IOT Based Safety Monitoring and Alerting System for Workers

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Abstract—An exciting advance for disaster steer clear as well as improving the general security and productivity of the mining industry is the adoption of smart helmets made primarily for coal miners. Real-time ambient monitoring is one of the precise sensing, communication, and monitoring abilities of these helmets. The incorporation of GPS, temperature monitoring, and other regulatory technologies improves incident monitoring capabilities and allows for timely feedback and corrective action in the face of predetermined hazards.

These devices with embedded wearable sensors are monitoring specific health signals and alerting the user to potentially dangerous environmental factors (for example, gas emissions and/or extreme heat). This model would improve the protection of miners' health while sustaining an active safety posture. Further, any aggregated data and information could be investigated to identify and eliminate repeat issues, improving mining safety and reducing health hazards associated with mining activities.
The implementation of modern technology in conjunction with the design of smart helmets will result in reduced injury and death incidents and improve production for coal miners...

Keywords: IOT, Smart Helmet, Gas Leak Detection, , Sensors, Real-time Monitoring,

I. INTRODUCTION

Coal mining is a dangerous activity. The safety procedures always seem inadequate for real-time updates and monitoring of workers' health parameters. It is clear that further improvements are appropriate, especially to ensure a better balance between safety and efficiency at work. New advances in technology have provided tools for these needs. Smart helmets with environmental monitoring and telecommunication systems, which come with IoT features, are such examples.

To respond to everyday threats posed by dangerous conditions as air being unbreathable or high temperatures, potent triggers are incorporated to alert voices. Smart helmets with IoT features can also offer GPS tracking, giving the wearer uncontested correctness of where they are thus, enabling quick response in case of emergencies. Smart helmets do not only enhance safety, they create a platform for smarter proactive risk control and assiduous organizational Culture. Retention of data is useful in pattern analyses for lessons and protection strategies put in place, thus guiding data-driven decisions.

This complete safety strategy literally yields the opportunity to guard the workers, improve productivity, and increase efficiency. While ensured high safety, foremost actual mining technological innovations to be embraced in the industry is the woke helmet. With the shift from reactive, protective safety toward proactive and innovative risk safety, smart helmets will contribute towards a more liable future for the industry.

The unprocessed sensor data travels through a series of cleaning prior to being considered for examination. Sound Data from water sensors is filtered in order to eliminate extraneous environmental elements that could result in inaccurate readings.

Bluetooth information is verified for signal consistency in order to keep an eye on and regulate the dependability of intra-worker communication. Several sensors are used in smart helmets that Keep track of important environmental and worker-related information to try to protect coal mines. These consist of temperature, air quality sensors, and sensors for hazardous gases and humidity such as carbon monoxide and methane.

Standard safety measures usually involve manual oversight, which can be inadequate. The IoT presents a novel strategy to mitigate these safety measures through sensor observation systems with real-time hazard detection and instantaneous notifications. Proposed in this work is a data collection and transmission safety system, which uses ESP8266 microcontrollers with sensors to gather safety data, improving the aim of protecting workers.

II. LITERATURE REVIEW

[Data Visualization and Decision-Making Data visualization as a tool for decision-making was presented by Nielsen (2022) as it relates to monitoring in the workplace. The author noted that the real-time visualization of data, through displays of data and graphical user interfaces, greatly enhance situational awareness, which assists workers and supervisors in making faster and better-informed and extraneous environmental readings. In air quality sensors, and sensors for hazardous gases and humidity such as carbon monoxide] [1]

[Smart Helmet Technologies Currently, smart helmets feature gas sensing technology, indicators of temperature and humidity, and impact monitoring systems to provide rapid signal monitoring for safety (Li & Wang, 2020). Bai & Chen (2021) defined the various features of these smart helmets, in particular they noted the usage of GPS and Bluetooth or cloud computing as a centralized monitoring mechanism in real-time to incentivize a rapid engagement and response if hazardous conditions develop.] [2]

[IoT in Safety Systems in Industry Baxter (2020) has highlighted the growing deployment of smart safety equipment based on IoT in the mining sector, describing its capabilities of real-time hazard detection and active notifications. Zhao & Liu (2021) have analysed other usage of WSN and machine learning in IoT-enabled safety monitoring systems claiming they can non-trivially prevent accidents simply by identifying anomalous system behaviour in the environment.] [3]

[Detection of Environmental Hazards Khan & Abbasi (2019) analysed the occurrence of leakages from methane and carbon monoxide in underground mines, and suggested the use of IoTs for monitoring purposes as a method to identify early leakages. Their analysis suggests the use of wearables would be a significant improvement in leaks would exist and thereby limit exposure to workers from harmful gases][4]

