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ResQRide: Intelligent Crash Detection & Emergency Alert System

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LCD, LED, GSM, Internet of Things (IoT), Sensor Systems.

ABSTRACT

In high-risk environments such as construction sites, industrial plants, and roadways, timely medical assistance following an accident is critical to improving survival outcomes. This paper presents an intelligent crash detection and emergency alert system designed to enhance personal safety through real-time monitoring and rapid communication. The system is implemented via a smart helmet built around an Arduino Nano microcontroller, integrating key components such as an accelerometer or vibration sensor for impact detection, a GPS module for location tracking, and a GSM module for sending emergency alerts. Upon detecting a crash or fall, the system automatically transmits an SMS containing the GPS coordinates of the incident to a predefined emergency contact. An onboard LCD displays status or impact severity, while visual and audio indicators such as LEDs and buzzers provide immediate on-site alerts. This solution is adaptable for both two-wheeler riders and industrial workers, bridging the gap between conventional personal protective equipment and modern safety technologies. By significantly reducing emergency response times, the smart helmet system contributes to increased survival rates and workplace safety.

1. INTRODUCTION

There are numerous individuals who have tried to find a replacement for human work and efforts with new advancements in embedded design technology as technology for robots has improved and become an essential part of our lives, particularly when people risk their lives in fire hazards. This enables robots to function to the best of their abilities and comprehend complicated and challenging conditions in the wake of a disaster, but it would be labor-intensive for the robots to prevent fire threats rather than react to their occurrence. Cities and large towns are required to have manufacturing systems,

and this robot has been designed to work in the challenging topographical conditions found there. There are gas and smoke detectors, both of which are typically simple and affordable fire detection solutions. Recent modifications include fire extinguishing spread and flame sensors. This module makes use of wireless sensor structures with IR sensors to detect impediments and move in response to them. Robotics has reduced human intrusion, and they are now frequently utilized for safety purposes. Fire errors have become common in everyday situations and can occasionally create hazards that make it difficult for the firemen to preserve human life. To prevent fire accidents, the firefighting robot is used to protect people's lives, property, and environment. Here, we use two robotic operation modes. It is a robot that battles fire or gas that can be used to either protect our homes, businesses, and other buildings from fire or hazardous gasses. The research's unique and fresh idea is that, while no one is home or at work, our robot is going to move towards a suffocating fire or hazardous gasses in our houses or in buildings housing other companies. This robot will use an infrared sensor gas sensor MQ6 to determine the presence of fire. When it has done so, it will use water pump to extinguish the fire it has found before sending a signal to an IOT server.

To address the significant safety risks faced by field engineers and laborers in hazardous environments, our work proposes an intelligent safety helmet. The key challenge is developing a system that can detect and alert workers to hazards like gas leaks, falling objects, and impact forces in real-time. By integrating connected safety features, the helmet enhances situational awareness and enables a coordinated response, ensuring better protection in construction sites, mines, and industrial plants.

This work aims to develop a real-time, intelligent accident detection and alert system integrated into a two-wheeler helmet to enhance rider safety through automated emergency communication. Centered on sensor fusion, GPS tracking, and GSM messaging, the Smart Helmet is designed for cost-effectiveness, low power consumption, modularity, and independence from smartphones—making it ideal for Indian roads and resource-limited settings. Using an Arduino UNO, the system integrates a vibration sensor, NEO-6M GPS, and SIM800A GSM module to detect collisions via a threshold-based algorithm, minimizing false alarms from minor bumps. Upon crash detection, it automatically sends the rider's GPS location via SMS to emergency contacts, supported by an I2C LCD for real-time feedback. The system emphasizes power efficiency for prolonged battery use, and where needed, Verilog HDL is used for custom interfacing. Performance is validated through metrics like response time, sensitivity, and power usage, and the prototype's scalability is demonstrated across varied environments. Ultimately, this work delivers a practical, low-cost, and life-saving smart helmet solution contributing to intelligent transport systems and road safety.

2. LITERATURE REVIEW

[1] This paper introduces a multifunctional helmet equipped with alcohol detection, accident alert, and ignition control features. The system integrates various sensors with a GSM module to alert emergency contacts during a crash. Its modular design and affordable implementation make it suitable for Indian traffic conditions. The study laid the groundwork for helmet-based safety systems targeting accident prevention and post-accident response

[2] The authors developed a basic accident alert system using vibration sensors for crash detection and GPS-GSM modules for alerting emergency contacts. The system sends real-time location data via SMS, reducing response time during accidents. This work highlights the effectiveness of using GSM technology for rapid communication. The simplicity and reliability of the approach inspired similar safety systems for two-wheelers.

