RIDER SAFETY JACKET WITH AIRBAG DEPLOYMENT AND TRACKING SYSTEM

Project Reference No: *48S_BE_0007*

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Keywords:

Airbag, Rider Safety, GSM, GPS, Accident Detection, Embedded System

Introduction:

Motorcycle riding is inherently risky due to the lack of external protection, making riders highly vulnerable during accidents. While helmets provide essential head safety, they do not shield the rest of the body from impact-related injuries. To bridge this gap, this project presents a **Rider Safety Jacket** equipped with an **automatic airbag deployment system**.

The jacket integrates sensors to detect sudden impacts or falls and inflates airbags instantly to protect vital areas such as the spine, chest, and neck. It also features a **GPS module** to track the rider's location and a **GSM module** to send real-time alerts to emergency contacts during accidents. These features ensure not only physical protection but also quicker emergency response in critical situations.

The system operates using a microcontroller that continuously reads and processes data from various onboard sensors, including gyroscopes, IR proximity sensors, and alcohol detection modules. This allows the jacket to intelligently respond to different scenarios, such as loss of balance, collisions, or unsafe riding conditions.

The innovation is designed to be lightweight, wearable, and portable, ensuring user comfort without compromising safety. It runs on battery power and is built for long-term outdoor use. The concept has strong potential for scalability, allowing it to be adapted for other applications such as **construction site safety gear**, **equestrian riding suits**, and **emergency responder uniforms**.

By integrating **embedded systems**, **real-time communication**, and **wearable technology**, this project offers a proactive and intelligent solution to reduce the impact of accidents and enhance personal safety in high-risk environments.

Objectives:

- Automatically detect accidents and inflate an airbag to minimize injuries.
- Capture live location using GPS.
- Send emergency alerts via GSM to predefined contacts or services.
- Ensure successful deployment of the airbag immediately after accident detection.
- Improve safety measures for high-risk riders and workers.
- Integrate multiple sensors (gyroscope, alcohol, IR) for intelligent safety monitoring.
- Design a wearable and comfortable jacket suitable for real-time deployment in outdoor conditions

Methodology:

The methodology of this project centres on the design, development, and implementation of a **smart wearable system** that provides real-time safety for motorcyclists through airbag deployment and automated emergency response. The jacket incorporates **embedded systems**, **sensor networks**, and **communication modules** to detect accidents and respond rapidly.

The heart of the system is an **Arduino Uno microcontroller**, which is responsible for managing data from various sensors and controlling the activation of the airbag deployment mechanism. The sensors include a **gyroscope** for measuring angular velocity and orientation, an **alcohol sensor** to detect intoxicated riding, and **IR proximity sensors** for object or obstacle detection. These sensors work together to analyse rider behaviour and identify critical events such as sudden falls or collisions.

Once an accident is detected, the microcontroller initiates two critical actions:

1. **Deployment of the airbag** to cushion the rider from injury.
2. Activation of the **GSM module** to send a text message alert along with GPS coordinates obtained from the **GPS module**.

The airbag is triggered using a **solenoid or actuator mechanism**, powered by a compact battery. The GSM module is pre-programmed with emergency contact numbers and delivers location information using an integrated message format.

