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Conceptual View of a Smart Helmet for Accident Detection with GSM-based SMS Alert System

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***Abstract*— The work presented in this research paper gives a conceptual view of a smart helmet for accident detection with GSM-based SMS alert system for vehicle riders. This project introduces a Smart Helmet system designed to enhance road safety for two-wheeler riders by detecting accidents in real-time and instantly notifying emergency contacts with the victim's location. By integrating an accelerometer, GPS module, GSM module, and a microcontroller, the helmet autonomously identifies collisions and sends out an SMS alert containing a Google Maps link to the rider's location. It ensures timely emergency intervention, even when the rider is unconscious or unable to act. Lightweight, cost-effective, and user-friendly, this wearable solution operates without manual input, aiming to reduce fatalities caused by delayed medical response.**

Through seamless integration of hardware and software, the system represents a practical and life-saving application of IoT technology in everyday commuting. Two-wheeler riders are frequently involved in accidents that go unreported, which delays medical help and increases the number of fatalities.

This project presents a smart helmet system that can identify collisions in real time and instantly provide emergency contacts with the victim's location. The system guarantees quick emergency reaction by continuously tracking the rider's motion and detecting unexpected impacts.

This solution is proactive and life-saving because it combines automated alert messaging with real-time location tracking. The smart helmet bridges the gap between accident occurrence and emergency intervention and is designed to be small, dependable, and easy to use. Key features of the system include real-time accident detection, automatic location-based emergency alerts, and fully autonomous operation, requiring no action from the rider once worn. The system is designed to be lightweight, cost-effective, and highly responsive, making it suitable for everyday use. Overall, the smart helmet acts as a silent guardian, significantly reducing the time between an accident and medical response. It offers a practical, life-saving solution aimed at enhancing road safety and promoting responsible riding through technology.

***Index Terms*— Real-time accident detection, Automatic location-based emergency alerts, Full autonomous operation, GPS, SMS, Communications.**

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I. Introduction

In a nation like India, where the majority of day-to-day transport is on two-wheelers, road safety has turned out to be an emerging issue. With rising traffic bottlenecks and rash driving practices, the incidents of accidents of two-wheeler riders are alarmingly on the rise. Most of these accidents involve major injuries or even death, not because of the accident itself, but because of the delay in receiving medical care. In many cases, the lack of timely warnings or witnesses can turn an otherwise survivable collision into a catastrophic event. To curb this fatal problem, this project introduces a Smart Helmet Accident Detection System, which is programmed to sense accidents in real time and immediately alert emergency contacts with the location of the rider.

This system is constructed based on essential hardware parts such as the ADXL335 accelerometer, which detects sudden motion or unusual movement; the NEO-6M GPS module, which offers precise latitude and longitude information; and the SIM800L GSM module, which sends the alert message as an SMS. Arduino Uno acts as the central controller, gathering and processing sensor data. When an unusual acceleration is sensed—indicating a crash—the system initiates a brief countdown timer so the system can be cancelled on a false alarm. Failing cancellation, it automatically sends an SMS with a Google Maps link to the rider's location to one or more pre-specified emergency contacts. This intelligent helmet is a wearable, low-cost IoT solution that runs autonomously without any manual intervention once activated. It makes sure that emergency messages are delivered even if the rider is unconscious or unable to respond. With the addition of motion sensing, GPS tracking, and GSM communication, this system is a small but efficient life-saving device.

II. Literature Survey / Review

Over the years, researchers have proposed various wearable and embedded systems aimed at improving road safety, particularly for two-wheeler riders. Mohanraj et.al. [1] developed an intelligent helmet system with alcohol detection and accident notification features, using GSM and GPS modules for real-time alerts. Similarly, Patil and Pawar et.al. [2] focused on helmet-based accident detection using an accelerometer and a GSM module to ensure rapid emergency response. Srinivas et.al. [3] proposed a microcontroller-based smart helmet that monitors head movement and sends location alerts during an accident, emphasizing portability and cost-effectiveness. In another study, Vinoth Kumar and Senthil Kumar et.al. [4] utilized the MPU6050 sensor for enhanced accuracy in crash detection, showing promising results in simulated environments.

