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# Advancing Safety Standards with Real-Time Embedded Smart Jacket

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**Abstract:** This review paper investigates how technologically advanced safety jackets can be made safer for miners by incorporating innovative technologies. The study analyses existing hazard difficulties and the unique risks encountered by miners, with a focus on addressing the major safety issues in mining. In addition to highlighting the creative use of Atmega 328p and NodeMCU controllers in safety wearables, the study looks at how these smart jackets provide protection and can even save the lives of miners working in unsafe conditions. This paper provides a thorough analysis of how innovative safeguarding jackets are set to transform safety standards in the mining sector, highlighting a major shift towards making sure the welfare and security of underground workers. It does this by reviewing recent literature and technological advancements.

**Keywords:** Safety jacket, Real-time monitoring, IoT- enabled application, Miner safety.

## I. INTRODUCTION

The production of energy across the globe has long depended on the mining sec-tor. Nonetheless, the prosperity of this sector entails the need to provide the security and welfare of miners, who works in hard, demanding conditions below the surface of the Earth.

One innovative way to address the risks they encounter on a daily basis is the creation and application of sophisticated safety jackets specifically made for miners. Modern safety jackets are the subject of a thorough examination aimed at enhancing and protecting miners' lives. Examining the present safety concerns in mining, the particular difficulties that miners have, and how cutting- edge safety jackets driven by Atmega 328p and NodeMCU controllers might transform the industry's safety requirements. Since sophisticated mining equipment has been developed, miner safety has significantly improved.

With the development of sophisticated safety jackets for miners, driven by Atmega 328p and NodeMCU controllers, a major improvement in miner safety has been realized. These jackets are protective gear designed especially to satisfy the unique needs of miners; they are also smart, life-saving companions. The mining industry's standards for safety and emergency response are raised by their integration of real-time networking, gas detection, fall detection, and health monitoring. These advancements show our commitment to safeguarding the lives of subterranean labourers and ensuring them safe return home at the conclusion of each shift.

The objective of this paper is to transform miner safety by incorporating cut-ting-edge technologies into wearable gear. These jackets have sensors that detect gases, such as methane and carbon monoxide, which are frequent in deep mines. By alerting miners to these gases, the jackets can avert explosions or poisoning. Moreover, accelerometers are used by the fall detection system to identify abrupt movements or falls, promptly alerting emergency response teams to potentially dangerous situations. An additional important function of these jackets is health monitoring. Through constant monitoring of vital signs like body temperature and heart rate, the device can detect indicators of health decline or discomfort.

## II. REVIEW ON DIFFERENT WORKING PRINCIPLE AND TECHNOLOGIES

Various types of real-time smart jackets for enhanced personal safety rely on diverse working principles and technologies.

### A. Gas System Integration

An important development in gas detection systems is the use of several sensors, which guarantees thorough monitoring of dangerous gases. The MQ-5 sensor for methane, the MQ-2 sensor for propane/butane, and the MQ-8 sensor

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for hydrogen is combined to provide a comprehensive approach to gas detection in the system. This improves detection precision and permits prompt reactions to possible threats, which is essential for next generation gas detection systems. The system's capacity to identify a broad variety of gases is improved by the seamless coordination of various sensors, providing preemptive measures to successfully reduce gasrelated hazards.

### B. Accelerometer System

One significant development is the use of accelerometer sensors into a variety of applications, particularly those designed for fall detection systems in the elderly. Using advanced frameworks such as Neyman- Pearson detection, this integration deviates from conventional techniques by optimizing detection thresholds for increased accuracy. Using accelerometer sensors—like the ones in the TelosW mote— ensures accurate movement data recording, which improves the system's ability to detect possible falls without being intrusive. This integration provides a dependable and unobtrusive solution that allows senior citizens to keep their mobility while guaranteeing ongoing fall monitoring for their safety. Beyond accuracy, the advantages include proactive fall prevention, as prompt alarms and actions lower elders' risk of suffering catastrophic injuries.

### C. Heart Rate Monitoring System

Heart rate monitoring is essential for tracking fitness and health using wearables like the SFH7051, which uses sensors to give real-time cardiovascular health information. With the help of this proactive function, users can identify abnormalities quickly and take early action to address potential health problems like arrhythmias. In general, heart rate monitoring encourages proactive steps for pre-serving cardiovascular wellbeing and leading to a healthy lifestyle by providing users, families, and healthcare providers with essential information.

