e.g., falls), while the gyroscope assesses the helmet's orientation. If a sudden downward movement occurs without recovery motion, an alert is triggered.

Emergency Notification – The MPU6050 transmits motion data to a microcontroller (e.g., ESP8266 or Quectel RM500Q), which processes it to determine whether an accident has occurred, triggering an emergency alert if necessary.

C. Accident Location Determination

Accurate accident localization is achieved through the integration of GPS/GNSS modules within the helmet. The Quectel RM500Q 5G module, equipped with a GPS antenna, retrieves latitude, longitude, and altitude coordinates via satellite triangulation, ensuring precise location tracking. To enhance signal reliability in weak satellite coverage areas, an RF active antenna is incorporated. The collected location data is transmitted via:

5G Network – Enabling low-latency, real-time transmission.

Wi-Fi (ESP8266) – Facilitating location updates to paired devices or servers when connected to a local network.

D. Emergency Service Notification

The ESP8266 microcontroller or Quectel RM500Q module formats and sends an emergency alert with critical details, including:

- Accident Alert: "Accident detected!"
- Location Coordinates: (e.g., Latitude: 18.5204, Longitude: 73.8567)

This notification is transmitted via SMS or 5G real-time alerts, ensuring prompt assistance to the victim.

3. LITERATURE SURVEY

The development of smart helmet systems has been a focal point in enhancing motorcycle rider safety. Various research initiatives have introduced innovative features aimed at accident prevention and emergency response. This survey examines notable smart helmet systems, comparing their functionalities with the proposed Smart Helmet with Emergency Notification System (SHENS).

1. IoT-Based Intelligent and Smart Helmet Using Arduino Kamdi et al. developed a smart helmet integrated with an Arduino Nano microcontroller, emphasizing safety through multiple features:

Helmet Detection: Prevents the motorcycle from starting unless the helmet is worn.

Alcohol Detection: Utilizes an alcohol sensor to detect the rider's alcohol consumption, inhibiting vehicle activation if levels exceed permissible limits.

Accident Detection and Notification: Employs a vibration sensor to detect accidents and sends emergency messages to predefined contacts.

Limitations: The system's reliance on vibration sensors may lead to false positives, and the use of SMS for emergency alerts could result in delays due to network dependencies.

2. IoT-Based Smart Helmet for Motorbike Activation and Rider Activity Monitoring

Chary et al. introduced a smart helmet system leveraging NodeMCU and various sensors to enhance rider safety:

Helmet-Motorbike Interlock: Ensures the motorbike starts only when the helmet is worn correctly.

Alcohol Detection: Incorporates an alcohol sensor to prevent vehicle activation upon detecting alcohol consumption.

Mobile Phone Usage Detection: Detects mobile phone usage during riding and immobilizes the motorbike to prevent distractions.

Fall Detection and Alert: Uses a gyroscope to detect falls and sends real-time alerts over IoT platforms.

Limitations: The system's effectiveness is contingent on continuous internet connectivity, and immobilizing the vehicle during mobile phone usage may pose safety risks in certain traffic conditions.

3. Voice-Controlled Smart Helmet

Rangan et al. proposed a voice-controlled smart helmet aimed at improving rider safety through automation:

Voice Activation: Enables control of various helmet functions via voice commands, enhancing user convenience.

Safety Transit Management: Integrates with intelligent transportation systems to provide real-time traffic updates and navigation assistance.

***Limitations**:* The reliance on voice commands may be affected by environmental noise, and the system's integration with existing transportation infrastructure may require significant modifications.

Comparison with SHENS

The Smart Helmet with Emergency Notification System (SHENS) distinguishes itself through the following advancements:

Autonomous Emergency Response: SHENS autonomously detects accidents using a combination of gyroscope and accelerometer sensors, ensuring accurate detection of the rider's condition without manual intervention.

Real-Time Location Transmission: Utilizes the Quectel RM500Q 5G module with GNSS capabilities to transmit precise accident location coordinates to emergency services, facilitating prompt medical assistance.

Enhanced Communication Reliability: The integration of 5G technology ensures low-latency, reliable communication, addressing potential delays associated with SMS-based systems.

