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COAL MINE SAFETY MONITORING AND ALERTING SYSTEM USING IOT

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***Abstract*— The coal mining industry suffers from various threats, consisting of gasoline decks, fire and a tunnel collapse, which are major risk risks for workers' safety. Traditional monitoring structures are often dependent on guide inspections, which may be inadequate to detect and response from real -time. This article proposes an Internet of Things (IoT) -based security tracking and notification machine designed to reduce these risks. The system continuously monitors the important parameters with methane fuel awareness, temperature, humidity and activist, which speeds up the use of the sensors related to the wireless network. The information is processed and analyzed using a Sky-intelligent-based analysis system, which produces real-time signals while unsafe conditions are detected. The effectiveness of the gadget is evaluated in a false mine environment, which demonstrates its ability to increase safety by providing initial warnings and enabling active intervention. The proposed unit represents a fee power and scalable response to strengthen the safety of coal mines.**

Keywords*— IoT, coal mining safety, environmental monitoring, wireless sensor, real -time alert, dangerous detection

I. Introduction

Coal mining is still an important region of energy production, but it is associated with different environments And security threats. The miners are made aware of the dangers such as gas leaks, fire hazards and the collapse of the tunnel.

Traditionally, coal mines have used periodic inspections and depend on manual monitoring Gas concentrations and environmental conditions as parameters. However, these methods are often Reactive, which leads to delayed reactions in case of dangers. The Rise of Internet of Things (IoT) Technology provides an opportunity to improve security Continuous, real -time monitoring of environmental parameters. The purpose of the proposed system is to find out that Dangerous conditions such as high gas concentrations, abnormal temperature, humidity level and movement to notify security personnel and miners immediately.

In this letter, we design and implement an IoT-based safety monitoring system that integrates different Appeals cloud -based analysis for sensor and real -time warning to detect the danger. We evaluate Demonstrate the system in a false coal mining environment and demonstrate the efficiency Improvement in safety management.

II. Literature review

A. Current Safety System for Coal Mine Historically, coal mines have rely on basic gas sensors and periodic safety management examination. However, manual systems are time consuming and can remember significant signals of potential dangers. Recent progress in IoT technologies has improved the capacity of security systems in coal mines By integrating real -time monitoring. Several studies have proposed IoT-based monitoring systems. Coal mine safety. For example, Zhang et al. (2018) developed a gas detection system based on IoT, Where methane and carbon monoxide concentrations were monitored in real time. Permission for this Quick hazard identification but the system was limited by the dependence of wired communication, which was limited Is unsuitable for underground applications. Other studies have discovered to integrate temperature, humidity and speed sensors with IoT

More comprehensive security system. However, these solutions often face wireless challenges. Censorship calibration in communication reliability, energy consumption and tough underground conditions.

III. System Architecture

Suggested IoT-based coal mines Security system consists of several intermediate layers, as shown Figure 1. The system integrates environmental sensor, a communication network, data processing A vigilant mechanism for providing units and continuous safety monitoring of the time.
A. Sensor layer
The sensor layer consists of different sensors designed to monitor environmental parameters:
• Gas sensor: Methane (CH_4) and carbon monoxide (CO) sensors detect dangerous gas levels Can cause explosion or poisoning. The usual sensors used include the MQ-2 and MQ-7 series.
• Temperature and moisture sensor: These sensors monitor temperature and humidity level Find out abnormal environmental changes that may indicate fire or other danger. DHT22 is The temperature and humidity are used for both monitoring.
• Movement sensor: Passive infrared (pir) sensor is used to detect labor movement and Inactivity. If no movement exists in a dangerous area, it sends notice to the system Control center.
• Vibration sensor: Vibration sensor is used to detect shock or land movements, Which may indicate an adjacent collapse or structural failure.
B. Communication team
The communication layer ensures that the sensor data is well transmitted from the underground sensor For the central system. Many wireless communication protocols are considered:
• Wi-Fi: For coverage areas, Wi-Fi is used to transfer data quickly and well.
• Lura: For Wi-Fi-deficiency areas, Lura (long distance) communication is used. It gives a low effect, Solution with wide area suitable for long distance and challenging environment Underground mines.

