Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, June : 2024

SMART HELMET BASED PROXIMITY WARNING SYSTEM AND GAS DETECTION FOR UNDERGROUND MINE WORKERS

[1]Polinati Srinivasu, [2]Kasarapu Hysritha Sai, [3]Gujjaru Chandini, [4]Rachakonda Gayatri Swathi, [5] Padamati Lakshmi Sree
[1]Associate Professor, [2,3,4] UG Scholar, VIGNAN's Institute of Engineering for Women, Visakhapatnam, India
hysritha@gmail.com,chandnigujjaru.998@gmail.com

ABSTRACT.
In industries where safety hazards are prevalent, such as construction sites, factories, or mining operations, ensuring the well-being of workers is paramount. To address this, we propose a Smart Helmet-based Proximity Warning System integrated with Gas Detection.
The system employs wearable smart helmets equipped with sensors to monitor both proximity to potential hazards and the presence of harmful gases in the environment. The proximity warning system utilizes RFID module to detect obstacles or hazardous zones within the vicinity of the worker. When a hazardous condition is detected, the helmet alerts the wearer through visual cues, thereby enabling them to take appropriate precautionary measures. By integrating proximity warning and gas detection functionalities into appropriate precautionary measures. By integrating proximity warning and gas detection functionalities into a single wearable device, the proposed system provides comprehensive safety monitoring for industrial workers, enhancing their awareness of potential hazards and minimizing the risk of accidents or injuries.

Keywords:
Smart Helmet, Proximity Warning System (PWS), Gas Detection, Radio Frequency Identification (RFID).

1 INTRODUCTION

The mining industry is crucial to global economies, supplying essential raw materials for construction, manufacturing, and energy production. However, underground mining operations pose significant safety challenges due to confined spaces, exposure to toxic gases, and heavy machinery. Despite safety regulations and technologies, accidents persist, necessitating innovative solutions for worker safety.
Worker safety in underground mines is often compromised by collisions between equipment and pedestrians or other machinery. To mitigate these risks, proximity warning systems (PWSs) have been developed to alert workers to approaching hazards. These systems provide visual and/or audible alerts to equipment operators, pedestrians, or other machinery when they come within a certain distance of each other. Construction workers face various dangers associated with exposure to harmful gases while working in confined spaces. Previous studies have identified hydrogen sulphide (H2S), methane (CH4), carbon monoxide (CO), and ammonia (NH3) as prevalent gases encountered in such environments.
The concept of a smart helmet offers a promising solution by continuously monitoring the surrounding environment using wireless sensors and communication technologies. Powered by a reliable microcontroller such as the ESP32, the smart helmet serves as a proactive guardian for miners. Smart Helmet can detect dangers before they occur. It is equipped with gas sensors that can detect harmful gases like methane and carbon monoxide, as well as proximity sensors that alert miners to nearby machinery or obstacles. This early warning system helps miners make quick decisions to stay safe. The proximity warning system embedded within the Smart Helmet is a sophisticated safety feature specifically engineered to detect and alert miners to potential hazards in their immediate surroundings.

2 LITERATURE SURVEY

[1] Kim, Yeanjae, Jieun Baek,Yosoon Choi - Smart helmet-based proximity warning system for

underground mine workers 2021. The Smart Helmet-based Wearable Personnel Proximity Warning System (PWS) offers a robust solution for enhancing safety in mining environments. By using Bluetooth beacons and LED warnings, it prevents collisions in real-time. Summary: From this article, I have considered the concept of the Bluetooth Low Energy signals and Proximity Warning System. [2] Baek, Jieun, Yosoon Choi- Bluetooth-beacon-based underground proximity warning system for preventing collisions inside tunnels 2018. To address collisions in underground tunnels caused by limited visibility and tight working spaces, a Bluetooth-beacon-based warning system has been proposed. This system receives signals from Bluetooth beacons attached to mine workers and equipment via smartphones in vehicles. It provides drivers with primary and secondary alerts based on signal intensity, helping them avoid collisions. Summary: From this article, I have considered the concept of Bluetooth beacons and generation of alerts. [3] Sharma, Mayank, Tanmoy Maity,2018 - To address the safety challenges in underground mines, this work proposes the use of a mobile wireless sensor network integrated into miners' safety gear. Each node on the gear contains various sensors and a microcontroller to monitor parameters like flammable and noxious gases. The system generates alarms and light indicators to alert miners of dangerous conditions. Additionally, it wirelessly transmits data to a control room, keeping responsible personnel informed. This prototype model aims to enhance safety in underground mines by providing real-time monitoring and alerts for potentially life-threatening situations.