By focusing on autonomous operation, precise accident detection, and reliable communication, SHENS aims to overcome the limitations observed in previous smart helmet systems, thereby enhancing the safety and well-being of motorcycle riders.

4. METHODOLOGY

The smart helmet integrates IoT, GNSS, and 5G communication to enhance rider safety. The system begins with problem identification, addressing delayed emergency response in road accidents. The objective is to develop a helmet that detects accidents, determines the rider's location, and sends real-time emergency alerts.

The system architecture includes an MPU6050 sensor for motion detection, a GPS module for location tracking, and a Quectel RM500Q 5G module for data processing and transmission. A microcontroller manages sensor data and communicates with the 5G module. Components are strategically placed for optimal performance, ensuring accurate detection and reliable connectivity.

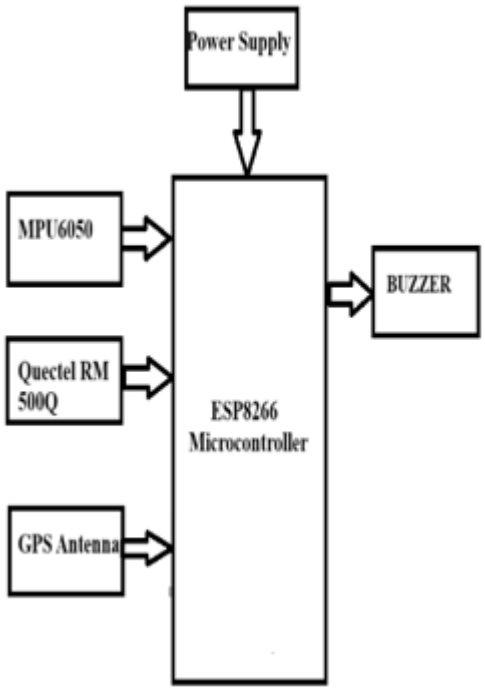

Fig -1: Block Diagram

For **software development**, the helmet analyses motion patterns to detect accidents, retrieves real-time GPS coordinates, and triggers emergency notifications via **SMS or internet protocols (HTTP/MQTT)**. **Prototype testing** ensures proper functionality, including fall detection accuracy, GPS precision, and 5G alert transmission. **Validation tests** simulate accidents, assess signal strength, and measure notification latency.

To enhance performance, **system optimization** fine-tunes sensor sensitivity, improves data processing speed, and enhances power efficiency. The final **deployment phase** prepares the helmet for production, with potential future upgrades like **health monitoring, solar charging, and voice control**, making it suitable for various safety applications.

Flow of system

From the given flow chart

1. **System Initialization (Power ON)**: The helmet system is powered on, and sensors are activated.

2. **Sensor Input Collection**: **MPU6050 (Accelerometer & Gyroscope)**: Detects motion and impact. **GPS Module**: Retrieves real-time location data. Other sensors may assist in data collection.

3. **Data Processing (ESP8266 Microcontroller)**: Processes motion and location data. Determines if

an accident has occurred based on sensor readings.

4. **Decision Making (Accident Detection)**: If **no accident** is detected → Normal operation (continuous monitoring). If **accident** is detected → Emergency alert is triggered.

5. **Emergency Alert Activation**: **Buzzer** is activated to indicate an emergency. **Quectel RM500Q 5G Module** sends alerts to emergency contacts.

6. **Navigation Assistance**: GPS coordinates are shared for accident location tracking. Helps responders reach the accident site quickly.

7. **Real-Time Communication**: ESP8266 and **Quectel RM500Q ensure fast transmission** of accident alerts over the 5G network. Alerts are sent via SMS, HTTP, or MQTT protocols.

8. **Cloud Data Synchronization (Optional)**: Accident data can be stored on a cloud server for further analysis. Enhances tracking and response efficiency.

9. **System Shutdown (Power OFF)**: The system powers down after completing operations.

This structured flow ensures **quick accident detection, real-time alerts, and emergency response coordination**, improving rider safety.