• Zigbee: Zigbee is another low -power protocol used for communication of thumbnail, Connect local sensors to the input.
C. Data processing team
Data from the sensor is transferred to the cloud, where it is treated and analyzed in real time. Use Cloud platforms such as AWS IoT or Thingspeak are stored and analyzed using machine learning Algorithms to detect deviations and predict potential dangers. For example:
• Threshold -based notice: If a gas level is higher than a threshold (eg 1.5% methane), the system Sends immediately notice.
• Pattern recognition: By analyzing historical data, the system can predict potential dangers Depending on the pattern, such as an increase in gas levels associated with certain mining activities.

D.ViligilanceSystem
The vigilant mechanism is designed to inform miners and security personnel about dangerous conditions Real time. Notification is sent by pushing information for SMS, e -post and mobile devices, reflecting nature And the father's location. The system can also trigger a sound alarm or flashing light to inform the system Workers immediately on the site.

IV. Execution

A.Hardware Setup
The system was implemented using the following hardware components:
• Gas sensor: MQ-2 (for methane) and MQ-7 (for carbon monoxide) were used to detect gas.
• Temperature and humidity sensor: DHT22 -Sensor was used to monitor the temperature And moisture.
• Movement sensor: PIR sensor was used to locate the activist movement.
• Microcontroller: A Raspberry Pie 4 was chosen as a central controller to collect sensor data And management of communication with clouds.
• Wireless communication module: The system used an ESP8266 Wi-Fi module to transfer Sensor data for the shooter.

B. Software and cloud platform
The system was developed using Pythan for Sensor Data Acquisition, Processing and Communication. Cloud platforms, Thingspek, were used for data visualization and notification. The recining The platform provides the built analysis and visualization tools, making it easier to manage real time data.

C. Data analysis and notify logic
The system uses threshold -based arguments to trigger notice:
• Gas concentration warning: If methane is more than 1.5%, or carbon monoxide is more than 50 ppm, Notification is generated.
• Temperature and moisture warning: If the temperature is more than 45 ° C, or if the moisture falls out Safe range, alerts are triggers.
• To detect speed: If no movement is found for a long time, a worker is a safety warning Organized.

V. Proposed Design

The coal mine's safety monitoring and alert system is designed to increase the safety of miners using IoT Constant environmental conditions and monitoring of mineral health. The system integrates different IoT devices, Data processing unit to detect danger of real time and provide notice and communication networks.

1. System architectural observation

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The system can be divided into the following main components:
• Censorship layers: for real -time data collection.
• Edge Computing Layer: For data preprocoming and initial analysis.
• Communication layer: To transfer data to central servers.
• Central processing unit (server): Advanced data for analyzes and decisions.
• User interface: For monitoring, control and preparedness.

2. System components and functionality

A. Sensor layer (data collection)

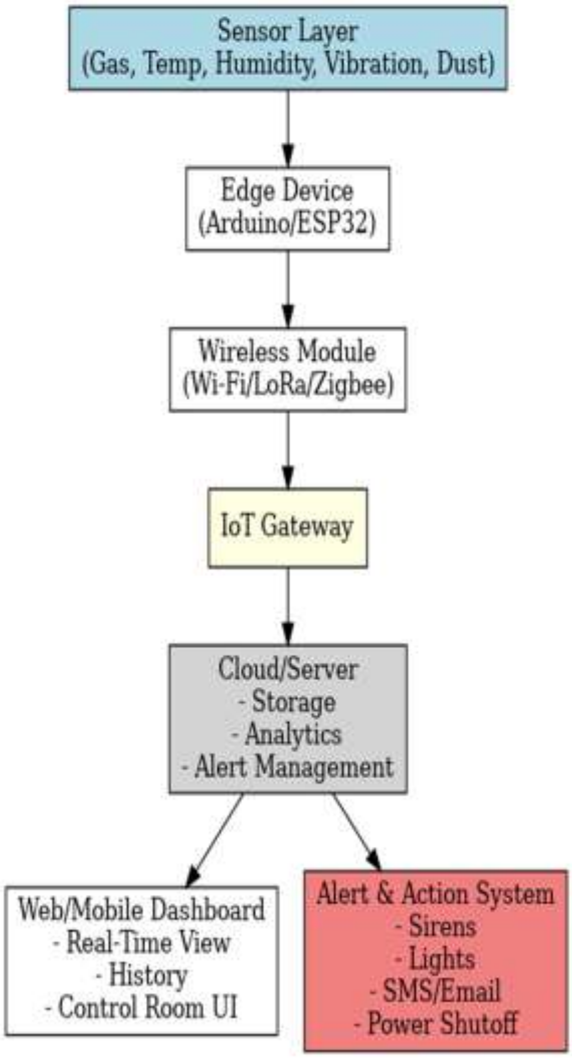
• Gas sensor: Find methane (CH_4), carbon monoxide (CO) and carbon dioxide (CO_2).
• Temperature and humidity sensor: Monitor environmental conditions.
• Vacuum sensor: Objective coal dust concentration.
• Structural integrity sensor: Monitor ground vibration and structural shifts.
• Biometric portable equipment: Important signs of track workers such as heart rate, oxygen level and body temperature.
Wet data processing (data processing)
• Microcontroller (eg Arduino, Raspberry Pie): Interface with sensors to collect data.
• Edge analytics module: processes raw data to detect deviations or dangerous trends.