3 EXISTING METHOD

The existing method for the proximity warning system (PWS) based on Bluetooth beacons and smart helmets revolves around the seamless interaction between the two key components. In this system, the smart helmet worn by the worker acts as a pivotal receiver, capable of detecting Bluetooth Low Energy (BLE) signals transmitted from strategically deployed Bluetooth beacons throughout the mine site.

Upon reception of a BLE signal, typically emitted by a beacon attached to heavy equipment, management vehicles, or hazardous areas, the smart helmet promptly triggers a visual alert. This alert serves as a real-time warning mechanism, notifying both the wearer of the smart helmet and nearby equipment operators or drivers of the worker's proximity to the beacon. By facilitating immediate proximity alerts directly through the smart helmets, this system empowers workers and equipment operators to swiftly identify and respond to potentially hazardous situations, thereby enhancing overall safety within the mine environment.

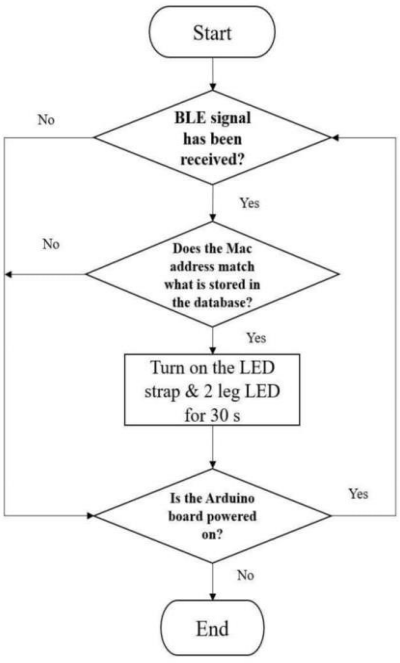

Fig.1. Flow Chart of Existing Method

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, June : 2024

4 PROPOSED METHOD

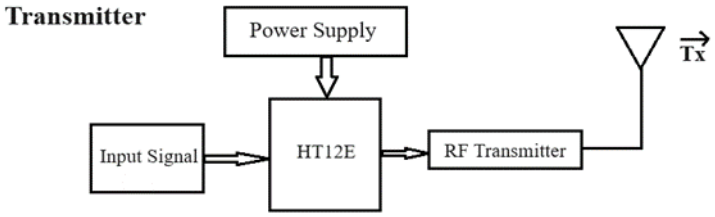

Fig.2. Transmitter Section

The transmitter section features an HT12E RF transmitter powered by an 11.1V lithium-ion battery, ensuring efficient wireless communication. Proper wiring establishes a secure power supply, vital for the transmitter's operation, with attention to voltage compatibility and insulation to prevent damage or short circuits.