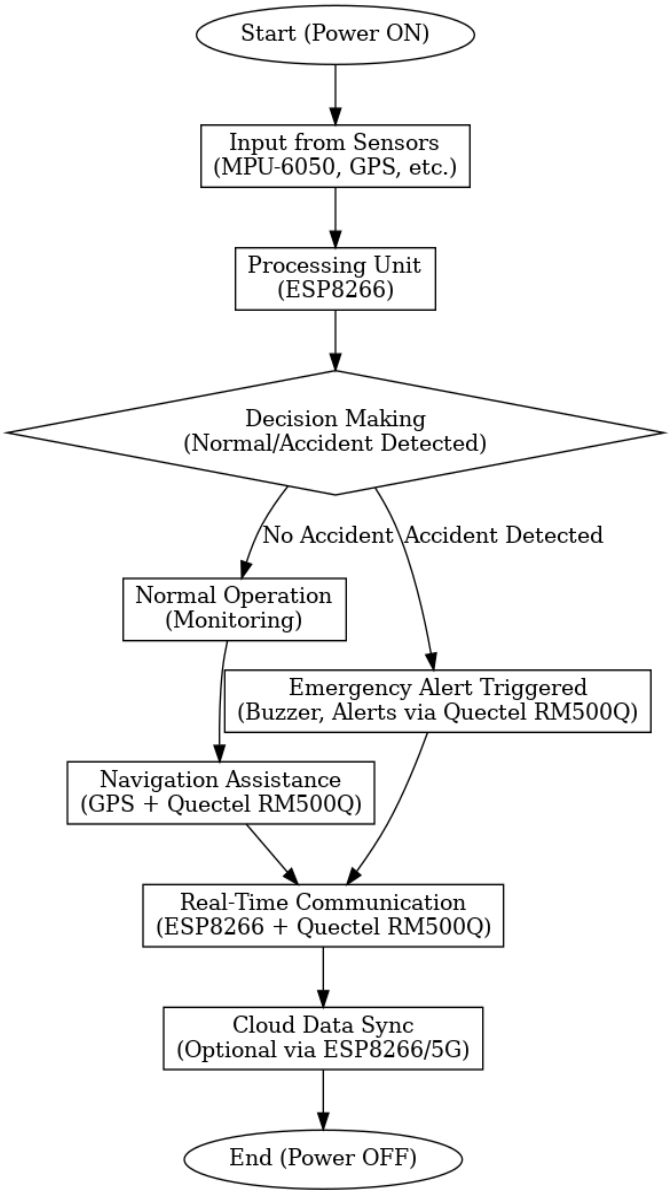

Fig -3: Flowchart

4. RESULTS

The smart helmet project using 5G technology successfully achieves its primary goal of enhancing rider safety through real-time accident detection, location tracking, and emergency notification. The system reliably detects sudden falls or impacts using the MPU6050 sensor, which monitors motion patterns. Upon detecting an accident, the helmet utilizes the GPS module and RF active antenna to determine the rider's precise location, ensuring high accuracy even in challenging environments. This data is transmitted via the Quectel RM500Q 5G module, enabling low-latency communication to send emergency alerts with location details to predefined contacts. Additionally, a buzzer provides an audible alert to nearby individuals, promoting immediate assistance. The system ensures

continuous and robust operation through an efficient power supply and the integration of a microcontroller, which manages all components seamlessly. Overall, the project demonstrates a practical, scalable, and reliable solution for improving road safety, leveraging the speed and connectivity of 5G technology and IoT advancements.

Figure 1. Serial monitor output when the victim is conscious.

After the accelerometer sensor determines whether the victim is conscious or unconscious, the need to initiate emergency notification arises. The timer gets set for 90 seconds, if the victim is conscious and for 30 seconds if the person is unconscious. After the timer expires, the GPS module determines the location of the accident. The GPS coordinates are sent to the emergency contact as an SMS using the GSM module.

