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IOT Based Smart Helmet for Coal Mining Tracking

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ABSTRACT

Energy production remains heavily reliant on the coal mining industry, yet this sector poses significant occupational hazards to miners, including exposure to toxic gases, temperature, air pollution and various accidents. The IoT enabled Smart Helmet for Coal Mine Workers represents an innovative solution that was conceived and implemented in this research study. The helmet is equipped with a suite of sensors, such as temperature, humidity, and gas sensors, designed to detect harmful substances and environmental changes. These sensors continuously collect real-time data, which is transmitted wirelessly to a centralized monitoring system. This research paper thoroughly explores the design, features, benefits, and underlying IoT architecture of the Smart Helmet. By incorporating this model, the coal mining industry advances toward adopting safer, more sustainable, and environmentally responsible mining practices.

Keywords: Smart helmet, coal mining, IoT, safety, environmental monitoring.

1. INTRODUCTION

Coal remains a vital resource for every nation due to its extensive commercial applications. The coal mining industry is a vast sector that involves complex and hazardous operations conducted within tunnels and underground environments. Numerous fatal accidents are reported globally from mines, with a predominant cause being the concentration of hazardous gases, such as methane, carbon monoxide, and other toxic emissions released during excavation. The mining processes, often carried out in unsafe manners, vary widely depending on the extraction methods used, with longer mines posing greater risks. Safety protocols in coal mining are notoriously inadequate, exacerbating the already perilous working conditions. As the depth of the mine increases, so does the risk to human workers. It is exceedingly challenging to monitor the dynamic and hazardous environmental conditions manually within a coal mine. Coal serves crucial roles in thermal power generation, cement production, steel manufacturing, and as a fuel source for various applications. The hazardous conditions prevalent in coal mines, such as extreme temperatures, high humidity, and the release of toxic gases, create perilous working environments for miners.

Consequently, many workers are either leaving the coal mining industry or are no longer willing to pursue mining as a profession, thereby creating significant challenges in maintaining a workforce. To address these pressing safety concerns, there is an increasing demand for innovative solutions to enhance the working conditions in coal mines. One such advancement is the development of IoT based smart helmets tailored specifically for coal mining operations. These helmets, equipped with IoT sensors, offer continuous monitoring of the mine's environmental conditions, including real-time tracking of harmful gases such as carbon monoxide, methane (CH4), and other gases. In the event of a hazardous situation, the helmet features an alert system, utilizing a buzzer to immediately notify the wearer of impending danger.

2. LITERATURE REVIEW

A smart helmet to prevent noise-induced hearing loss by integrating feedforward and feedback active noise cancellation (ANC) technologies. Equipped with microphones to monitor external noise and air velocity, the helmet adjusts ANC levels in real-time to protect the rider from harmful noise exposure. The system was validated through wind tunnel and freeway tests. Additionally, the helmet features sensors, with an Arduino based system that detects coal environment conditions. Data is transmitted to the cloud.

To overcome the lack of safety features in traditional coal mine monitoring system, a sophisticated smart

helmet has been engineered through integration of Internet of Things (IoT) technologies in coal mining has led to significant advancements in worker safety, with the development of IoT based smart helmets for real-time tracking and monitoring of miners. These helmets incorporate a range of sensors and devices, including the Arduino Uno microcontroller, MQ-2 and MQ-4 gas sensors, DHT11 sensor, LDR sensor, ESP8266 Wi-Fi module, LED lights, relay, buzzer, and LCD screen, to provide comprehensive monitoring and safety mechanisms. The Arduino Uno serves as the central processing unit, gathering data from the various sensors embedded in the helmet. The MQ-2 and MQ-4 sensors detect hazardous gases, such as methane and carbon monoxide, that are prevalent in coal mines, and MQ-135 air quality sensor to detect natural gases and air pollution and DHT11 sensor to detect temperature and humidity levels inside the coal mining environment, alerting miners and control centers to potential dangers. LDR sensors are used to monitor ambient light levels, ensuring visibility and safety in low-light conditions through relay signal. The system also integrates the ESP8266 Wi-Fi module, which enables the helmet to transmit real-time data to cloud servers or a central monitoring system, allowing for continuous tracking of the miner's health and environmental conditions. The helmet's safety features are further enhanced with buzzer that activate when gas levels or other monitored parameters exceed safe limits.