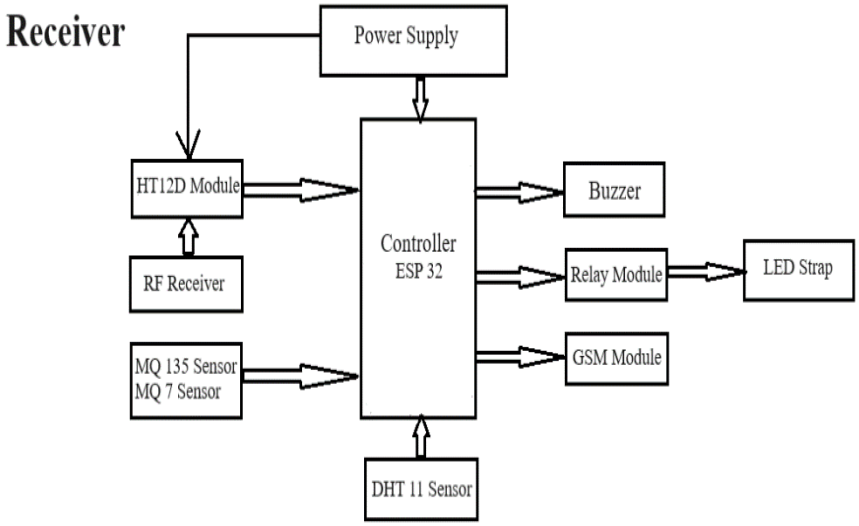

Fig.3. Receiver Section

On the receiver side, components such as the ESP32 microcontroller, HT12D module, RF receiver, gas sensors (MQ-135 and MQ-7), temperature/humidity sensor (DHT11), buzzer, relay module, GSM module, LED strap, and power supply form a comprehensive system. The ESP32 serves as the central controller, orchestrating sensor data collection and system operation. Gas sensors monitor air quality, while the temperature/humidity sensor ensures effective environmental control.

The buzzer provides audible alerts, the relay module enables device control, and the GSM module facilitates remote communication via SMS or GPRS. The HT12D RF receiver extends wireless communication capabilities, and the LED strip offers visual feedback. This integrated system, driven by the ESP32 microcontroller, delivers versatility, intelligence, and connectivity, enabling applications like home automation, environmental monitoring, safety systems, and remote control. Each component contributes to the system's functionality, ensuring effectiveness in various real-world scenarios.

5 RESULT ANALYSIS

The hardware setup for the smart helmet-based proximity warning system consists of various components, each serving a specific function in ensuring the safety of miners in underground mines. These components include the HT12D and HT12E encoder and decoder ICs, the DHT11 temperature and humidity sensor, a relay for controlling warning devices, the ESP32 microcontroller acting as the central control unit, an LED strip for visual alerts, a lithium battery for power, and a dot board for soldering and organizing connections.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, June : 2024