[3] This research integrates IoT modules in a smart helmet to detect accidents and immediately alert rescue services. It includes a vibration sensor, GPS, and GSM system, controlled by a microcontroller for real-time operation. The paper emphasizes cloud connectivity for accident data logging and analysis. This work reinforces the role of IoT in modern safety equipment for motorcycles.

[4] This IEEE paper focuses on an accelerometer-based helmet that captures abnormal movements indicating a crash. The GPS module then determines the exact location, and the GSM module transmits this data. The study analyzed accident force thresholds to reduce false alerts. It contributes significantly to improving accident detection accuracy using motion data.

[5] The paper presents a helmet with a GSM-GPS-based emergency alert system triggered by a vibration sensor. It also considers helmet-wearing detection for engine ignition, promoting responsible riding. The real-time crash alert system enhances road safety by enabling quick emergency response. The research validates the effectiveness of sensor integration in wearables.

[6] This work presents a complete embedded system using Arduino, vibration sensor, and GSM module for accident detection. The design focuses on minimizing false triggers using a threshold-based logic. GPS coordinates are automatically shared upon impact, helping nearby hospitals or police respond faster. This paper demonstrates a low-cost yet effective life-saving mechanism.

[7] The authors propose a helmet that includes alcohol detection, crash detection, and engine control modules. It incorporates multiple sensors interfaced through a microcontroller to ensure rider safety and rule compliance. The alcohol detection prevents vehicle ignition when intoxication is sensed. This multi-layered design is highly practical for Indian road safety challenges.

[8] The study introduces a smart helmet capable of real-time crash monitoring and location tracking using MEMS accelerometers. It measures shock levels during impact and sends alerts via GSM. The system also integrates emergency calling and live tracking. The research addresses latency issues in message delivery and proposes a reliable solution for fast communication.

[9] This paper details a helmet design that uses IoT services for crash data storage and reporting. Real-time alerts and GPS tracking are pushed to a cloud server, enabling remote monitoring by family or emergency services. The system enhances transparency and record-keeping in accident-prone zones. The work emphasizes the future potential of cloud-integrated smart helmets.

[10] This work uses Arduino UNO, vibration sensors, and GSM-GPS modules to build a budget-friendly crash alert system. It prioritizes simplicity and accessibility for rural riders. The Arduino platform allows easy integration with other safety features. The paper's design was instrumental in developing the control logic for Smart Helmet.

[11] This official source outlines India's road safety statistics and the government's vision for reducing accidents. It emphasizes the importance of wearable safety devices in saving lives, especially in two-wheeler crashes. Reports support that accident response within 10 minutes increases survival chances by 40%. It validates the necessity of smart helmet systems.

[12] The datasheet provides vital information about the GPS module's accuracy (2.5 m CEP), startup time, and baud rate configurations. It supports real-time location tracking essential for accident alerts. This technical reference informed hardware selection and configuration strategy. The NEO-6M's low power and high accuracy make it ideal for helmet system.

[13] This document covers the GSM module's AT command structure, voltage range, message formats, and interfacing techniques. It was critical in developing the SMS alert functionality. It also discusses network latency and optimizations for mobile networks. This guide was used for coding the GSM- related functions of Smart Helmet.

[14] These textbook outlines microcontroller interfacing, sensor integration, and embedded programming essentials. It helped structure the logic behind Arduino-based hardware systems. The authors cover real-time system design, which is crucial for a crash-response helmet. It also discusses power-efficient design principles helpful for wearable electronics.

[15] This work demonstrates a working prototype that uses real-time sensor data to detect crashes and send SMS alerts. It evaluates performance across different crash intensities and compares GPS accuracy. The design was field- tested, ensuring practical relevance and helping shape the testing phase of work. The paper also proposes design improvements like heartbeat sensors.

In summary, SMART HELMET incorporate various sensors, autonomous navigation, extinguishing mechanisms, and wireless communication to effectively detect and combat fires. The ongoing research and development in this field continue to enhance the capabilities and efficiency of these robots.

3. METHODOLOGY

To address the limitations of existing accident detection systems that rely on smartphones or fixed-threshold sensors, this work introduces a fully autonomous smart helmet designed for real-time crash detection and immediate emergency alerting. Using a vibration sensor and an Arduino UNO microcontroller, the system

employs a dynamic threshold algorithm to accurately distinguish genuine accidents from minor shocks, significantly reducing false alarms. Integrated with a NEO-6M GPS module and a SIM800C GSM module, the helmet automatically sends SMS alerts with precise location data to emergency contacts upon detecting a crash. An I2C LCD provides real-time feedback on system status and impact magnitude, while the design emphasizes low power consumption and compactness for everyday usability. The hardware is developed and validated using Verilog HDL on FPGA platforms and Arduino prototypes to ensure high detection accuracy, low latency, and operational stability. With robust noise filtering, environmental adaptability, and a user-centric interface, this scalable, cost-effective smart helmet offers a major safety upgrade, especially for riders in remote or low-connectivity regions, by reducing emergency response time and enhancing road safety.