### D. Real-Time GPS Tracking System

Accurate position tracking is made possible via real- time GPS tracking, which is mostly used in emergency response systems such as ambulances. Real-time GPS tracking works by using GPS modules to continuously send a worker's coordinates to a central server. This function updates personnel' whereabouts in real time, ensuring timely emergency response. Additionally, it improves the effectiveness of transportation by making route optimization and traffic navigation easier, which eventually results in time and resource savings. Additionally, it improves security and safety by enabling law enforcement to keep a close eye on employee movements and react quickly to events, providing comfort to both employees and service providers. All things
considered, real-time GPS tracking has numerous ad- vantages for all kinds of businesses, enhancing productivity, security, and employee happiness.

### E. Temperature Sensor Monitoring System

Healthcare systems rely heavily on temperature sensor monitoring, which makes it possible to continuously watch patients' body temperatures and obtain vital health information. This function quickly identifies unusual temperature readings, alerting users to possible health problems like fever or hypothermia. Health issues can be stopped from getting worse with prompt medical attention. Furthermore, by offering a non-invasive means of ongoing monitoring and reducing interference with their rest and recuperation, temperature sensor monitoring im-proves patient comfort. It makes remote monitoring possible, doing away with the necessity for regular physical temperature checks. To put it simply, temperature sensor monitoring is essential to contemporary healthcare since it provides pre-emptive treatments for the best possible care and wellbeing as well as real-time insights into patient health.

### F. ThingSpeak Integration

ThingSpeak is an open-source Internet of Things (IoT) analytics platform developed by MathWorks that allows users to collect, store, analyze, visualize, and act on data from various sensors or devices. Designed for ease of use, ThingSpeak facilitates real-time data collection and supports data transmission over HTTP and MQTT protocols, making it suitable for a wide range of IoT applications. Users can create both public and private channels for data storage, ensuring that sensitive information remains secure.

A key feature of ThingSpeak is its integration with MATLAB, which enables users to perform advanced data analysis and visualization directly within the platform. This integration supports various analytical tasks such as filtering, data smoothing, pattern recognition, and more, allowing for sophisticated real-time data processing. Users can visualize their

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data through a variety of tools provided by ThingSpeak, including customizable charts, gauges, and maps, which make it easier to monitor and interpret sensor data. Dashboards can be tailored to display the most critical data in a user-friendly manner. In addition to data visualization, ThingSpeak offers the ability to set up triggers and alerts based on specific data conditions. This feature allows users to respond to changes in data in real-time by sending notifications, activating other devices, or taking other actions when predefined thresholds are met. The platform's RESTful API provides developers with a flexible way to access and manipulate data, enabling seamless integration with other applications and services.

## III. Literature Review

In order to verify the efficacy of the suggested model, the literature review integrates conclusions from multiple investigations that have assessed analogous methodologies via simulations and actual situations.

These analyses shed light on the advantages, difficulties, and possible drawbacks of putting in place a cutting-edge safety monitoring system for miners' jackets. The research examined in this study explores how modern technologies like Internet of Things (IoT), cloud computing, and Global Positioning System (GPS) are used in smart wearable devices for miners. These technologies are shown in the papers to have the capability to boost safety measures in mining settings, speed up emergency responses, and enhance overall worker efficiency.

The paper [1] proposes a gas detection and notification system comprising sensors for hydrogen, LPG, and methane connected to an Arduino controller. This system activates different components including lamps (green indicating safety, yellow for medium risk, and red for danger), an exhaust fan, buzzer, LCD display, and GSM module for SMS alerts. Notably, it has been successfully tested up to 50 inches.

The paper [2] introduces a fall detection system targeted at the elderly, aiming to enhance their safety and well- being. This system utilizes accelerometer data and an optimized detection framework to achieve a balance between accuracy and false alarms. Its objective is to provide an effective solution for detecting falls and alerting caregivers promptly, thus ensuring the elderly's safety.

The paper [3] presents a gas detection device aimed at preventing environmental disasters in industries and vehicles, particularly emphasizing safety in the after-math of India's tragic Bhopal Gas Tragedy. It is designed to detect gas leaks and avert potential catastrophes by providing early warnings.

The paper [4] presents a user-friendly solution for medication adherence. A wearable device monitors heart rate, triggering a vibration and email reminder when significant changes occur, ensuring timely medication intake.