Additionally, the inclusion of an LCD screen on the helmet allows for real-time display of critical information, such as gas levels, temperature level, and system status, ensuring that miners can immediately respond to potential hazards. By leveraging these interconnected technologies, the smart helmet creates a robust system for monitoring environmental and health risks, ensuring the safety of coal miners by providing timely alerts and enabling swift emergency responses. This IoT based approach to mining safety offers the potential for significant improvements in accident prevention, environmental hazard detection, and overall operational efficiency in underground mining operations.

3. METHODOLOGY

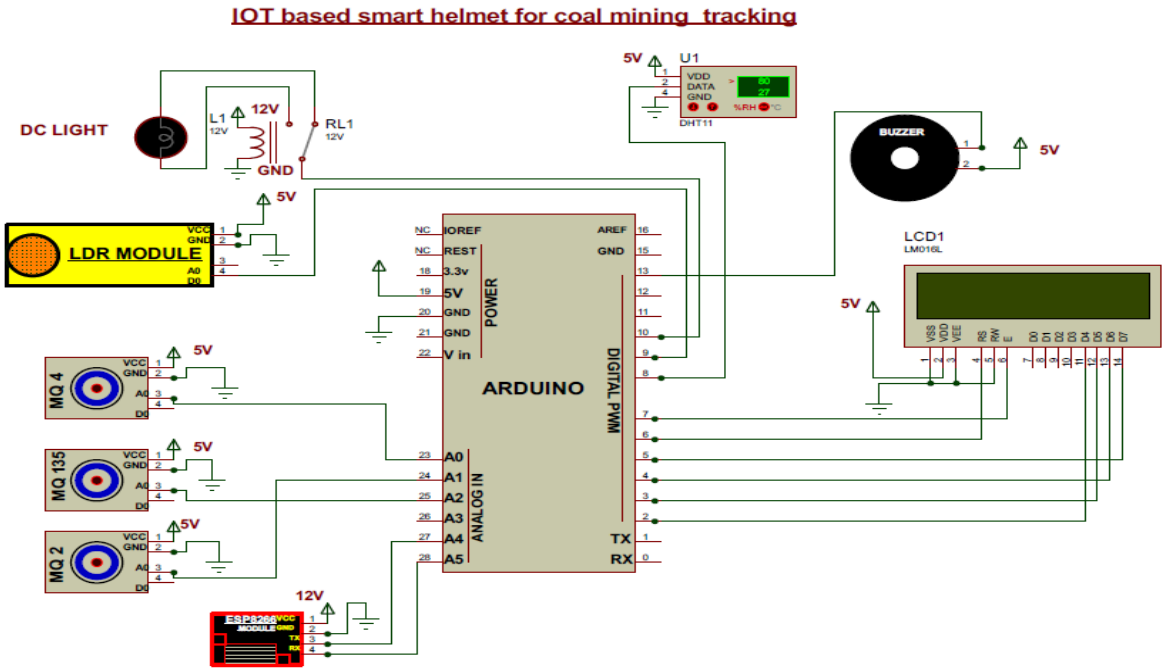

Fig.1 Block diagram of IoT based smart helmet for coal mining tracking

As shown in Fig.1, This system uses Node MCU module which detects variables in a coal mine and a cloud based monitoring is provided. Live readings are provided by the DHT11 temperature and humidity sensor, MQ2

sensor, MQ4 sensor, LDR sensor, and MQ135 sensor. The data is sent to the microcontroller, and communication between the gateway and the node is done via Wi-Fi. In an abnormal situation and also for every 1 minute the data will be uploaded to the cloud, which is also displayed on an LCD screen and an alert is provided through buzzer for abnormal conditions. Node mcu is provided by power supply. DHT11 sensor and LDR sensor have 3 pins GND connected to ground of the microcontroller, D0 connected to digital output pin and Vcc connected to 5V power supply. Whereas, MQ135, MQ2, MQ4 sensors also has one analog pin in addition to these 3 pins which is connected to analog output pin for measuring the gases. Buzzer and LCD are also connected to give an alert and to display message respectively when there is an abnormal situation.