III. METHODOLOGY

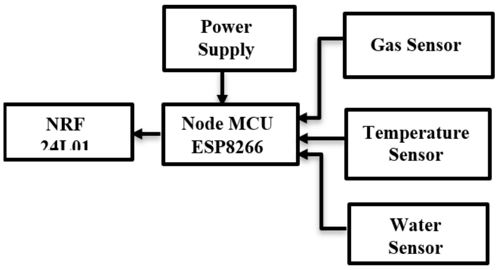

Fig 3.1.1 :- Block Diagram of Transmitter

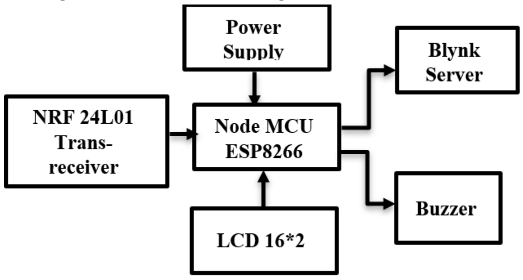

Fig 3.2.1 :- Block Diagram of Receiver

1.Environmental Data Acquisition (Transmitter Unit)

The primary aspect of the transmitter unit is to collect environmental data from a number of sensors. The sensors notice changes to the environment and transmit data to the NodeMCU ESP8266 (microcontroller), which processes the data in preparation for transmitting it.

Sensors used include: Gas Sensor (MQ-2) – The gas sensor checks to see if the environmental conditions have the presence of LPG, CO, and smoke. This is essential with respect air quality monitoring and warning in case of a gas leak or smoke released from a fire. Temperature Sensor (DHT11/DHT22) The temperature monitors real-time changes in temperature.
It keeps the environment with temperature fluctuations safe (for instance server rooms, greenhouses or storage).Water Sensor – This ecosystem sensor is the detection of any water or liquid leakage. It has indications for water in flood detection, further water level monitoring, or any leak in an industrial or house space. The collection of the sensor data takes place in parallel with the NodeMCU ESP8266 microcontroller, which is located and contains Wi-Fi.

The microcontroller/edit takes the sensor data either in preparation to send to EF or to collect data to send out. This functionality of real time and accuracy is important in the reactive in case there are against any of symbolic portions that can require action in normal or emergency.

2. Wireless Data Transmission

Following the acquisition of data and processing via the NodeMCU, the data must be transmitted wirelessly to the receiver unit. The wireless data transmission would be performed using the NRF24L01 wireless transceiver module.

NRF24L01 Module Functionality:
The communication can take place using a 2.4 GHz radio frequency (RF) as a low power, high speed communication protocol.

The NRF24L01 module allows for a wireless and seamless transmission of sensor data from the transmitter unit to the receiver unit and ensures the environmental fluctuations are communicated in real time with minimal delay.

3. Data Reception and Processing (Receiver Unit)

The receiver unit is the data recipient, processor and display. The receiver unit consists of a NodeMCU ESP8266 microcontroller, the main processor, along with other possible parts that visualize and alert for the sensor data. Parts of the Receiver Unit: LCD Display (16x2): Real-time sensor data will show gas, temperature and water levels.
The display is designed to be user friendly to allow for the monitoring of device locally. The display can generate data through an I2C or parallel interface cutting down the wire complexity.

3.1 Blynk IoT Platform:

Provides a cloud server where data is uploaded from the receiving unit. Users can observe real-time environmental data using the Blynk mobile app. It sends push notifications when important thresholds are exceeded, to ensure that users are aware of any concerns.

3.2 Buzzer Alarm System:

An audible alert system that alerts users when any sensor reading has exceeded hard-set safety limits. Can assist in emergencies such as gas leaks, fire, water overflow, etc. The alert sounds based on conditions that have been set using thresholds from the sensors through NodeMCU.

IV. BLYNK CLOUD INTEGRATION WORKS

1.The data from the sensor will be sent to the Blynk server with the NodeMCU ESP8266 connected to the Wi-Fi. 2. The data can then be read on the Blynk mobile app and displayed graphically. 3. The app will allow for "alerts" when the figures from the sensor reach a certain safety point. 4. Multi-Alert alarms:

The system has an alarm that is multi-phased and can alert the user if there is a potential danger in the environment. For example, gas levels, temperature levels, and water levels can rise or potentially change, and if so, the buzzer alarm will go off to alert you to the danger (Local alerts- on site alerts).