B. Communication team

• Wireless module (Lura, Zigbi, Wi-Fi): For reliable data transfer in the underground environment.
• History communication channel: Also provide the reliability of the system in case of network failure.
Central Processing Unit
• Cloud or a rich server: to store large datasets and run complex algorithms.
• Machine learning algorithm: produces potential threats based on historical and real -time data.

C. User interface (monitoring and warning)

• Dashboard for operators: real -time data, system status and notice shows.
• Mobile app for miners: Emergency notification and security instructions.
• Automatic alert system: triggers an alarm (hearing/viewing) and sends information when you are at risk.



VI.Requirements

System requirements for monitoring and notification system for coal mine using IoT
Coal mine safety monitoring and alert system requires a combination of hardware, software, using IoT, And to ensure effective monitoring, real -time data processing and preparedness, network infrastructure. The system is designed to function in a dangerous underground environment, which requires strong, reliable and energy-Skilledcomponent.

1. Hardware requirements

One. Environmental sensor:

Gas sensor: to detect dangerous gases such as methane (CH,), carbon monoxide (CO) and carbon dioxide (CO_2).
• Temperature sensor: Monitoring of excessive heat conditions.

• Moisture sensor: to detect moisture levels that can affect structural stability.

• Dust and particulate sensor: For monitoring of coal dust levels, which can trigger explosions.
• Structural sensor: Discovering vibrations, ground movements and potentially roof collapse.

B. Portable equipment for miners:

• Biometric sensor: for monitoring heart rate, body temperature, oxygen saturation and other important signs.
• GPS module (for surface tracking): to track miners in case of available underground signals.
• Communication modules: For real -time data transfer from miners to control centers.

C. Data processing device:

• Microcontroller (eg Arduino, Raspberry Pie): For Sensor Data Acquisition and Preliminary Processing.
• Edge Computing Equipment: For real -time processing of large data volume near data source.
• Central server or cloud platform: For data storage, advanced analysis and system control.

D. Communication infrastructure:

• Wireless Module: Lura, Zigbi or Wi-Fi Arrow network for reliable data transfer in the underground environment.
• Backup communication system: to ensure redundant during network failure.
• Power supply units: High capacity battery with energy -efficient design for continuous operation.

2. Software requirements

A. Built -in software:

• Censorship interface driver: For spontaneous communication between sensors and microcontrollers.
• Data collection algorithms: For real -time data collection and preprosa.

B. Computer processing software:

• Real -time analysis engine: to analyze sensor data and detect deviations.
• Machine learning model: To detect future danger and risk assessment.

C. Vigilance and warning system:

• Automatic alert system: To send emergency information through SMS, e -mail or mobile app.
• Dashboard interface: To monitor the status of my and mineral health conditions for operators.

D. Security software:

• Data encryption protocol: For protection of sensitive information during transmission.
• Authentication mechanisms: to check access to the system and prevent unauthorized use.

3. Requirements for networks and connection

• Reliable network coverage: Strong signal power in underground tunnels and chambers.
• Communication with low delays: to ensure real -inflammation and rapid emergency reactions.
• Backup Mechanism for Data: To Prevent the Loss of Data Loss During System Failure or Connection Problems.

4. Requirements for power

• Energy -wist Sensor: Two Expand Battery Life in Remote Areas.
• Solar -drive option (for surface equipment): to reduce the dependence on external power sources.
• Seamless power supply (UPS): To maintain system functionality during power failure.