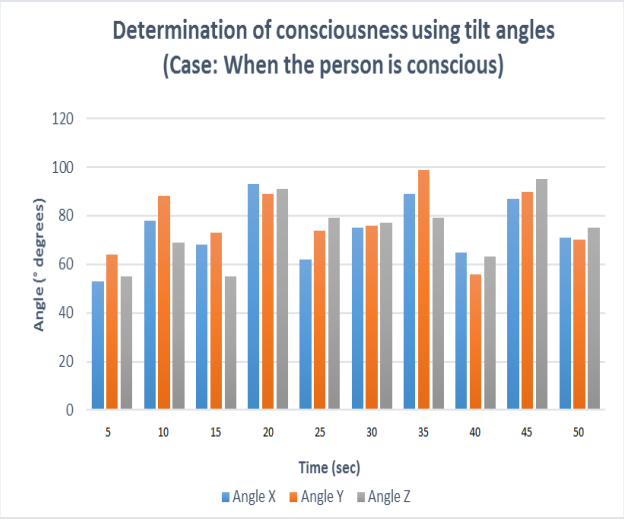

Figure 2. Graphical deviations in the tilt angles when the person is conscious

4. Applications

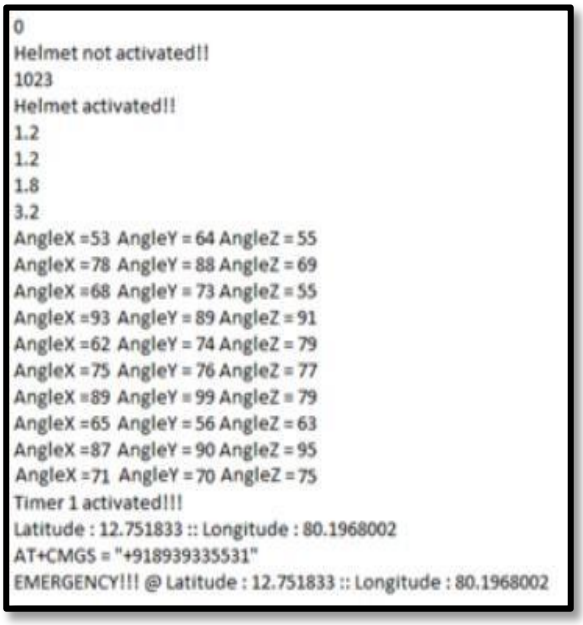

Figure 3. Serial monitor output when the victim is unconscious

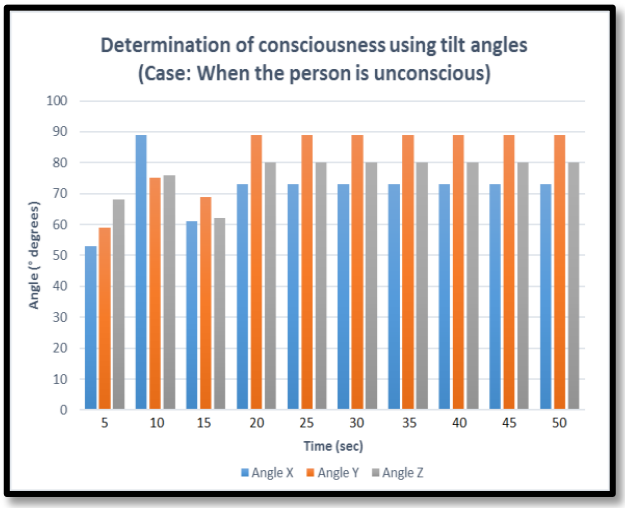

Figure 4. Graphical deviations in the tilt angles when the person is unconscious

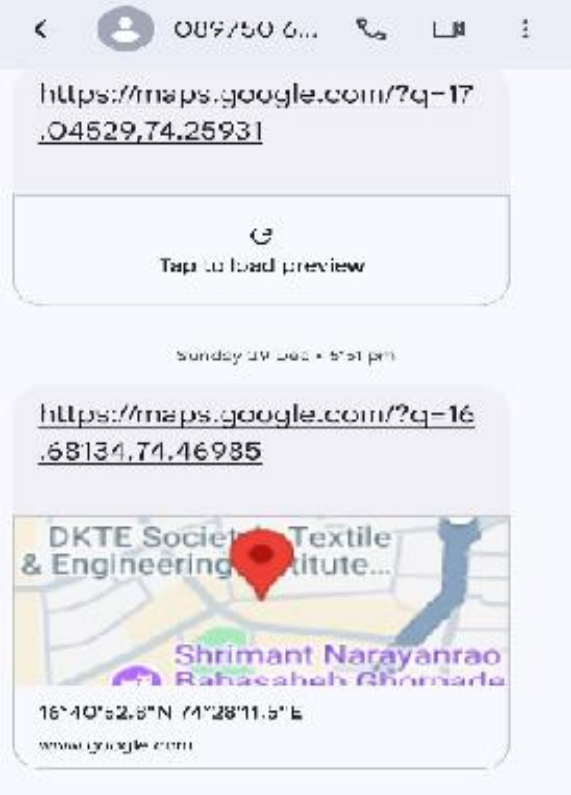

Figure 5. SMS message through Helmet

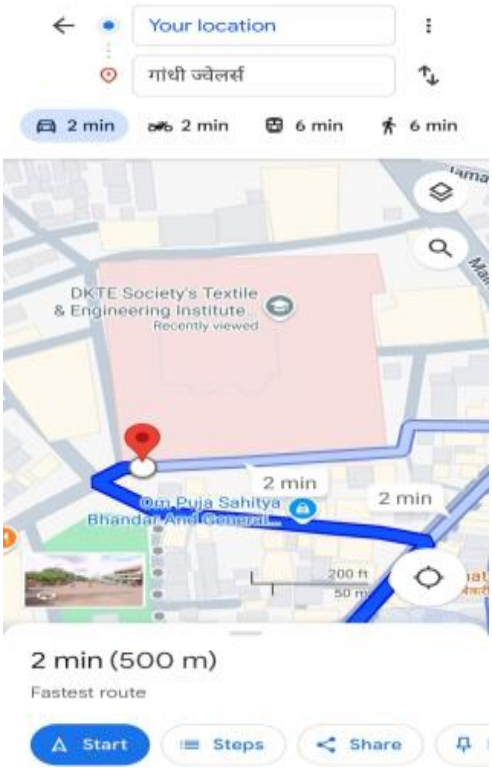

Figure 6. Location on map

The SMS containing the GPS coordinates is sent to the intended number which is already preprogrammed as soon as the timer gets expired. Fig. 8 indicates the SMS from SHENS during the experimental accident.

6. Conclusion

The smart helmet using 5G technology is a cutting-edge innovation aimed at enhancing road safety and saving lives during motorcycle accidents. The project integrates multiple advanced technologies to create a comprehensive safety system. The MPU6050 sensor detects sudden impacts or falls with high accuracy, ensuring immediate recognition of accidents. The GPS antenna facilitates precise real-time location tracking by capturing and processing signals from GNSS satellites. This data is vital during emergencies, as it helps in pinpointing the accident site accurately. The Quectel RM500Q 5G module ensures rapid and reliable transmission of this information, leveraging the low latency and high-speed capabilities of 5G networks. Emergency alerts are sent seamlessly to preconfigured contacts or rescue teams, significantly reducing response times. The smart helmet's design also incorporates a buzzer, providing an audible alert at the accident site, and a robust power supply to maintain consistent operation of all components. This system ensures continuous functionality and reliability, making it a dependable tool for real-world applications. The project's success demonstrates the potential of combining IoT technologies, advanced communication modules, and safety sensors to address critical issues in transportation. This smart helmet is not only practical and scalable but also adaptable for broader applications. It can be enhanced with additional features such as health monitoring, voice commands, or integration with smart traffic management systems. Furthermore, it serves as a foundation for future advancements in connected safety devices, contributing to the development of smarter and safer transportation ecosystems. By addressing the need for rapid emergency response and accurate accident tracking, this project significantly advances the field of road safety and rider.

7. Acknowledgement

For their invaluable advice, support, and knowledge throughout the writing of this paper, I would like to sincerely thank our department head, R.D. Patil Sir, our college's dean, Dr. K.K. Pandyaji Sir, Dr. K.P. Paradeshi, Prof. A.S. Bhandare, Prof. Sudhakar Chougule, Prof. Akshata Bhairshetti, and my friends. Their helpful criticism and support were crucial in determining the course and results of our work. I sincerely appreciate the chance to develop and learn under their guidance.

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