The paper [5] focuses on an IoT-based system that connects smart devices to enhance daily life, including health monitoring. This system collects patient data and advises medical steps, prioritizing accurate health assessment.

The paper [6] introduces an IoT project for enhancing paramedic services in densely populated areas. Ambulances with GPS and GSM modems send coordinates to a cloud server during emergencies for route calculation. The system integrates GSM Module SIM900A, Arduino UNO, and cloud computing, aligning with traffic signals to mitigate gridlock in emergency services.

The paper [7] presents a smart helmet for coal miners, utilizing Zigbee technology and sensors for gas, temperature, and humidity. It wirelessly communicates with a control station to alert miners of hazardous conditions, significantly improving safety and response times in coal mines.

## IV. Proposed Methodology

We are proposing a model that relies on the literature review to offer a thorough method that incorporates findings from previous research and adds to the body of knowledge already available on the topic.

A complete analysis of the body of research is required to develop a real-time smart jacket that complies with strict safety regulations our suggested method aims to fill important gaps in the area and add to the body of knowledge by combining ideas from different studies with their ability to process and analyse massive amounts of data in real-time via cloud-based infrastructure real-time smart jackets represent a paradigm change in personal safety by continuously monitoring ambient conditions wearer biometrics and contextual elements to deliver proactive alarms and help these jackets offer unmatched benefits above standard safety gear the wearers safety is improved in a variety of settings and optimal situational awareness is ensured by this dynamic analysis.

 

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Careful planning is necessary during the design process in order to convert conceptual requirements into a reliable solution this stage forms the basis for specifying the smart jackets hardware and software architecture including parts modules interfaces and data structures in addition to having an impact on the end products quality system design detail makes scalability and smooth integration possible our smart jacket design blueprint has autonomous guiding elements that use cloud data to provide the wearer with timely alerts and recommendations this sets new standards for wearable technology usability and safety.

The Fig. 1 illustrated shows the block diagram of the Proposed System having all the sensors connected to Atmega328p microcontroller, the data is then sent to cloud server as shown in the figure.

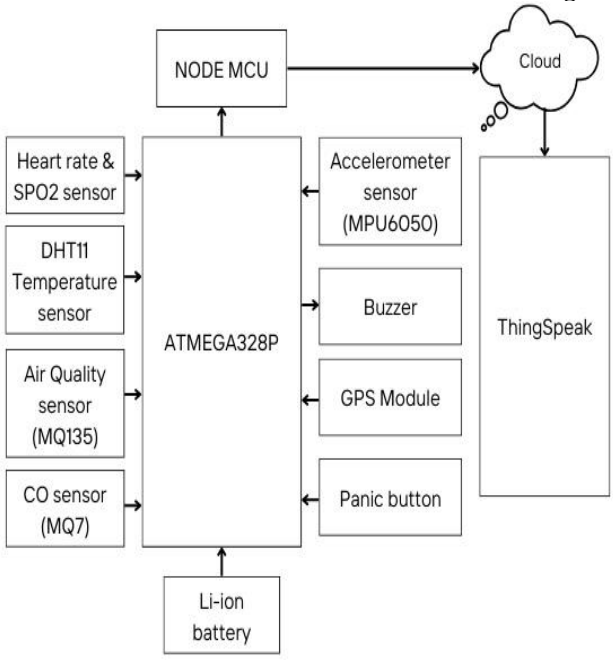


**Fig. 1** Block Diagram of the Proposed System

- Our system's brain is the Atmega328p mini-computer, which talks to various sensors like an activity sensor, heart rate monitor, blood oxygen checker, temperature gauge, GPS tracker, and air quality detectors.
- The Atmega328p processes data from gas and carbon monoxide sensors, and NodeMCU helps in sounding alarms if the air quality is bad.
- The Atmega328p also keeps an eye on the miner's movements through an activity sensor and can raise an alert if someone falls. NodeMCU then shares the GPS location.
- It monitors the heart rate and lets us know if something unusual is happening through alerts sent by NodeMCU.
- The blood oxygen levels are checked by the Atmega328p, and if they are low, NodeMCU sends out alerts.
- The GPS tracker in NodeMCU helps in tracking the exact location of the miners in real-time, especially during emergencies.
- There's a panic button on NodeMCU, which, when pressed, sends emergency signals to the central system and triggers loud alarms.
- Using the Blynk mobile app, NodeMCU keeps us updated with real-time information about gas levels, heart rate, blood oxygen, and GPS locations. The Atmega328p also keeps an eye on the temperature, warning miners if it gets too hot.