The proposed Smart Helmet system integrates a dedicated embedded platform using Arduino UNO with a vibration sensor, GPS (NEO-6M), and GSM module (SIM800A), enabling fully autonomous crash detection and alerting without requiring smartphone connectivity.

- It employs a dynamic, threshold-based accident detection algorithm designed to reduce false positives by distinguishing between actual crashes and non-critical vibrations.
- The system automates emergency SMS transmission with real-time GPS coordinates to predefined contacts immediately upon crash detection, ensuring rapid and reliable communication.
- An integrated I2C LCD provides local real-time status updates, impact magnitude, and GPS connectivity feedback, enhancing user awareness and system transparency.
- The hardware design prioritizes low power consumption and compactness for practical, prolonged use on two-wheeler helmets.
- The entire architecture is developed and tested on FPGA/embedded platforms to validate performance, power efficiency, and response latency under real-world conditions.
- The proposed method emphasizes modularity, scalability, and cost- effectiveness, making it suitable for mass deployment in diverse environments, including areas with intermittent network coverage.

Overall, the proposed design improves reliability, user autonomy, and emergency response speed compared to existing smartphone- dependent or fixed-threshold detection methods.

The work introduces a fully automated safety system utilizing a smart helmet equipped with multiple sensors to address current workplace safety deficiencies. The helmet continuously monitors environmental hazards such as toxic gases, impact forces, and worker vitals. It communicates wirelessly with a microcontroller, ensuring real-time alerts and immediate response to potential dangers. This system not only enhances worker safety but also improves workplace efficiency by providing instant hazard detection and automated emergency notifications.

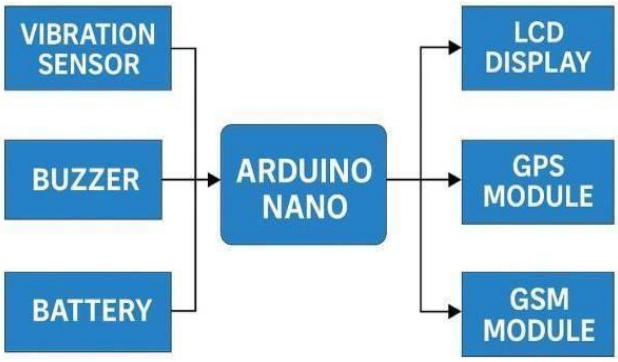

Fig.1. Block diagram

At the heart of this innovative system lies the Arduino Nano, meticulously integrated with sensors like gas sensors, accelerometers, and temperature sensors to detect hazardous conditions in real time. The helmet also features IoT-enabled connectivity, leveraging the advanced GSM SIM800L module to transmit critical alert messages and emergency calls to supervisors and emergency contacts. This ensures a swift and coordinated response, minimizing risks and enhancing overall workplace safety.

The main components used are:

- ARDUINO NANO
- SIM800C GSM MODULE
- RECHARGEABLE Li-ion BATTERY
- BUZZER
- GENERAL PURPOSE BOARD

Whenever a hazardous event or abnormal condition is encountered, the Smart Helmet's integrated sensor network detects potential threats in real time. Upon a sudden impact or accident, the vibration sensor

generates a signal corresponding to the shock intensity, which is instantly processed by the Arduino UNO microcontroller. Using a dynamic threshold algorithm, the system confirms whether the impact is severe enough to qualify as an accident. Once validated, the NEO-6M GPS module retrieves the rider's current geographic coordinates, while the SIM800C GSM module immediately sends an emergency SMS alert containing the precise location to pre-configured emergency contacts. Simultaneously, the system updates the status on a 16x2 or 20x4 I2C LCD, providing visual feedback such as accident confirmation, GPS lock status, and ongoing alert transmission. A buzzer is also activated locally to notify the rider of system activity and serve as an additional warning indicator.

4. RESULTS AND DISCUSSION

The Smart Helmet, demonstrates a significant step toward enhancing two-wheeler rider safety through the integration of real-time accident detection and automated emergency alerting using embedded systems and IoT components like Arduino Nano, vibration sensors, GPS, and GSM modules. Designed to detect crash-related vibrations, display impact magnitude on an LCD, and instantly transmit GPS coordinates via SMS to emergency contacts, the system aims to reduce response time during the critical "golden hour" after an accident. Thorough testing validated the system's accuracy in detecting impacts, reliable GPS tracking, and timely SMS delivery, though occasional false positives and GSM dependency were noted. Challenges included managing sensor noise, ensuring power reliability, and maintaining cost-effectiveness. Despite these hurdles, the work offers a practical and scalable solution for accident response in regions with high two-wheeler usage. Future improvements could include machine learning for better crash detection, mobile app integration, health monitoring features, and enhanced communication and power solutions, ultimately contributing to a smarter and safer transportation ecosystem.