Ramya and Bhuvaneswari et.al. [5] explored the use of Arduino boards and vibration sensors for accident identification in rural areas, where emergency help is typically delayed. Their findings highlighted the potential of integrating location tracking to save lives. Meanwhile, Rakesh and Manjunath et.al. [6] introduced a voice-activated smart helmet for real-time health monitoring and crash detection. John et.al. [7] presented a Bluetooth-enabled smart helmet that connects with mobile applications, expanding its functionality beyond crash alerts. Manoj Kumar and Ravi et.al. [8] developed a GPS-GSM integrated smart helmet prototype that reduces emergency response time significantly. Ramesh and Jayashree et.al. [9] implemented a cloud-based approach for real-time helmet data monitoring, enhancing both accident detection and data logging. Furthermore, Supriya and Akshay et.al. [10] integrated biometric sensors to monitor vital signs post-accident, such as heart rate and consciousness levels.

Nandhini and Haritha et.al. [11] experimented with the ADXL345 accelerometer for more reliable detection of tilt and shock, proving effective in motorcycle fall detection. Singh and Verma et.al. [12] suggested a novel approach using machine learning algorithms to differentiate between false alarms and real crashes, offering an intelligent decision-making mechanism. According to Bharathi and Deepika et.al. [13], integrating camera modules into helmets can provide valuable evidence during accidents, which can be beneficial for insurance and legal processes. Anand and Preethi et.al. [14] discussed the importance of having voice prompts and alert systems for elderly riders, showing a shift toward user-centric smart helmet design. Karthik and Priya et.al. [15] designed a multi-functional helmet with traffic violation detection capabilities, adding an extra layer of road safety compliance. Sharma and Tiwari et.al. [16] proposed a low-cost system combining GSM and LoRa for rural connectivity, ensuring accident alerts reach contacts even in areas with weak mobile coverage.

Nikhil and Aravind et.al. [17] emphasized the significance of continuous GPS tracking and offered a power-efficient circuit design to ensure prolonged battery life. Meanwhile, Latha and Kavitha et.al. [18] implemented speech-controlled modules for disabled riders, expanding the system's inclusivity. Bhavya and Prakash et.al. [19] conducted a comparative study of various GSM modules (SIM900 vs. SIM800L) and found SIM800L more compact and efficient for helmet integration. Finally, Yadav and Sharma et.al. [20] highlighted the benefits of integrating cloud and IoT platforms for real-time data visualization and analysis, paving the way for smart traffic and emergency ecosystems. Like this, a number of researchers have worked, here, we have listed some of the works which had been used by us in the preparation of the project report.

II. PROPOSED SYSTEM

The proposed system is a Smart Helmet Accident Detection System designed to enhance rider safety by automatically detecting accidents and promptly notifying emergency contacts of the rider's location. This system integrates multiple sensors and communication modules to ensure a quick and reliable response in case of accidents, especially for two-wheeler riders. The key components of the system include following –

- Accelerometer Sensor (ADXL335 or MPU6050): Continuously monitors the helmet's movement and orientation to detect sudden impacts or abnormal changes in acceleration indicative of an accident.
- Microcontroller (Arduino Uno): Acts as the brain of the system, processing data from sensors to identify accident events and control other modules.
- GPS Module (NEO-6M): Provides real-time geographical location coordinates of the helmet to pinpoint the accident site.
- GSM Module (SIM800L): Sends an emergency SMS containing the accident alert and GPS location to predefined emergency contacts.

The system works by continuously analyzing accelerometer data to detect a threshold impact or tilt, signaling a potential accident. Upon detection, the microcontroller fetches the latest GPS coordinates and uses the GSM module to automatically send a detailed alert message.

This rapid communication aims to reduce the response time of emergency services, potentially saving lives and minimizing injury severity. Overall, the proposed smart helmet system offers an affordable and practical solution to improve road safety for motorcyclists, addressing critical delays in accident detection and emergency notification.

