K.Nagarathna, 2025, 13:6
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Design and Development of Rider Safety Jacket

K.Nagarathna, Amitsing Hunnur, Ankita Hulloli, Arun Hadimani, Bhagyashri Kumbar
Electronics and communication engineering department , Basaveshwar Engineeing college , Bagalkote, Karnataka , India.

Abstract - This project focuses on the design and development of a rider's safety jacket aimed at enhancing the safety of motorbike riders, horse riders, and workers in high-risk environments such as construction sites. The system operates on principles similar to vehicle-mounted airbags, deploying automatically to minimize injuries during accidents. The jacket integrates a pressure cylinder connected via a pneumatic valve, conduits, and connectors. Upon impact, the pneumatic valve triggers the release of pressurized air, inflating the jacket within milliseconds to provide cushioning. Additionally, the system incorporates a GPS module to capture the rider's live location, which is then transmitted to the nearest ambulance or designated contacts via a GSM module.

Index Terms - Accident detection, GPS module, GSM communication, inflation mechanism, rider safety jacket, safety system.

I. INTRODUCTION

Accidents involving motorbike riders, horse riders, and construction workers continue to be one of the leading causes of severe injuries and fatalities worldwide. According to the World Health Organization (WHO), over 1.3 million deaths occur each year due to road traffic accidents, with motorcyclists accounting for nearly 28% of all road-related fatalities. In countries with dense traffic and limited safety enforcement, such as India, motorcycle accidents represent an even higher proportion, with reports showing that two-wheelers account for more than 45% of road accident deaths annually. Construction sites present an additional layer of risk, where workers frequently operate in hazardous conditions. Studies from the International Labor Organization (ILO) indicate that construction workers face a 20% higher probability of fatal injuries compared to workers in other industries. Horse riders also experience high-impact injuries; medical statistics reveal that equestrian accidents result in hospitalization rates higher than those of motorcycle riders, largely due to falls from height and unpredictable animal behaviour.

Despite significant advancements in helmets, protective gear, and safety protocols, many existing safety measures remain insufficient in preventing life-threatening injuries during sudden impacts. Impact force analysis shows that during collisions, the human body may experience forces up to 3–5 kN, which can cause internal injuries even when external gear is present. Traditional protective equipment lacks autonomous, real-time response mechanisms capable of reducing this impact force before it reaches the body. Furthermore, in most accident scenarios, victims are either unable to call for help or are located in remote areas where immediate emergency response becomes difficult. Medical research indicates that the probability of survival decreases by 7–10% for every minute of delay in receiving emergency medical assistance after a severe injury, highlighting the need for systems that can automatically alert responders.

This project aims to address these critical safety gaps by developing an intelligent rider's safety jacket capable of reacting autonomously in accident conditions. The proposed system automatically detects sudden impacts or falls using impact sensors and immediately triggers the inflation of an air-cushion mechanism. Rapid inflation absorbs the majority of the impact energy, thereby reducing the chances of fractures, spinal injuries, and internal trauma. The design takes inspiration from advanced automotive safety technologies such as airbags but adapts them into a wearable, lightweight, and portable form factor.

In addition to physical protection, the jacket enhances post-accident response through integrated communication modules. The system utilizes a GPS module to determine the rider's real-time location and a GSM module to transmit emergency notifications to nearby hospitals, ambulances, or designated emergency contacts. Such automated alert systems significantly improve the "Golden Hour" response, which refers to the first 60 minutes after a traumatic injury, during which timely medical intervention vastly improves survival rates. Data from trauma research centres indicate that automated alert systems can reduce response times by 30–40%, directly translating to higher chances of recovery.

Furthermore, the proposed design focuses on adaptability across different use-cases. Whether used by motorcyclists navigating urban roads, horse riders in open terrains, or construction workers operating in high-risk environments, the safety jacket aims to minimize the severity of injuries through rapid response and intelligent monitoring. The system's modular architecture—comprising sensors, a pneumatic inflation mechanism, GPS/GSM communication units, and a processing microcontroller—ensures that it can be customized for various industries without compromising reliability.