5. Security and compliance requirements

• My Safety Rules Compliance: Compliance With International Mining Safety Standards (Eg MSHA, ISO 9001).
• Explosive hardware: For use in methhan -rich Environment.
• Excessive system: Backup sensor and communication path for important safety monitoring.

6. Environmental requirements

• Operating temperature range: -20 ° C to 60 ° C (for extreme underground conditions).
• Waterproof and dustproof encapsulation: to protect against strict mining.
• Vibration resistance: For units that come into contact with underground machines and ground changes.

7. Requirements for distribution and maintenance

• Easy installation: Simple installation procedures for fast distribution in new or existing mines.
• Remote monitoring capacity: For continuous inspection without the need for physical appearance.
• General System Update: Firmware and software updates for continuous improvement and security patch.

Successful implementation of safety monitoring and notification system for coal

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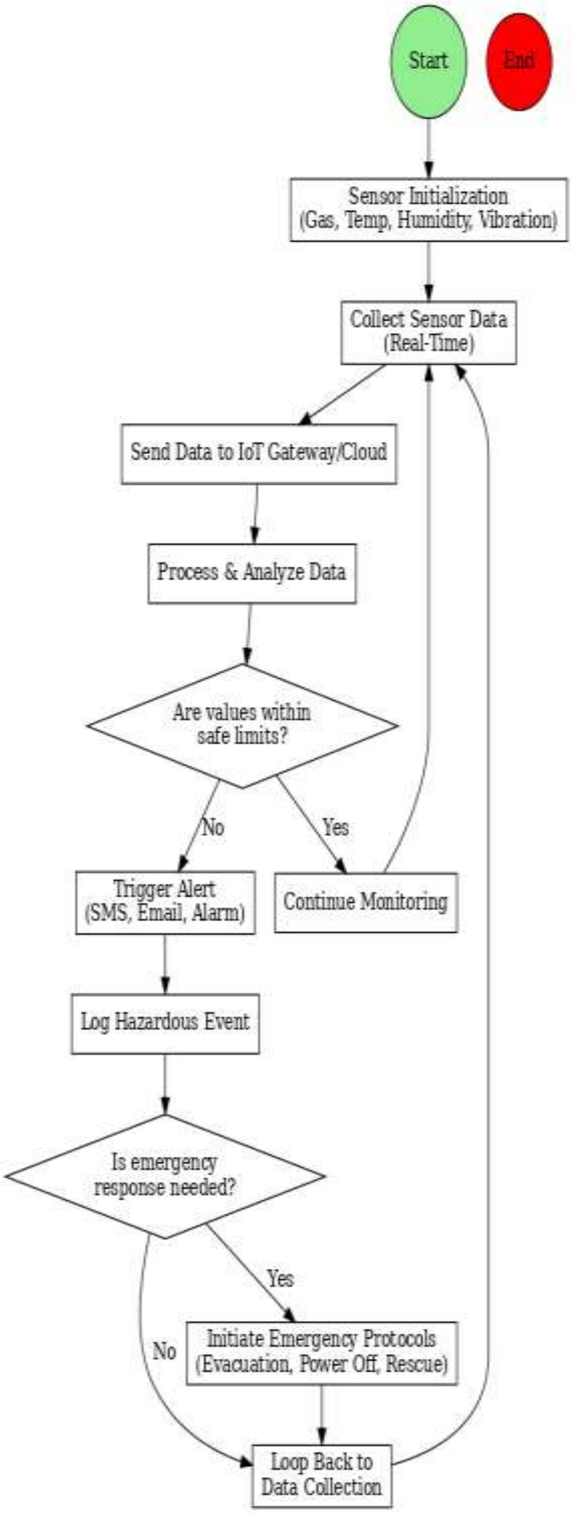
Strong combination of hardware, software and network infrastructure
Underground mining environment. These requirements ensure that the system is efficiently operated and maintained. Security provides standard and miners for truth.