III. BLOCK-DIAGRAM OF THE PROPOSED METHODOLOGY

The block diagram is as follows as shown in the Fig. 1, which gives a overview of how the project is going to be completed.

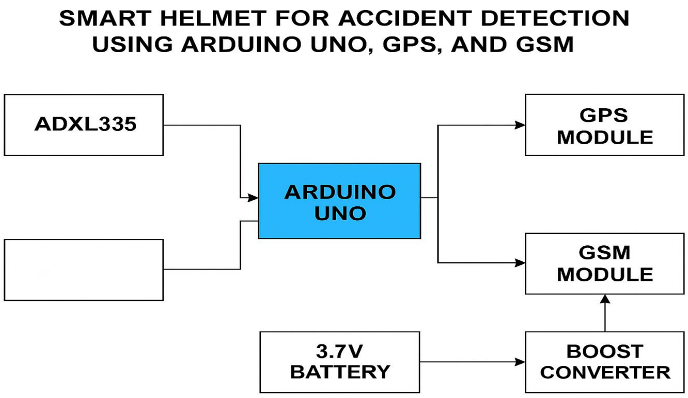

Figure 1. Block diagram of the proposed methodology of developing the smart helmet

The main components used are Accelerometer, GPS Module & GSM Module, which are explained as follows.

Figure 2. Pictorial representation of a ADXL335 Accelerometer, Neo 6M GPS Module & SIM800L GSM Module