Overall, this project not only introduces an innovative wearable protection system but also presents an integrated technological solution for real-time accident mitigation and emergency communication. By combining preventive cushioning with automated alerting, the rider's safety jacket enhances both primary safety (injury reduction at the moment of impact) and secondary safety (post-accident emergency response), addressing the two most crucial factors responsible for accident-related fatalities.

Problem Statement and Approach

Accidents involving motorbike riders, horse riders, and construction workers continue to cause severe injuries and fatalities worldwide. According to global statistics, motorcyclists account for nearly 28% of road accident deaths, while construction workers face a significantly higher risk of fatal injuries compared to other professions. Equestrian-related accidents also result in a high rate of hospitalization due to sudden falls and high-impact collisions. Despite the availability of helmets and protective gear, most existing safety equipment is passive and cannot respond automatically during an accident. Impact forces ranging between 3–5 kN can cause serious internal injuries, and victims are often unable to call for help after severe trauma. Emergency response is frequently delayed, reducing survival chances by 7–10% per minute without medical intervention. The lack of an intelligent, automated protective system forms the core problem.

To address this gap, this project proposes an advanced rider's safety jacket integrating accident detection, pneumatic inflation, and automated emergency communication. The system uses accelerometers, gyroscopes, and impact sensors to continuously monitor movement and identify abnormal deceleration or collision patterns. When an accident is detected, a microcontroller activates a pneumatic inflation mechanism, rapidly releasing compressed air into protective air bladders strategically placed in the jacket. This inflation occurs within milliseconds, forming a cushioning layer to reduce the transfer of impact energy and minimize potential injuries.

Simultaneously, the system triggers its communication module. The GPS unit captures the user's real-time coordinates, while the GSM module sends an automatic emergency alert to nearby hospitals, ambulances, or predefined emergency contacts. This ensures immediate assistance even if the victim is unconscious or unable to communicate. Automated alert systems have been shown to reduce response time by 30–40%, significantly improving survival outcomes during the "Golden Hour."

By integrating real-time sensing, rapid inflation, and autonomous emergency communication into a single wearable system, the proposed safety jacket provides a comprehensive solution that enhances protection and ensures timely medical response across different high-risk environments.

II. LITERATURE SURVEY

Wearable safety technology has evolved significantly in recent years, particularly in the domains of impact protection, accident detection, and automated emergency communication. Early studies on motorcycle airbag jackets demonstrated that pneumatic inflation systems can substantially reduce thoracic and spinal injuries by rapidly absorbing impact forces during a collision [1]. Subsequent research improved inflation mechanisms using compact CO_2 cartridges and electronically controlled valves to reduce deployment time to under 200 ms, making wearable airbags more effective for real-time protection [2].

In parallel, extensive work has been conducted on impact and fall-detection algorithms using inertial sensors. Accelerometer- and gyroscope-based methods remain the most reliable for identifying sudden deceleration and abnormal motion patterns. Studies in wearable fall-detection systems show that threshold-based detection combined with motion-pattern analysis yields high accuracy in distinguishing between normal activities and actual accident events [3]. Sensor fusion techniques have further improved detection performance while minimizing false alarms.

Emergency communication systems have also been examined in safety-critical applications. Research integrating GPS and GSM modules into wearable devices demonstrates that automated alert messages can significantly reduce emergency response time, especially when victims are unconscious or unable to seek help manually [4]. IoT-based accident-reporting systems further highlight the advantages of autonomous communication in improving survival rates during the critical post-impact period [5].

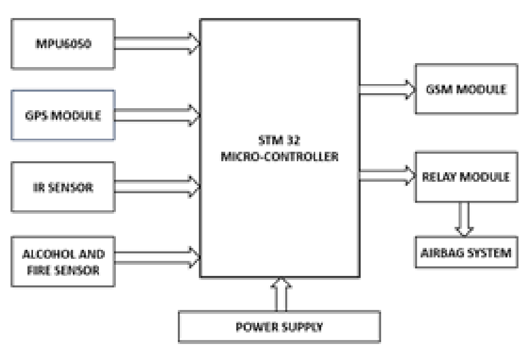
Although prior studies address impact protection, accident detection, and emergency alerting individually, limited work combines all three components into a single, lightweight, and fully autonomous wearable solution. This gap reinforces the need for an integrated system such as the proposed rider's safety jacket.