4. RESULTS - SYSTEM DEMONSTRATION

Fig. 4(a) Overall hardware setup (Front view)

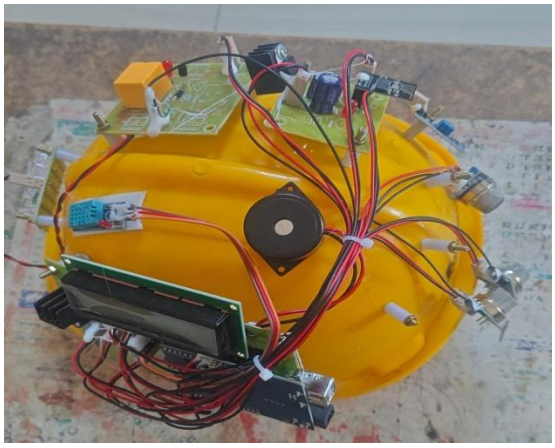

Fig. 4(b) Overall hardware setup (Top view)

Fig. 4(c) LCD (Output readings)

The above Fig. 2(a), 2(b), 2(c) shows the hardware setup of the overall system. We have used DHT11 sensor which takes the temperature and humidity readings, LDR sensor which detects the light intensity, MQ135 sensor which detects the level of air quality, MQ4 sensor to detect methane gas, MQ2 sensor to detect CO gas.

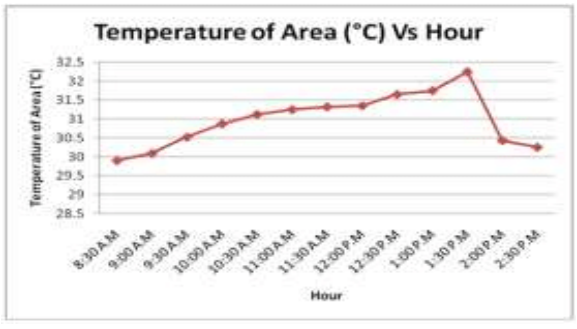

Fig. 4(d) Temperature Vs Time graph

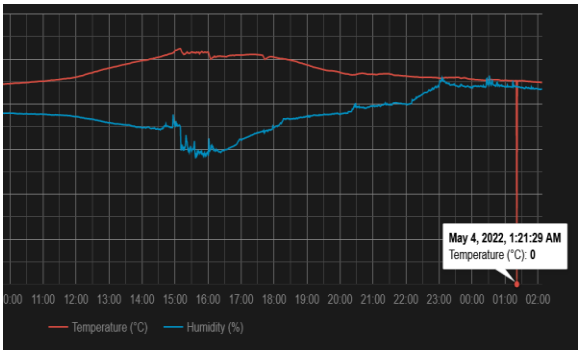

Fig. 4(e) Temperature and humidity Vs Time graph

As shown in above Fig. 3(a), 3(b), During the testing phase, the results demonstrate that the IoT based safety helmet system is a highly robust and efficacious solution for augmenting safety in coal mining operations. Its capability to detect and adapt to dynamic and unpredictable conditions in real-time, coupled with its user-friendly interface and exceptional reliability, establishes it as an invaluable tool in safeguarding the health and well-being of miners.

5. CONCLUSION

The IoT based smart helmet for coal mining represents a groundbreaking innovation, seamlessly integrating advanced technology with the challenging coal mine environment. By leveraging a range of sensors, real-time data analysis, and communication capabilities, the system provides essential information on toxic gas levels, temperature, ensuring miners' safety and enabling rapid responses to potential hazards. Its proactive monitoring of both working conditions and miner health helps prevent accidents, reduce fatalities, and enhance overall safety. Additionally, it optimizes resource utilization, driving cost savings and operational efficiency. This transformative technology not only safeguards lives but also enhances productivity and sustainability, offering a promising future for safer and more efficient coal mining.

6. REFERENCES

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