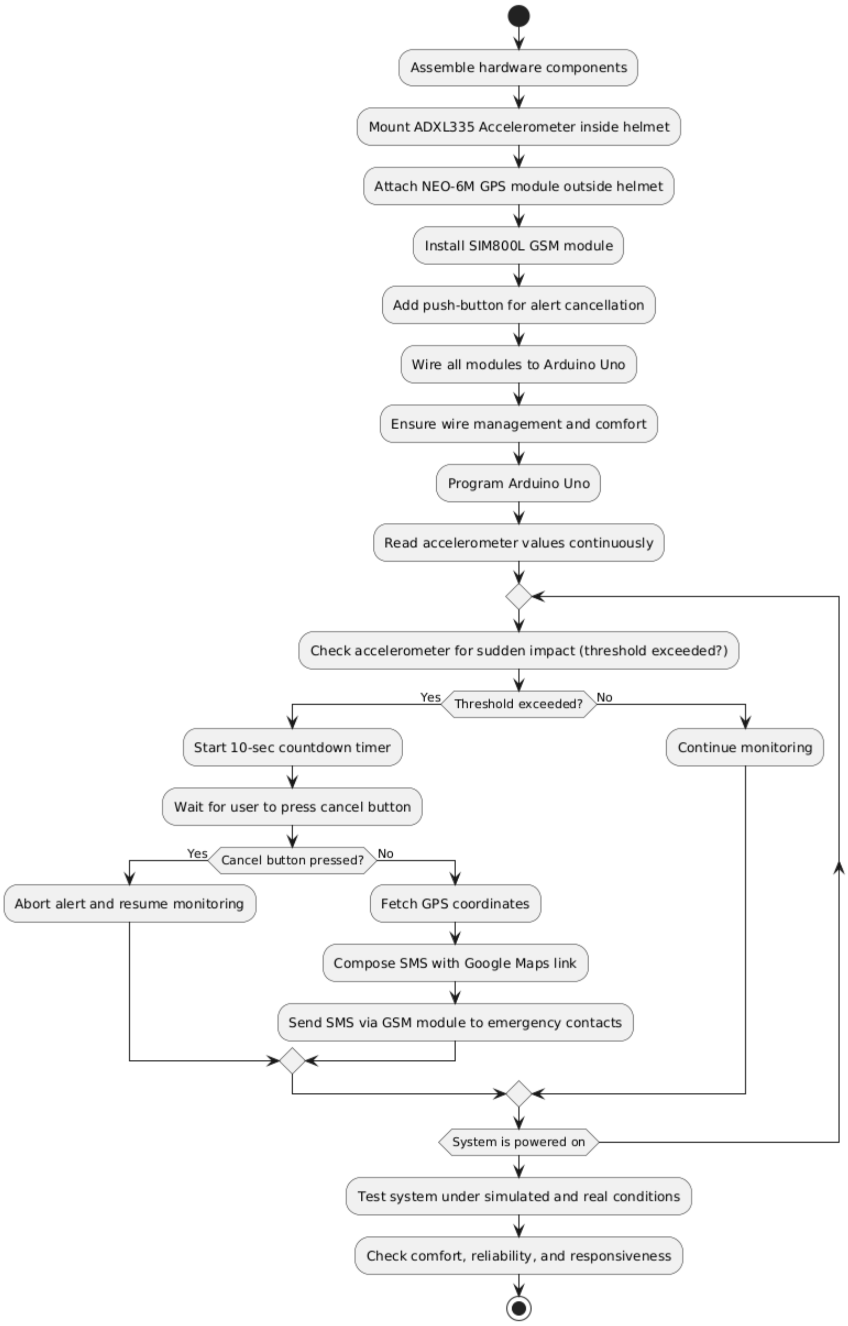

Figure 3. Flow chart for developing the smart helmet

A. ADXL335 Accelerometer

The ADXL335 is a small, thin, low-power, complete 3-axis accelerometer with signal-conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The pictorial representation is shown in Fig. 2.

B. Neo 6M GPS Module

The Neo-6M is a highly versatile and compact GPS module designed to receive signals from multiple satellites in orbit and process them to determine your precise geographic location. This includes critical information such as Longitude and Latitude, which pinpoint your position on the Earth's surface. In addition to basic location data, the Neo-6M is capable of providing other valuable metrics, including altitude (your height above sea level), speed (useful for tracking movement or navigation), and time-related data synchronized with global standards. The pictorial representation is shown in Fig. 2.

C. SIM800L GSM Module

The SIM800L is a GSM module from Simcom that gives any microcontroller GSM functionality, meaning it can connect to the mobile network to receive calls and send and receive text messages, and connect to the internet using GPRS, TCP, or IP. Another advantage is that the board makes use of existing mobile frequencies, which means it can be used anywhere in the world. Pictorial representation is shown in Fig. 2.

III. STEP-BY-STEP ALGORITHM FOR SMART HELMET ACCIDENT DETECTION AND ALERT SYSTEM

This practical, stepwise algorithm, will be able to build a smart helmet that actively monitors for accidents, acquires the rider's location, and sends automated SMS alerts to emergency contacts—all while keeping comfort and usability in mind. This process combines both the hardware assembly and software logic to create an effective and life-saving solution for two-wheeler safety. Here, follows the algo… along with the flow-chart as shown in the Fig. 3.

Step 1: Assemble Hardware Components
- Securely mount the ADXL335 accelerometer inside the helmet to detect motion and impacts.
- Attach the NEO-6M GPS module to the outside of the helmet for good satellite reception.
- Install the SIM800L GSM module in a safe spot on the helmet and connect it to a reliable power supply.
- Integrate a push-button to allow the user to cancel false alerts.

Step 2: Wire Components to the Microcontroller
- Connect the accelerometer, GPS module, GSM module, and push-button to the Arduino Uno (or similar microcontroller) according to their pin requirements.
- Ensure proper insulation and wire management for durability and rider comfort.

Step 3: Program the Microcontroller
- Write and upload code (using Arduino IDE) to continuously read acceleration values from the ADXL335 sensor.
- Set a threshold value to distinguish between normal riding and potential accident scenarios (e.g., sudden impact or abnormal tilt).

Step 4: Accident Detection Logic
- Continuously monitor real-time accelerometer readings.
- When readings exceed the set threshold, treat this as a possible accident event.

Step 5: Countdown Timer for False Alarm Cancellation
- Trigger a countdown timer (e.g., 10 seconds) after detecting a possible accident.
- During this period, check if the user presses the cancel button.
- If the button is pressed, abort the alert and resume monitoring.