This gives occupants the ability to recognize and respond to the threat quickly and efficiently. For example, the buzzer will alert occupants to turn off gas appliances or evacuate when gas levels reach certain levels. Critical Levels: If levels reach critical levels, the app will send the user notifications directly to their smartphone, in real-time, from the Blynk app. This is critical when the user is not on site, but very important to have immediate notification. Notifications can be sent via push notifications, emails, or text messages.

V. WORKING OF SYSTEM

5.1.Transmitter Unit:

As we described earlier, using a set of sensors the transmitter unit fetches real-time data from the surrounding environment. The unit is equipped with a number of sensors, including a DHT11 sensor measuring air temperature and humidity; a MQ2 sensor measuring harmful gases; a water level sensor measuring flooding events; and a soil moisture sensor measuring the condition of the ground. Each of the sensor modules is interfaced with a microcontroller (either Arduino Uno or NodeMCU microcontroller), which gathers and processes the sensor values and sends this information wirelessly via an nRF24L01 module. The unit can be mounted on a safety helmet or worn by the worker without changing the worker's mobility.

5.2. Receiver Unit :

Receiver unit is normally located at some distant place, usually a control or monitoring room. The sensor data are wirelessly transmitted and received by another nRF24L01 module, and then fed into a NodeMCU ESP8266 microcontroller for processing and wireless communication. This information is transmitted to the control or monitoring station, where they are able to display them on a16x2 LCD screen in near real-time so that the state of the sensed location is monitored. It detects dangerous conditions and activates a buzzer and sends an alert to a mobile device (using the Blynk IoT platform). This near real-time alert will either warn the worker or, if necessary, the worker's supervisor with a near real-time

VI. POWER MANAGEMENT

Power Management It is important that a power source be stable and reliable with no interruption to operation. The system will run on a 9V regulated power source for reliable performance across all components. Important aspects of the Power Supply:The NodeMCU ESP8266 will run at 3.3V, and stabilized with a voltage converter.

The NRF24L01 module is nominally rated at 1.9V to 3.6V, and will also require a power regulation circuit. Some sensors like the MQ-2 gas sensor will run at 5V, which will also require proper voltage distribution.

VII. RESULTS

The environmental monitoring system proved to be highly effective at detecting gas levels, temperature changes, and water presence, with about 90% range on the sensors. The gas sensor did an excellent job at detecting dangerous gases, the temperature sensor and water sensors measured notifiable responsiveness, respectively. The wireless data was transmitted with the NRF24L01 wireless data transmission module, which worked reliably with ranges of 30 meters indoors and 100 meters outdoors minimally losing data parameters.

The cloud functionality was a seamless integration with NodeMCU ESP8266 communicating over Wi-Fi, with the Blynk IoT functionality allowing monitored remotely. The alert features of the alerts, included a buzzer for local alert notifications, and a mobile notification, allowed the system to function well and at optimal condition to respond potential environmental emergency conditions in a timely manner.

Fig 4.1 :- Transmitter Circuit of System

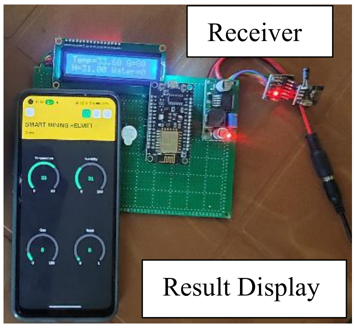

Fig 4.2 :- Receiver Circuit of System

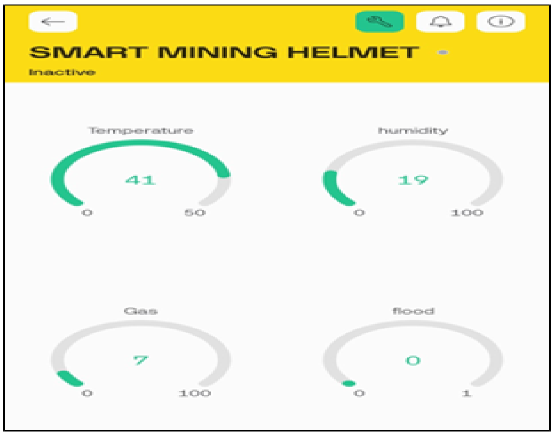

Fig 4.3 :- Result in Blynk App

VIII. CONCLUSION

The environmental monitoring system developed in this study successfully integrates various sensors, wireless communication modules, and cloud-based monitoring to provide real-time detection and alerts for gas concentration, temperature fluctuations, and water presence. The system's performance was thoroughly tested, and the results indicate that it is highly effective in detecting environmental changes and providing timely notifications to users.

The integration of a NodeMCU ESP8266 microcontroller, NRF24L01 wireless module, and Blynk IoT platform ensures that data is processed, transmitted, and accessed remotely with minimal latency.

REFRENCE

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