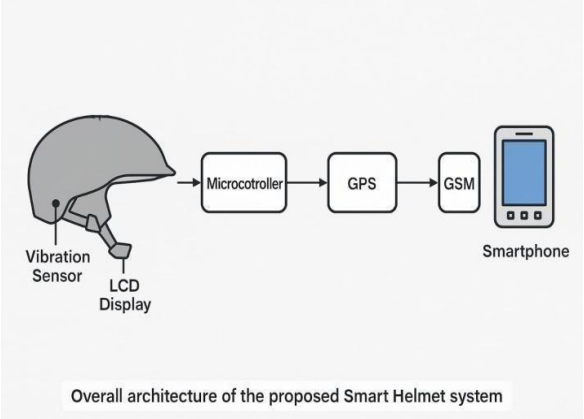

Fig 2 Circuit Diagram of Smart Helmet

The system starts with a vibration sensor mounted on the helmet, which detects shocks or impacts experienced by the rider. This sensor is connected to a microcontroller (such as Arduino UNO), which serves as the central processing unit. Alongside, an LCD display is also interfaced with the microcontroller to show real-time status updates like accident alerts, GPS lock, and system readiness.

When an accident is detected, the microcontroller activates the GPS module, which retrieves the rider's current location coordinates. These coordinates are then passed to the GSM.

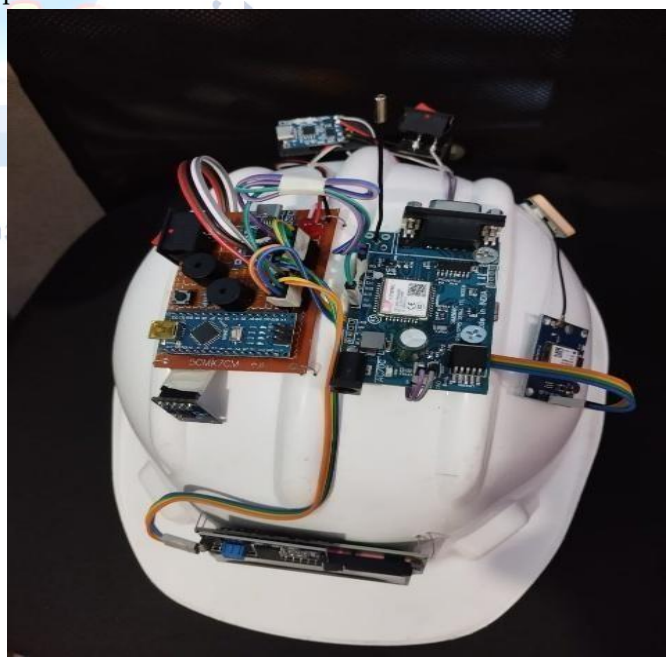

Fig 3 : Top view of smart helmet

The image shows a detailed view of the Smart Helmet prototype equipped with various integrated modules for accident detection and safety monitoring. Mounted on a white safety helmet, the setup includes an Arduino UNO board centrally placed to act as the main microcontroller

unit. Adjacent to it is the SIM800L GSM module, responsible for sending emergency SMS alerts upon accident detection. A GPS module is connected via colored jumper wires to provide real- time location tracking. The front section houses a compact LCD display for status updates and alerts, while the orange breakout board features a buzzer and sensors for impact and environmental detection. Multiple modules like the MQ135 gas sensor, temperature sensor, and vibration module are distributed across the helmet and interconnected for comprehensive monitoring

5. CONCLUSION

This work highlights the transformative potential of IoT technology in enhancing fire detection and emergency response. By integrating automated fire detection with real-time alerting capabilities, the system ensures swift communication of critical information to designated contacts and emergency services. Its simplicity, reliability, and efficiency make it a valuable solution for improving fire safety in various environments. GSM module, which sends an SMS alert to a predefined smartphone or emergency contact. This alert contains vital information such as the GPS location and accident notification, ensuring quick assistance and improved rider safety.

Furthermore, the work demonstrates the ability of IoT to optimize resource allocation and minimize response times during emergencies. With its seamless integration into Android-based platforms, this system represents a significant step forward in modern fire safety technology. Future enhancements could further refine its functionality, making it an indispensable tool for proactive hazard management.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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