Step 6: Location Acquisition
If the countdown finishes without cancellation, fetch the current latitude and longitude from the GPS module.

Step 7: Compose Emergency Alert Message
- Create an SMS alert containing a clear message and a Google Maps link generated from the GPS coordinates.
- Add any extra info, such as the time of the event, if desired.

Step 8: Send SMS to Emergency Contacts
Use the GSM module to automatically send the alert SMS to pre-stored emergency contact numbers.

Step 9: System Testing and Validation
- Simulate different accident scenarios (falls, sudden impacts) to ensure the accelerometer correctly detects events and the GSM module reliably sends messages.
- Test GPS signal acquisition and location accuracy, both indoors and outdoors.
- Validate the cancellation feature by intentionally triggering false alarms and canceling them.

Step 10: Final Integration and Comfort Optimization

- Secure all modules inside the helmet in a compact, lightweight arrangement.
- Double-check that the helmet remains comfortable, wearable, and safe.
- Make sure wire routing is neat and all components are securely fastened.

Step 11: Field Trials

- Conduct real-world testing with actual riders to ensure reliability, comfort, and responsiveness.
- Collect feedback and make minor adjustments to thresholds, timing, or placement if necessary.

IV. IMPLEMENTATION PROCEDURES

Implementation of the Smart Helmet Accident Detection System is through the integration of embedded software and hardware components into a dependable, real-time safety solution. The setup starts from the hardware. The ADXL335 accelerometer is mounted securely inside the helmet to sense movement along all three axes. Its analog outputs are wired to the analog input pins on the Arduino Uno, which acts as the central controller of the system. The NEO-6M GPS module is mounted on the external side of the helmet to receive full-strength satellite signals, while the SIM800L GSM module is encased in a safeguarded unit and supplied with power from a regulated power source. A push button is provided for the rider to cancel the alert manually in the event of a false trigger of an accident. The Arduino is programmed using the Arduino IDE. It continuously reads the acceleration data from the ADXL335. When acceleration is sensed beyond a specified limit, the system assumes a possible crash and initiates a countdown timer, usually of 10 seconds. During this period, the rider can cancel the alert by pressing the reset button. If the countdown completes without cancellation, the Arduino captures the current location from the GPS module.

The latitude and longitude values are then encoded into a Google Maps link, which is transmitted by SMS to saved emergency contact numbers using the SIM800L GSM module. After integrating all the modules, the system is subjected to tests under various conditions to ensure its functionality. Simulated accident conditions, such as sudden collisions, falls, and abrupt movements, are used to test the accelerometer's responsiveness. The GPS module is tested for accuracy and for prompt acquisition of satellite signals in both indoor and outdoor environments. The GSM module is verified for reliable and timely SMS transmission across different mobile networks. All components are organized in a lightweight and compact configuration to ensure that the helmet remains comfortable for the rider. Proper wire management and insulation are implemented to improve durability and overall performance. This application efficiently integrates motion detection, GPS location tracking, and GSM communication into a wearable system that enhances the safety of two-wheeler riders by ensuring instant response during emergencies.