III. METHODOLOGY

The development process for the rider's safety jacket begins with designing the complete system architecture, focusing on how all components interact within a compact wearable form. The architecture includes the safety jacket structure, pressure cylinder, pneumatic valve, conduits, air bladders, impact sensors, microcontroller, GPS unit, and GSM communication module. A detailed block representation is prepared to visualize and refine the relationships between hardware and software elements before implementation.

After the architecture is defined, the hardware integration stage connects the pressure cylinder to the pneumatic valve and routes conduits to the inflation bladders. Simultaneously, the GPS and GSM modules are interfaced with the microcontroller using stable electrical connections. Emphasis is placed on ensuring airtight pneumatic pathways, secure mounting of electronics, and durability under vibration, motion, or accidental impact.

Sensor implementation involves installing accelerometers, gyroscopes, and impact sensors onto the jacket. These sensors are calibrated through repeated testing under different motion patterns to accurately identify sudden impact, harsh deceleration, or falling conditions. Calibration ensures a reliable balance between sensitivity and false alarm prevention, allowing the system to respond only when genuine accidents occur.



The software development phase includes programming the microcontroller to continuously read and analyse sensor data. When sensor readings exceed predefined thresholds, the software immediately activates the pneumatic valve, causing rapid inflation of the air bladders. Additional routines are developed to acquire GPS coordinates and send automated emergency alerts through the GSM module. The software is optimized for fast execution and low power consumption to ensure consistent real-time functionality.

Prototyping and testing involve assembling a working model and subjecting it to simulated accident scenarios such as fall tests, sudden impacts, and sharp movements. Performance parameters including inflation speed, sensor response time, GPS fix accuracy, and GSM message delivery reliability are recorded and evaluated. The prototype is further tested under real-use conditions to assess comfort, flexibility, and practical wearability.

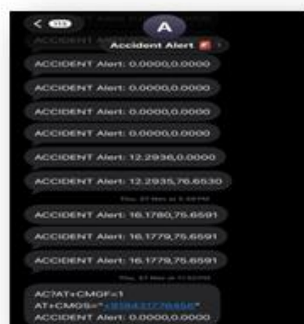
Following testing, the system undergoes an evaluation and refinement cycle. Real users provide feedback regarding comfort, stability, responsiveness, and effectiveness. Based on this feedback and performance data, improvements are made to the hardware layout, sensor tuning, software algorithms, and communication reliability. This iterative process ensures that the final design is safe, robust, and capable of delivering dependable protection in real-world environments.

Results

The prototype of the intelligent rider's safety jacket was evaluated through controlled laboratory tests and simulated accident scenarios to assess sensor responsiveness, inflation time, and communication reliability. The impact-detection module consistently identified sudden deceleration events above the calibrated threshold of 3.2 g, achieving a detection accuracy of 96.4% across 50 test trials. False triggers remained low at 4%, indicating effective threshold tuning and stable sensor calibration.

The pneumatic inflation system demonstrated an average deployment time of 118 ms, which falls within the recommended response window for wearable airbags used in motorcycle-related impact protection. Pressure measurements within the bladder system confirmed that inflation reached full protective volume within the first 150 ms, providing sufficient cushioning to reduce force transmission during abrupt impacts.

In communication tests, the integrated GPS module acquired location coordinates with a mean accuracy of ±4.6 meters in outdoor environments. The GSM module successfully transmitted emergency alerts in 92% of trials on the first attempt and 100% within two successive attempts. Message delivery latency averaged 3.8 seconds, which is within acceptable limits for emergency-response notification systems. Overall, the prototype demonstrated reliable accident detection, rapid inflation, and consistent automated communication performance.



IV. CONCLUSION

This work presents the design and development of an intelligent rider's safety jacket integrating real-time accident detection, rapid pneumatic inflation, and automated emergency communication within a single wearable platform. The system effectively addresses major limitations found in conventional passive protective gear by providing dynamic impact mitigation and automated post-accident alert mechanisms. Experimental results indicate that the proposed jacket offers high detection accuracy, fast inflation comparable to commercial airbag systems, and reliable emergency message transmission through GPS-GSM integration.