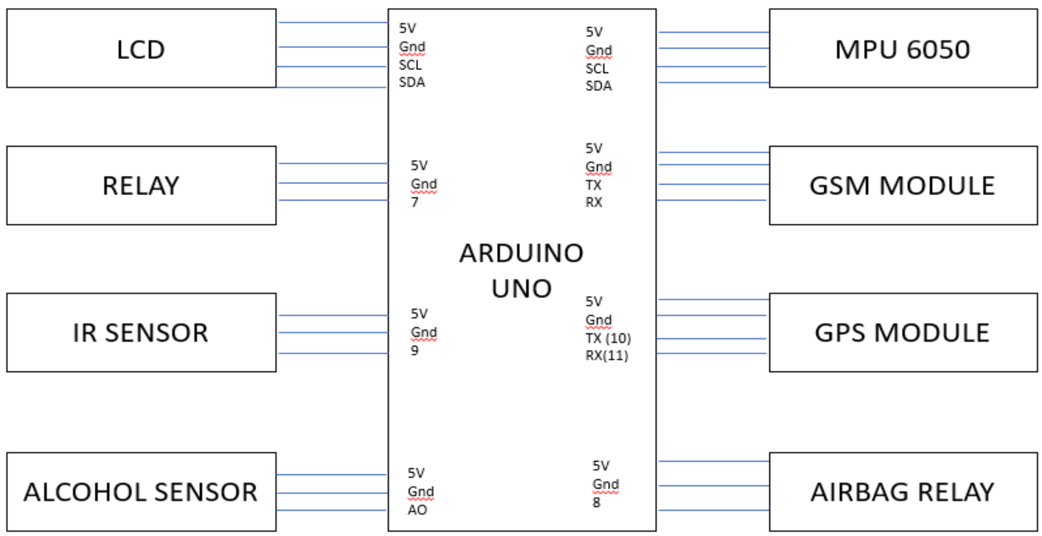
The system is built in multiple phases:

- **System Design and Component Interfacing**: Careful selection of compatible components (sensors, GSM, GPS, power supply, valve mechanism) and schematic design using embedded platforms.
- **Sensor Calibration and Testing**: Calibration of gyroscope, IR, and alcohol sensors to ensure accurate readings under various conditions.
- **Embedded C Programming**: Development of code using **Embedded C** within Arduino IDE, ensuring real-time data acquisition and event-driven responses.
- **Hardware Integration**: Mounting sensors and modules into a prototype jacket, with durable connections, PCB layout (if applicable), and wiring for flexibility and safety.
- **Airbag Activation Testing**: Controlled experiments using dummies and simulated falls to verify response speed and inflation reliability.

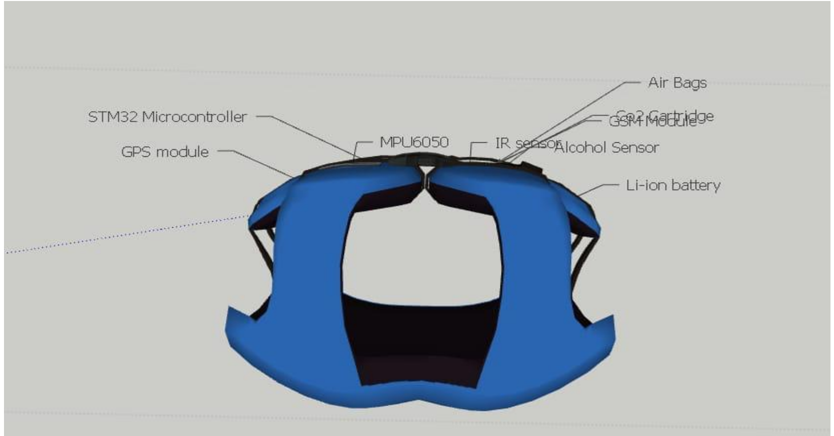
- **GSM and GPS Communication Validation**: Testing message accuracy, latency, and delivery success across different mobile networks and locations.

- **Prototype Fabrication and Evaluation**: Final integration of electronics into a wearable fabric design and testing under real-world use cases to measure durability, efficiency, and accuracy.

Circuit Diagram:



3D Model of Air Bag Prototype



Result and Conclusion:

The developed prototype has successfully demonstrated the core functionalities of accident detection and responsive safety deployment. Upon identifying impact or fall conditions—using MEMS-based inertial sensors—the system promptly triggers the inflation of an airbag mechanism. This rapid deployment is critical in mitigating the severity of injuries during two-wheeler accidents.

