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IOT Based Coal Mine Monitoring and Alerting System

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Abstract - The nation's most important economic sector depends on coal mining operations that supply energy for steel industry extraction of iron from stone and cement production. The underground mining industry requires continuous surveillance of all critical monitoring factors, from methane gas to high temperatures and fire-related incidents and more. A crucial step in mine safety consists of environmental monitoring due to the complexity of mining operations and their diverse range of actions. Our proposed project, "IOT-BASED COAL MINE MONITORING AND ALERTING SYSTEM," provides a solution to this problem. The system performs basic safety checks and supervises key coal mine safety aspects, which include fire controls alongside temperature and humidity regulation and gas emission alerts.

Key Words: IoT, Coal Mine Safety, Safety Monitoring, Alerting System, Arduino, Gas Detection, Temperature Sensing, Humidity Monitoring.

1. INTRODUCTION

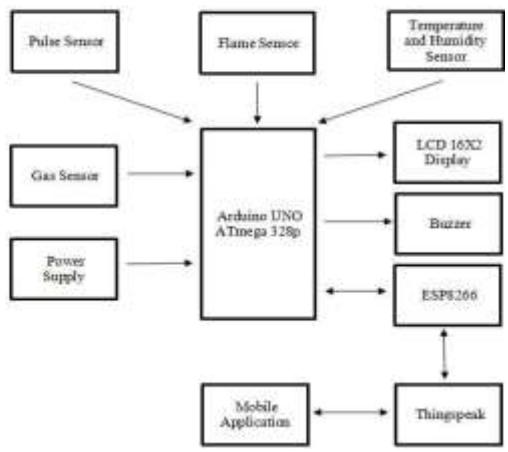
Mining operations are among the most hazardous environments, with thousands of workers losing their lives each year due to explosions, toxic gas leaks, and outdated safety practices. Historical disasters, especially in China, underscore the critical need for improved safety measures, as incidents have resulted in catastrophic fatalities, including over a thousand deaths in a single event. To address these challenges, modern solutions emphasize real-time monitoring through the integration of IoT devices and sensor networks.By equipping miners with helmet-integrated sensors that continuously track environmental parameters—such as gas levels, temperature, and humidity—these systems can quickly detect hazardous conditions and alert emergency response teams. This innovative approach, which leverages microcontroller-based circuits and cloud data storage, aims to significantly enhance worker safety and mitigate the risks inherent in underground mining operations.

2. EXPERIMENTAL DETAILS

2.1 METHODOLOGY

The IoT Based Coal Mine Monitoring and Alerting System operates through continuous hazardous condition scanning of coal mines for immediate real-time safety alerts to protect miners. At system power-on the Arduino Uno establishes communication with all connected peripherals and sensors which consist of the DHT11 temperature and humidity unit and the MQ-2 combustible gas sensor as well as the flame detection sensor and the heartbeat monitoring device. The Arduino uses particular analog pins for sensor connection so it can continuously acquire and interpret raw data from each device. The system takes the acquired measurements through data processing that references predetermined threshold definitions for safety. Any sensor reading above safe thresholds will activate the buzzer to produce an audible alert which warns employees about dangers in the area. The system shows present sensor data on a 16×2 LCD monitor that uses an I2C expander for its connection. This enables real-time feedback at the local site. The sensor data from the ESP8266 Wi-Fi module automatically sends to an IoT platform running in the cloud where it records information remotely. The local and remote monitoring combination allows immediate detection of hazardous scenarios which triggers immediate response followed by continuous safety management in the coal mine environment.