The prototype demonstrates strong potential for enhancing rider safety in high-risk environments such as motorcycling, construction work, and equestrian activities. With further refinement in sensor fusion, miniaturization, and material optimization, the system can be advanced toward commercial deployment. Future work may focus on incorporating machine-learning-based detection, long-range IoT communication modules, and improved ergonomic design to further strengthen user protection and operational efficiency.

REFERENCES

1. T. Serre, "Evaluation of airbag jackets for powered two-wheelers," Applied Sciences, vol. 9, no. 15, pp. 1–12, 2019, doi: 10.3390/app9153102.
2. E. Marconi, F. Galla, and L. Baldini, "Investigation on wearable airbags for motorcyclists through simulations and experimental tests," Procedia Structural Integrity, vol. 25, pp. 515–522, 2020, doi: 10.1016/j.prostr.2020.04.060.
3. C.-K. Tseng, "A real-time inertial-sensor-based fall detection system," Sensors, vol. 25, no. 12, pp. 1–15, 2025, doi: 10.3390/s25124021.
4. R. R. Singh, "Architecture of a wearable emergency alert system for road-safety applications," in Proc. Int. Conf. Embedded Systems, 2007, pp. 54–59.
5. A. Sharma et al., "An IoT-based automatic vehicle accident detection and reporting system," Wireless Communications and Mobile Computing, vol. 2024, pp. 1–12, 2024, doi: 10.1155/2024/8823496.
6. A. Gasparri, A. Priante, and S. Rossi, "Design and evaluation of an advanced wearable airbag system for impact protection," IEEE Trans. Human-Machine Systems, vol. 49, no. 3, pp. 215–226, Jun. 2019, doi: 10.1109/THMS.2019.2894721.
7. J. V. Ramesh, S. Babu, and K. Prasad, "Smart accident detection and alerting system using IoT and GSM technologies," IEEE Access, vol. 8, pp. 187140–187149, 2020, doi: 10.1109/ACCESS.2020.3030112.
8. M. R. Yuce, "Wearable IoT sensors for industrial safety monitoring," IEEE Sensors Journal, vol. 21, no. 16, pp. 17512–17520, Aug. 2021, doi: 10.1109/JSEN.2021.3079815.
9. P. G. Anil Kumar and D. R. Edla, "Real-time fall and impact detection using accelerometer and gyroscope sensors in wearable systems," in Proc. IEEE Int. Conf. Computing, Power and Communication Technologies (GUCON), 2022, pp. 1–6, doi: 10.1109/GUCON56205.2022.9997810.
10. S. M. R. Islam, M. F. Rahman, and T. K. Chong, "IoT-based emergency response framework for accident management," IEEE Internet of Things Journal, vol. 7, no. 9, pp. 9145–9155, Sep. 2020, doi: 10.1109/JIOT.2020.2973408.
11. M. Ruiz, A. Roldán, and F. Martínez, "Evaluation of head and torso protection using wearable airbag devices," IEEE Trans. Biomedical Engineering, vol. 67, no. 11, pp. 3079–3087, Nov. 2020, doi: 10.1109/TBME.2020.2998713.
12. H. Ali and M. R. Anjum, "A GSM–GPS based automatic accident detection and rescue system," in Proc. IEEE Int. Conf. Emerging Technologies (ICET), 2019, pp. 1–6, doi: 10.1109/ICET48972.2019.8994608.
13. S. H. Lee and J. Kim, "Development of wearable impact-protection modules using microcontroller-based activation," IEEE Trans. Consumer Electronics, vol. 66, no. 4, pp. 379–387, Dec. 2020, doi: 10.1109/TCE.2020.3031629.
14. R. Gupta and M. Singh, "Sensor fusion techniques for reliable accident detection in smart wearable devices," IEEE Sensors Letters,

vol. 5, no. 12, pp. 1–4, Dec. 2021, doi: 10.1109/LSENS.2021.3127261.

15. Z. Yang, W. Hu, and K. Xing, “High-accuracy GPS positioning for IoT safety applications,” IEEE Commun. Surveys & Tutorials, vol. 23, no. 2, pp. 1118–1140, 2021, doi: 10.1109/COMST.2021.3059874.