Furthermore, the integrated GSM module effectively transmits the rider’s geolocation, obtained via the GPS module, to predefined emergency contacts. This real-time alert mechanism ensures that immediate assistance can be mobilized, significantly reducing the delay between accident occurrence and emergency response.The system was evaluated under controlled conditions simulating various accident scenarios. Results confirmed the reliability of the sensor fusion algorithm in distinguishing between normal and abnormal riding dynamics, with minimal false positives. The airbag deployment time was measured to be within acceptable safety limits (2.5 s), while the message delivery via GSM was completed within seconds, depending on network strength.

The compact and wearable nature of the prototype makes it suitable for integration into riding apparel. Its low power consumption and autonomous operation enhance usability and practicality, particularly for motorcyclists in both urban and remote settings.

This study establishes the feasibility of enhancing rider safety through the fusion of embedded systems and wearable electronics. Future iterations may explore improvements such as integration with mobile applications, cloud-based accident logging, and automated emergency service notification systems.

Project Outcome & Industry Relevance:

The proposed system holds significant potential for real-world applications across multiple domains. Primarily, it enhances **personal safety** for motorcyclists by providing proactive protection through real-time accident detection and rapid airbag deployment. In the event of a crash, the system's ability to transmit GPS location data ensures that emergency services can be alerted promptly, reducing response time and increasing the likelihood of survival.

Beyond personal transportation, the system can be adapted for use in **smart protective gear for industrial environments**, such as construction sites, manufacturing plants, and warehouses. In such settings, workers are frequently exposed to hazardous conditions. A wearable safety system capable of detecting falls, collisions, or sudden impacts can serve as an effective preventive measure, triggering protective mechanisms and alerting supervisors in real time.

Moreover, this technology aligns well with the vision of **smart transportation systems**, where vehicles and infrastructure are increasingly connected and intelligent. Integrating such wearable systems with vehicle-to-everything (V2X) communication protocols can enable enhanced situational awareness and automated safety responses across the transportation network. The broader implication of this work lies in showcasing how **embedded systems and wearable electronics** can reduce injuries and fatalities by enabling **faster response**, **automated emergency alerts**, and **intelligent safety mechanisms**. As such, this prototype sets a foundation for scalable, affordable, and practical safety solutions in both consumer and industrial sectors, contributing toward a safer, more responsive future in mobility and occupational health.

Working Model vs. Simulation/Study:

A fully functional working prototype is developed and tested with real sensors and hardware.

Working prototype image/output illustrating system components and real-time response.

Project Outcomes and Learnings:

• Embedded C programming and microcontroller interfacing

• Sensor calibration and integration

• GSM and GPS based communication

• Real-time embedded system development

Future Scope:

While the prototype demonstrates effective accident detection and response, several avenues exist for further enhancement and optimization. One of the most promising directions is the integration of **Artificial Intelligence (AI)** and **machine learning algorithms** for **predictive accident detection**. By analyzing real-time sensor data and rider behavior patterns, the system could anticipate potential accidents before they occur, enabling pre-emptive safety measures and significantly reducing reaction time.

Additionally, the current model can be enhanced to offer **multi-impact protection**, addressing scenarios where riders may experience multiple collisions during a single accident. Implementing **reinflatable or replaceable airbag modules** can support continued protection in such cases.

The **jacket-based design** also lends itself to adaptation for other protective applications. For instance, smart safety systems can be integrated into **helmets**, **industrial suits**, or **military gear**, extending the scope of usage to various high-risk environments such as construction zones, mining operations, and defence sectors.

Moreover, introducing **Vehicle-to-Jacket (V2J) communication**, where the vehicle can communicate directly with the wearable system can provide enhanced **situational awareness** for the rider. For example, alerts regarding sudden braking, blind-spot occupancy, or proximity to other vehicles can be relayed to the wearable device in real time.

For commercial viability, focus must also be placed on **further miniaturization** of hardware components and **robust waterproofing**, making the system more discreet, durable, and comfortable for daily use. These improvements would make the product more attractive for mass-market adoption and deployment in real-world conditions.