LORA BASED SMART HELMET FOR SAFETY AND MONITORING OF COAL MINERS

Project Reference No.: *49S_BE_5898*

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Keywords:
Long Range (LoRa) , IoT (Internet of Things) , Industrial IoT (IIoT)

Introduction:

Underground mining is inherently hazardous, with workers facing threats such as toxic gas exposure, poor air quality, unstable terrain, and limited communication. Traditional safety and monitoring systems often fall short in deep or remote mining environments, leaving miners vulnerable to life-threatening conditions. To address these challenges, this project introduces a LoRa-based smart helmet designed for real-time environmental monitoring and enhanced worker safety. The helmet is equipped with sensors to detect toxic gases, oxygen levels, temperature, and humidity. Utilizing LoRa technology, the system ensures long-range, low-power communication, transmitting critical data to a central platform that provides live updates and automated alerts. This innovation aims to improve situational awareness, enable faster emergency response, and significantly enhance the safety and efficiency of underground mining operations.

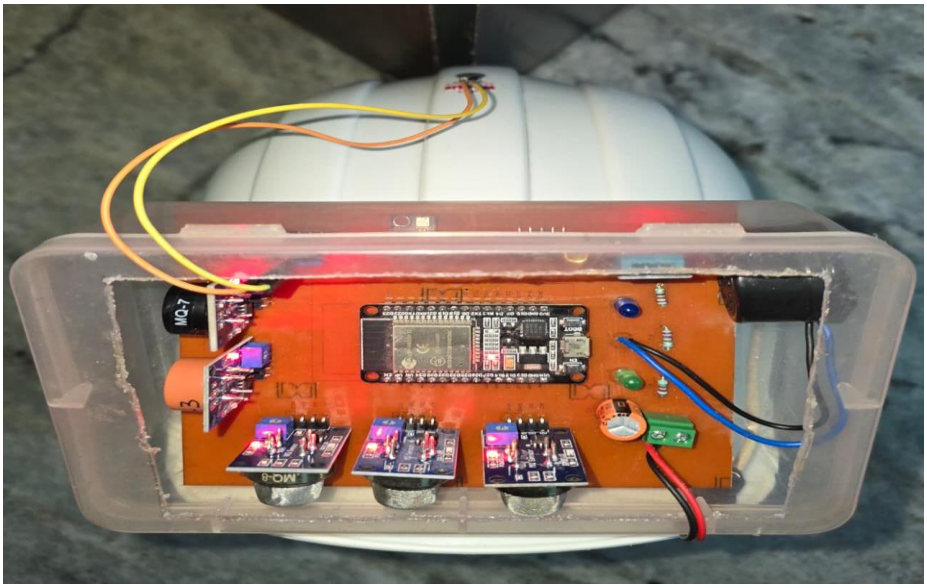

Figure 1. Helmet Prototype

Objectives:

1. To Develop a LoRa-based communication system for real-time data transmission from the smart helmet to a central monitoring platform.
2. To Integrate advanced sensors for detecting harmful gases, monitoring miner health.
3. To Create a software platform for visualizing sensor data, providing real-time alerts, and enabling quick safety responses.

Methodology:

The methodology adopted for developing the Smart Helmet Safety Monitoring System is structured into systematic stages to ensure reliability, real-time performance, and user safety. The proposed system uses a LoRa-enabled smart helmet integrated with environmental and safety sensors to continuously monitor hazardous gases, temperature, and humidity in underground mines. Sensor data is processed using a microcontroller and transmitted over long distances to a central monitoring application via a cloud backend. Predefined safety thresholds are used to detect hazardous conditions and trigger real-time alerts to both the miner and the supervisor, enabling quick preventive and emergency actions.

Result and Conclusion:

In conclusion, the “LoRa Based Smart Helmet for Safety and Monitoring of Coal Miners” was successfully developed using an ESP32 microcontroller, gas sensors, and LoRa communication. The system enables real-time data acquisition, cloud storage, and live dashboard visualization of safety parameters. It accurately detects hazardous conditions and provides timely alerts, improving worker safety. The project demonstrates reliable performance in underground environments and addresses challenges like sensor calibration and communication stability. It highlights the feasibility of integrating Industrial IoT into mining for intelligent safety monitoring.

Project Outcome & Industry Relevance

The key outcomes of the proposed system include:

- Development of a working prototype of the Smart Helmet equipped with sensors for environmental and health monitoring.
- Design and implementation of an Android-based application for supervisors to monitor workers in real time.
- Creation of a cloud-integrated dashboard for real-time data visualization, enabling remote access to critical parameters and analytics.

This project holds significant relevance in the mining and industrial safety sector, particularly in underground coal mines and other high-risk work environments.

Working Model vs. Simulation

The working model of this project demonstrates its practical implementation as compared to simulation-based approaches.

- The project is developed as a real-time working hardware prototype.
- ESP32 and sensors are used for actual data acquisition and processing.
- Demonstrates complete integration of hardware, software, and cloud systems.

Project Outcomes and Learnings

The project outcomes and learnings explain what we learned and experienced during the development of this system.

- Gained hands-on experience in IoT and embedded systems using ESP32.
- Understood challenges in real-time system synchronization.
- Developed understanding of LoRa for long-range communication.

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Future Scope:

The future scope of this project includes:

1. Addition of health monitoring sensors like heart rate and SpO_2.
2. Implementation of vibration or voice-based alert systems
3. Development of compact and ergonomic helmet design.