2.2 BLOCK DIAGRAM



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3. RESULT AND DISCUSSION

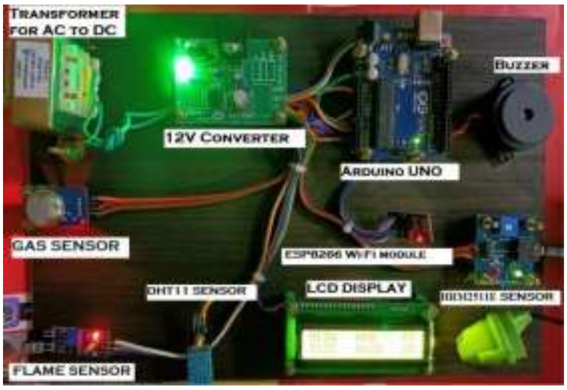

Fig -1: "IOT BASED COAL MINE MONITORING AND ALERTING SYSTEM"

A.) TEMPERATURE AND HUMIDITY SENSOR

An output from the DHT11 humidity and temperature sensor yields numerical readings after calibration. Any microcontroller that includes Arduino and Raspberry Pi units can be connected to DHT11 to generate instant feedback. The DHT11 represents an affordable humidity and temperature sensor which maintains exceptional lasting stability and dependable performance.

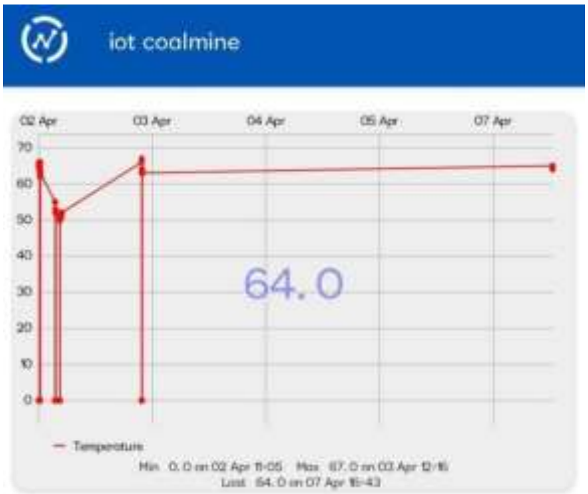

Fig -2: Temperature Sensor Output Graph

The graph shows that from 2nd April to 7th April, the **temperature sensor recorded values** that started with a low of 0.0—likely due to initial sensor calibration or a temporary disconnect—on 2nd April at 11:05 AM, peaked at 67.0 on 3rd April at 12:16 PM, and then stabilized to a consistent 64.0 by 7th April at 4:43 PM, indicating that after early adjustments the environmental temperature in the monitored area remained within a relatively steady and safe range.

Fig -3: Humidity Sensor Output Graph

According to the **humidity graph** humidity levels in the environment stabilized between 32.0 and 34.0 from the second to the seventh of April except for a brief 0.0 measurement at 11:09 AM on the second that probably resulted from a sensor error or communication bug. Atmospheric moisture within the coal mine environment showed stable conditions after setup as indicated by the readings of 34.0 humidity which both occurred at 4:51 PM on 7th April.

B.) FLAME SENSOR

The flame sensor achieves its best performance in flame alarm systems through its exceptional ability to detect light waves within the 760 to 1100 nm range. The device employs a 60 degree detection path with 100 cm flame detection range. The sensor needs to stay at a secure distance from flames to protect itself from the destructive impacts of high temperatures. This device fits various systems since it provides both analog and digital outputs and can be used by firefighting robots.

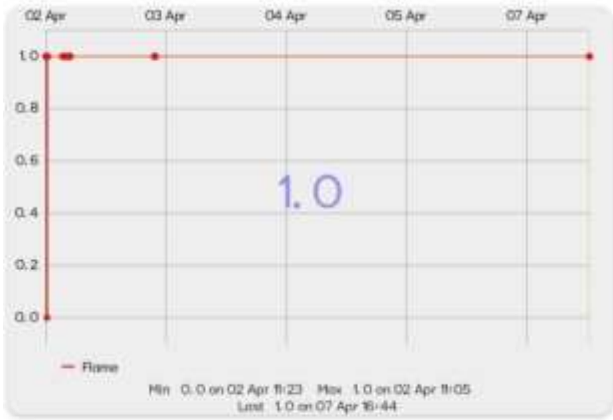

Fig -4: Flame Sensor Output Graph

The **flame sensor graph** shows the monitored area detected flame presence continuously across 2nd to 7th April while maintaining a steady value of 1.0.