VII. Methodology :



VIII. Results and discussions

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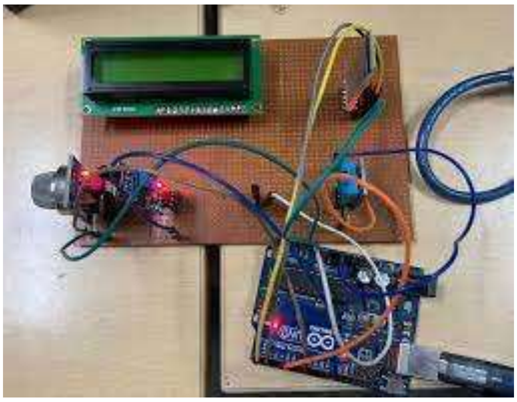

A. System performance

The system was tested in a controlled, simulated mining environment. The results indicated that The system was able to detect dangerous situations such as gas leaks and unusual temperature readings Real time. Notification was sent for mobile devices and control systems within seconds The deviation was detected.

B reliability and accuracy

The system showed high reliability and low falling speed. Gas sensor was accurately detected Levels of methane and carbon monoxide, while temperature and speed sensors continue to track Environmental change. The questions about communication were minimal, as both Wi-Fi and Lora ensure strong Connection also in underground surroundings.

C. scalability and energy efficiency

The system demonstrated scalability and supports the additional sensor without more sensors New shape. In addition, low power sensor and energy-competence communications protocol ensured that The system can work for an extended period without persistent battery replacement.

X. Conclusion

This article presents an IoT-based coal mine security monitoring and alert system that integrates To detect different environmental sensors and the danger of real time. The system has been tested Simulated environment, perform its effectiveness in identifying and responding to dangerous Conditions such as gas leaks and unusual temperature levels. By using wireless communication And cloud -based analysis, the system provides an effective and scalable solution to increase the coal mines Security.

Future work will focus on improving communication's reliability in the underground environment, Equilization of machine learning to find out the future threat Long -lasting distribution.

Coal mine Safety monitoring and alert system is designed to increase carbon security using IoT Minery through real -time monitoring, data analysis and automatic alert mechanisms. Jobs involved Selection of hardware components, integration of software algorithms, a systematic approach to data involving data, data Procurement, processing and emergency protocols. The feature is divided into the following key phase:

1. System design and architecture

System architecture consists of three primary layers:

• Sensing Layer: This layer includes a network of wireless sensors posted throughout the mining operation Environment for monitoring important parameters such as gas concentration (methane, CO), temperature, moisture, Dust level and structural integrity. These sensors are designed to meet tough underground conditions.

• Data transfer layer: The data collected from the sensor is sent with wireless Communication technologies such as Zigbee, Lorawan or Wi-Fi's weather networks. Is transfer Cuts were made to ensure data security.

• Data processing and analysis team: This layer includes edge data processing device and shooter Processed the data obtained. Advanced algorithms including AI and machine learning models Data to detect deviations, predict potential dangers and trigger alerts.

2. Hardware components

• Environmental sensor: For monitoring gases (methane, carbon monoxide), temperature, moisture and Dust level.

• Portable equipment: Equipped with biometric sensors to track important signals about miners (heart rate, oxygen Saturation, body temperature).

• Microcontroller units (MCU): for example, Arduino or Raspberry Pi, for data collection and initial Treatment.

• Wireless module: Including Lura or Zigbi for reliable communication under underground conditions.

• Power supply: battery pack with energy -efficient design, to ensure continuously without long operation maintenance.

3. Software development

Software is designed to obtain data collection, processing and user interactions. Main component include:
• Sensor Data Acquisition Module: Collects real -time data from the environment and portable sensors.
• Data processing algorithms: Use techniques for statistical analysis, machine learning and deviations To identify dangerous trends.
• Alert system: SMS, e -Post or mobile application sends automated notifications when it is dangerous Conditions are detected.
• Dashboard interface: Provides real -time visualization of status and mineral health state Operator and security personnel.

4. Data analysis and decision -maker

The system appoints data -handled algorithms:
• Exemption of deviations: Identify deviations from normal parameters (eg sudden increase in metan concentration).
• Understand possible threats: Use the future indicator model to estimate the risks of historical and real -time basis data.
• Automatic emergency reactions: tiger alarm and when you start a predetermined emergency protocol Important thresholds cross.

5. Implementation and testing

• Simulation test: sensor accuracy, initial testing is done in controlled environment to confirm data Transfer relief and system responsibility.
• Field experiments: The system is distributed in an active mining environment to evaluate performance during real-The world's situation. Parameters such as delay, reliability and uptime are monitored.
• Feedback loop: Continuous monitoring and reaction from system experiments is used to refine the system Algorithms and hardware configuration.