V. EXPERIMENTAL RESULTS

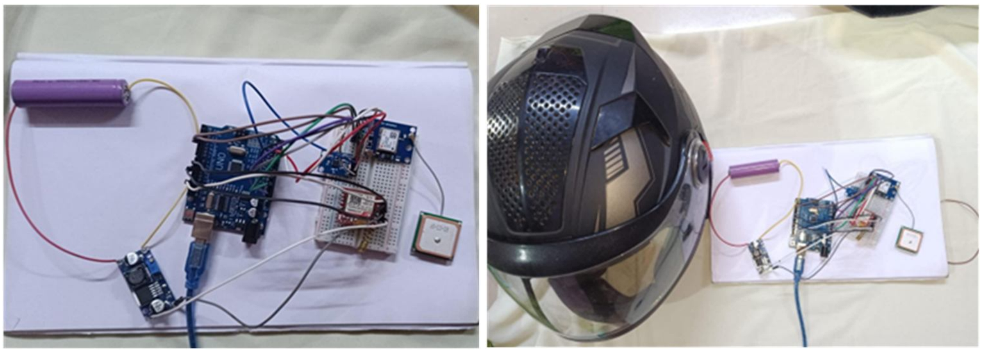

Figure 4. Developed smart helmet with its accessories

The Smart Helmet Accident Detection System works well under different test conditions. It correctly identifies simulated accident situations, including abrupt impacts, falls, and unnatural movements, and neglects regular riding motions. The alarm mechanism operates well with the system starting a countdown and permitting cancellation in cases of false alarms. As soon as the alert is confirmed, the system can send location-based messages successfully to emergency contacts. The messages are received instantly, giving a timely notification. During testing, the system does not get unstable, sluggish, or inefficient, nor consume much power, with no significant errors detected. The helmet is kept comfortable and easy to use, with the whole arrangement being light and compact. The system achieves its aim of offering a reliable, real-time safety mechanism to two-wheeler drivers by allowing for instant emergency response in case of accidents. The developed smart helmet & its accecosires could be seen in the Fig. 4.

VI. CONCLUSIONS

This project combines technical proficiency with a real-world safety concern to create a meaningful and impactful solution. It aims to contribute toward safer roads by offering two-wheeler riders an affordable, reliable, and autonomous safety companion. Especially in high-risk environments such as dense city traffic or remote regions, this system ensures that timely emergency alerts can help reduce the consequences of road accidents. The project not only demonstrates the practical implementation of IoT and embedded systems but also highlights the potential of technology to save lives. This also ensures the person wears the helmet mandatorily.

FUTURE SCOPE

The Smart Helmet Accident Detection System has great potential for future development and advancement. One key area of improvement is the integration of real-time mobile applications, enabling users and emergency responders to monitor live location and accident status instantly. Additionally, cloud logging can be incorporated to record travel history and incident data, which can be useful for analysis and insurance purposes. The system can also be enhanced by adding voice warnings, camera modules to capture incidents, and biometric sensors to monitor the rider's health indicators, such as heart rate and level of consciousness after an accident. Incorporating fall detection algorithms based on machine learning could further improve the system's ability to distinguish between real accidents and false alarms. Furthermore, embedding Bluetooth technology for call handling and navigation instructions would make the helmet more interactive and provide a richer smart riding experience. With advancements in technology, the solution can be miniaturized to improve aesthetics and comfort without compromising safety and functionality. Overall, this project lays a strong foundation for a scalable, feature-rich safety system with ample opportunities for expansion to meet evolving user needs and technological progress.

In conclusion, the Smart Helmet system stands as a thoughtful and practical response to the growing concern over two-wheeler safety. By blending real-time accident detection with instant location-based alerts, it offers a dependable and autonomous safety companion for riders. The design is not only technically sound but also mindful of real-world scenarios where quick medical help can make the difference between life and death. Its ability to function independently—without relying on rider intervention—makes it especially valuable during critical moments. Overall, this project successfully demonstrates how technology, when applied with purpose and precision, can genuinely save lives and foster a safer riding environment.

KEY ADVANTAGES OF THE DEVELOPED PROJECT

Some of the key advantages of the Smart Helmet system are listed as follows in the form of detection, emergency alerting, hands free operations, light weight, etc…

- Real-time accident detection: The helmet immediately identifies sudden impacts or crashes, ensuring no delay in response time.
- Automatic emergency alert system: It sends SMS alerts with precise GPS location to emergency contacts without needing any manual action.
- Hands-free operation: The helmet functions autonomously once worn, which is crucial if the rider is unconscious or unable to respond.
- Lightweight and wearable design: It maintains user comfort while integrating advanced safety technology in a compact form.
- Cost-effective and practical: The system uses readily available components, making it affordable for mass deployment.
- Life-saving application of IoT: It demonstrates how embedded systems and IoT can be harnessed to solve real-life safety challenges efficiently.
- Cost-effective & user-friendly.

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