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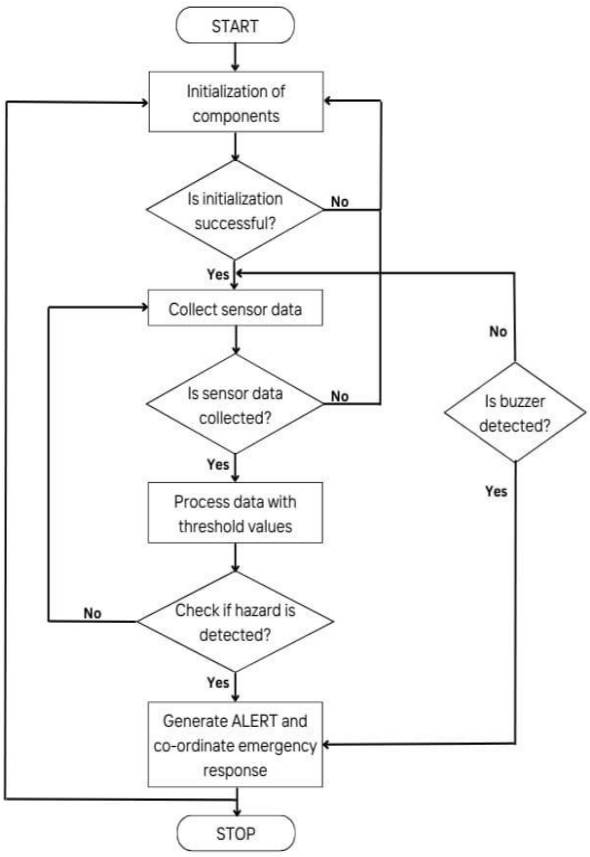


**Fig. 2** Flowchart of the Proposed Methodology

The flowchart illustrates the interactions and features of the real-time smart jacket system, emphasizing proactive monitoring and reaction mechanisms to ensure user safety which is shown in the following:

- The smart jacket system is initialized by the user.
- Real-time sensor data, including biometric and environmental data, is collected by the system.
- Predetermined thresholds are used in the processing of data to identify anomalies or risks.
- The system sends out a warning if it detects an emergency.
- The user can modify system settings to a limited extent, but they cannot enter or manage data.
- System settings and data can only be managed by authorized administrators.

A popular dual H-bridge integrated circuit for efficiently driving DC motors and stepper motors is the L298N motor driver. This integrated circuit is appreciated for its adaptability and stability in a variety of applications, including robots and DIY projects.Its dual H-bridge configuration allows both motors to be freely controlled. The L298N provides strong performance with a voltage handling capacity of up to 46V and a current rating of 2A per bridge. It has basic safety protections that protect the hardware from back electromagnetic fields, such as implicit flyback diodes. In addition, its compatibility with well-known microcontrollers like Arduino and Raspberry Pi makes it accessible to a wider user base. Additionally, the L298N has a heat sink for efficient intensity dissipation, which ensures steady performance even under demanding loads.

## V. Conclusion And Future Directions

To validate the effectiveness of our proposed real-time smart jacket, the literature survey incorporates insights from various studies that have evaluated similar approaches through simulations and real-world testing. These evaluations shed light on the benefits, challenges, and potential limitations of integrating advanced safety features into wearable technology.

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In conclusion, our proposal presents a novel approach that combines wearable personal safety technology with state-of-the-art technology in a seamless fashion. Our smart jacket improves user safety and situational awareness in a variety of scenarios by utilizing cloud computing and cutting-edge sensor technologies. With its real-time alerts and user support, this model is a major development in personal safety solutions. In the future, we want to achieve continuous progress through ongoing research and development activities, and we are dedicated to perfecting and putting our model into practice for real- world applications. We are confident that our smart jacket will improve personal safety and redefine expectations for wearable technology, all while keeping an eye on innovation and practicality.

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Their commitment to excellence and willingness to go above and beyond have had a profound effect on our project. As we move forward, we bring with us the skills and information we have acquired from their mentoring. We truly appreciate all of the lab staff members' vital contributions to our academic and professional development.

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