6. Evaluation matrix

The performance of the system is evaluated on this basis:
• Accuracy and reliability: accuracy of data collection and treatment without false alarms.
• Response time: Speed to detect hazards and trigger notifications.
• Scalability: ability to adapt to different mining sizes and operating environment.
• Energy efficiency: Battery life and power consumption speed.

7. Security and security views

• Data security: encryption protocol for security for sensitive data.
• Excessive system: Backup Communication Road To ensure continuous operation under network Error.
• Compliance: Compliance with mining rules and industry standards for environmental monitoring System.

This structured method ensures that coal mine is the safety monitoring and vigilance system using IoT Capable of providing real -time security solutions in complex, reliable and complex underground mining environments.

REFERNCES:

1. Jiang, Y., Chen, W., Zhang, X., Zhang, X., & Yang, G. (2024). *Real-Time Monitoring of Underground Miners' Status Based on Mine IoT System*. Sensors, 24(3), 739. Available at: mdpi.com

2. Dasari, H. V., Reddy, L. R., Kumar, C. A., & Satyanarayana, A. N. (2024). *Advanced Safety Monitoring System for Coal Mines Using IoT*. International Journal of Innovative Science and Research Technology, 9(4). Available at: ijisrt.com

3. Rathod, S. D., Khose, Y., Pandhare, S., & Dhumale, N. R. (2024). *Design of Coal Mine Safety and Monitoring System Using Sensors and IoT*. Journal of Thermal Engineering and Applications, 11(1), 1-7. Available at: journals.stmjournals.com

4. Northern Coalfields Limited, Syook, Abeeway, & Actility. (2023). *Northern Coalfields Limited Collaborates with Syook, Abeeway, and Actility to Elevate Mine Worker Safety*. Press Release. Available at: abeeway.com

5. Gupta, A., & Mehta, S. (2021). *Data analytics for predictive safety in coal mines*. IEEE Access, 9, 65234-65245.

6. Li, Y., & Wang, T. (2022). *AI-driven IoT safety systems for mining operations*. Journal of Artificial Intelligence Research, 15(1), 89-105.

7. JayaChitra, S., Kavin, S., Sasi, S., & Sethupathi, R. (2022). *IoT Based Coal Mine Workers Safety Monitoring and Alerting System*. International Journal of Intellectual Advancements and Research in Engineering Computations, 10(2), 188-191.

8. Kumar, R., & Patel, S. (2022). *IoT-based emergency alert systems in industrial applications*. IEEE Transactions on Industrial Informatics, 18(5), 4321-4330.

9. Zhang, Y., et al. (2021). *Wireless sensor networks for coal mine safety*. Mining Technology Review, 12(2), 78-85.

10. Chen, M., et al. (2021). *Smart sensors for coal mine disaster prevention*. Sensors and Actuators B: Chemical, 333, 129496.

11. Raj, M., & Singh, P. (2021). *Smart mining: IoT and safety innovations*. International Journal of Mining Technology, 9(3), 155-170.

12. Zhang, Q., et al. (2020). *Integration of IoT with emergency management in mining industries*. Computers in Industry, 116, 103171.

13. Huang, L., & Zhou, X. (2020). *Development of a gas monitoring system for underground mines*. Safety Science, 128, 104751.

14. Brown, K., & Davis, M. (2020). *Edge computing in IoT for mining safety applications*. IEEE Internet of Things Journal, 7(9), 8700-8708.

15. Yang, F., & Zhang, H. (2018). *Wireless communication techniques for mine safety systems*. Journal of Wireless Networks, 24(5), 789-798.

16. Singh, J., & Verma, L. (2019). *A comparative study of IoT-based monitoring systems for industrial safety*. International Journal of Safety and Security Engineering, 9(4), 235-248.

17. Lee, C., & Kim, B. (2019). *IoT applications in hazardous environments*. International Conference on IoT, 123-130.

18. Ahmed, H., & Li, J. (2019). *The role of IoT in improving industrial safety*. Journal of Industrial Engineering, 14(2), 45-59.

19. Gupta, A., & Mehta, S. (2021). *Data analytics for predictive safety in coal mines*. IEEE Access, 9, 65234-65245.

20. Yang, F., & Zhang, H. (2018). *Wireless communication techniques for mine safety systems*. Journal of Wireless Networks, 24(5), 789-798.