The sensor ceased flame detection at 11:23 AM on 2nd April before resuming constant detection of 1.0 that persisted through the analysis duration. The uniform high value indicates that either a persistent flame source remains active in the area or the sensor continuously detects flame emissions

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from a stationary heat or light source. The 7th April reading at 4:44 PM shows 1.0 being the current detection value according to the latest record.

C.) GAS SENSOR

The MQ2 gas sensor detects seven gas types including carbon monoxide, alcohol, hydrogen, methane and both propane and LPG and smoke. Detection occurs because the device functions as a chemiresistor that changes resistance level while being exposed to gas molecules. The sensor operates as a metal oxide semiconductor device at 5V DC power and measures gas concentrations with a voltage divider method. The device effectively detects gas concentrations ranging from 200 to 10,000 parts per million.

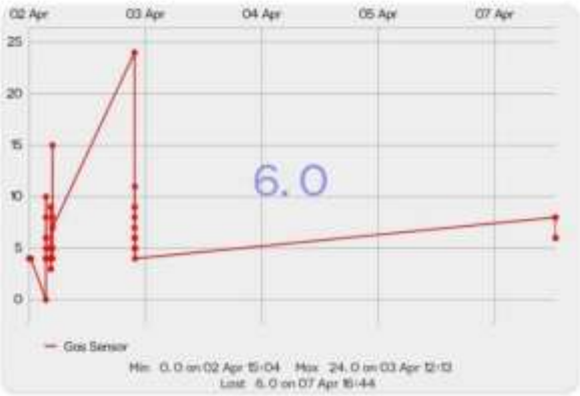

Fig -5: Gas Sensor Output Graph

The coal mine **gas sensor data** reveals variations of gas concentrations between 2nd to 7th April. During 2nd April the values started from 3.0 to 15.0 before reaching their pinnacle of 24.0 at 12:13 PM on 3rd April before decreasing gradually. At 3:04 PM on 2nd April the sensor reading reached 0.0 which could suggest brief sensor failure or that there was no gas present. At 4:44 PM on 7th April the recorded gas concentration reached 6.0 which demonstrates minimal yet detectable levels of gas presence. The collected data enables the evaluation of mine air quality along with the identification of possible threats.

D.) PULSE SENSOR

The Easy Pulse sensor utilizes photoplethysmography (PPG) to determine heart rate via blood volume changes that it detects in tissues using light sources and detectors. Through transmittance PPG a light passes from the body into the earlobe or finger before being detected by receivers located on the opposing side. Reliable heart rate measurements using Reflectance PPG are possible on different body areas because both the light source and detector operate from one side. The measurement of heart rate reaches high accuracy levels since the detected light variations correspond directly to blood flow pulses.

Fig -6: Pulse Sensor Output Graph

The chart tracks **pulse data** from April 2 through April 7 using date scales for the x-axis and pulse rate scales for the y-axis measured in beats per minute. The recorded pulse readings started at 0 bpm at 11:05 on April 2 and peaked at 96 bpm at 11:09 on the same day before registering 72 bpm at 16:44 on April 7. Pulse measurements appeared on April 2 before the system detected invalid readings over an unknown duration until it registered low pulse rates on April 7.

4. FUTURE ENCHANCEMENT

This project has a very good scope in future as well as in present. In future, if further improvement and investment is carried out we can reduce the size of the sensors making it compact and we can introduce LoRaWAN (Long Range Wide Area Network) instead of WiFi for greater communication range with low bandwidths. It is considered far more better than any other competing wireless data transmission technologies.

5. CONCLUSION

An IoT-based coal mine safety monitoring and alerting system serves as a modern solution that combines sensors with microcontrollers in an autonomous network to enhance mining environment safety through wireless communication technologies. Real-time alerts to users are possible through local alarms and IoT platforms as a result of continuous system monitoring of methane gas levels and temperature and humidity checks and water control measurements. The integrated system provides two advantageous features by lowering dangerous incidents and simplifying observation procedures while reducing maintenance requirements of traditional wired systems. The system functions as a budget-friendly and durable technology which strengthens safety operations in demanding underground mining situations to defend personnel while shielding property resources.

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