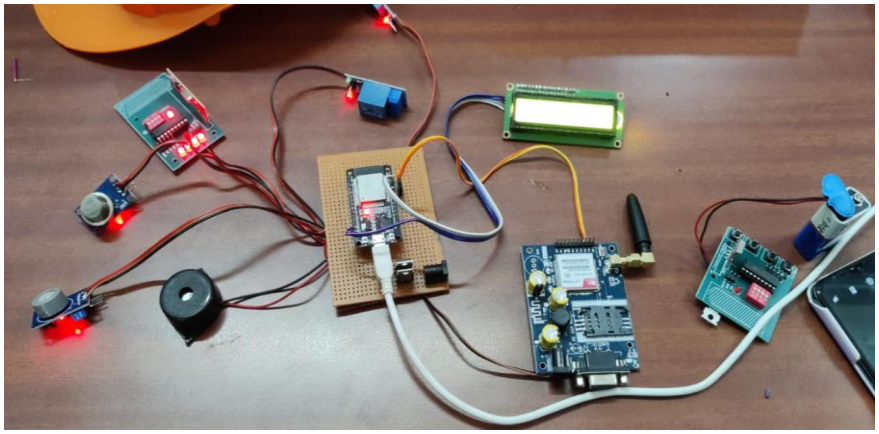

Fig.4. Hardware Setup

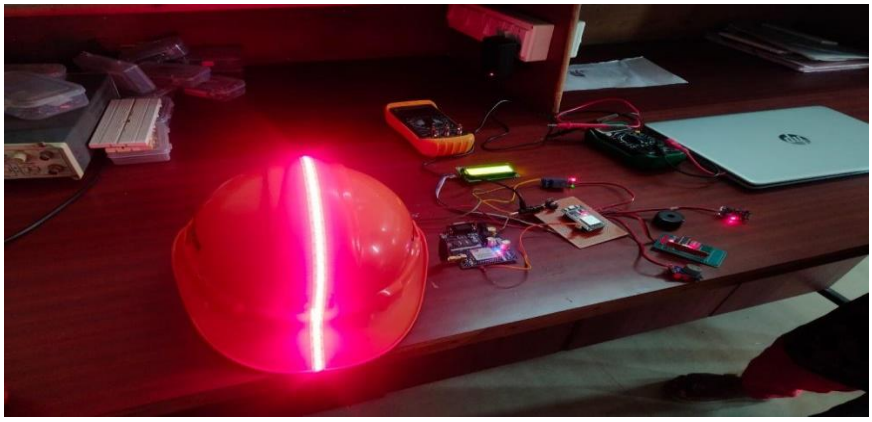

Fig.5. The output of Smart Helmet

The ESP32 analyses incoming data to detect the proximity of equipment or other workers, triggering visual and auditory alerts through the LED strip and buzzer if a collision risk is identified.
Additionally, the system's gas detection capabilities play a pivotal role in ensuring miner safety. If the gas sensors detect hazardous gas levels surpassing predefined thresholds, the ESP32 promptly activates alerts, warning the wearer of potential danger through the buzzer and LED strip.

Fig.6. Alerts through SMS

Moreover, the GSM module can be engaged to transmit SMS alerts to designated recipients, such as supervisors or emergency services, providing them with crucial information regarding hazardous gas levels in the mine.

6 CONCLUSION

In this paper, the development of the RF Module-Based Smart Helmet Proximity System addresses the concerns of collisions between equipment and pedestrians, as well as monitoring air quality for hazardous gases, this innovative system offers a comprehensive solution to mitigate risks and protect the well-being of miners. Through the integration of RF modules and gas detection sensors, the system not only provides real-time alerts to prevent accidents but also facilitates seamless communication among workers and supervisors. This holistic approach fosters enhanced situational awareness, enabling prompt responses to potential hazards and promoting a safer working environment underground.

Ultimately, the RF Module-Based Smart Helmet Proximity System stands as a beacon of innovation in mine safety, poised to significantly reduce the likelihood of accidents and safeguard the lives of miners.

REFERENCES

[1] Kim, Yeanjae, Jieun Baek, and Yosoon Choi. "Smart helmet-based personnel proximity warning system for imp roving underground mine safety." *Applied sciences* 11.10 (2021): 4342.

[2] Baek, Jieun, and Yosoon Choi. "Bluetooth-beacon-based underground proximity warning system for preventing collisions inside tunnels." *Applied Sciences* 8.11 (2018): 2271.

[3] Baek, Jieun, and Yosoon Choi. "Smart glasses-based personnel proximity warning system for improving pedestrian safety in construction and mining sites." *International journal of environmental research and public health* 17.4 (2020): 1422.

[4] Battistoni, P., M. Sebillo, and G. Vitiello. "An IoT-Based Mobile System for Safety Monitoring of Lone Workers. IoT 2021, 2, 476–497." (2021).

[5] Deokar, S. R., and J. S. Wakode. "Coal mine safety monitoring and alerting system." *International Research Journal of Engineering and Technology* 4.3 (2017): 2146-2149.

[6] Jo, Byung Wan, Rana Muhammad Asad Khan, and Omer Javaid. "Arduino-based intelligent gases monitoring and information sharing Internet-of-Things system for underground coal mines." *Journal of Ambient Intelligence and Smart Environments* 11.2 (2019): 183-194.

[7] Jo, Byung-Wan, et al. "Proximity warning and excavator control system for prevention of collision accidents." *Sustainability* 9.8 (2017): 1488.

[8] Park, JeeWoong, et al. "Improving dynamic proximity sensing and processing for smart work-zone safety." *Automation in Construction* 84 (2017): 111-120.

[9] Roja. P and D. Srihari. "Iot based smart helmet for air quality used for the mining industry." *Int. J. Res. Sci. Eng. Technol* 4 (2018): 514-521.

[10] Rajakumar, Janani Priyanka Perumpally, and Jae-ho Choi. "Helmet-mounted real-time toxic gas monitoring and prevention system for workers in confined places." *Sensors* 23.3 (2023): 1590.

[11] Sharma, Mayank, and Tanmoy Maity. "Low-cost low power smart helmet for real-time remote underground mine environment monitoring." *Wireless Personal Communications* 102.1 (2018): 149-162.