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Research Paper

SMARTMINE GUARDIAN: AN IOT-DRIVEN SAFETY AND ENVIRONMENTAL MONITORING SYSTEM FOR UNDERGROUND MINES

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ABSTRACT

The IoT-based coal mine monitoring system is meant to improve safety and environmental monitoring in underground mines by constantly checking important factors like temperature, carbon monoxide (CO) levels, seismic activity (earthquakes), and fire dangers. The system uses an Arduino microcontroller and sensors such the DHT11 for temperature and humidity, CO gas sensors, seismic sensors, and fire detectors to interpret real-time data and make sure that dangerous situations are found quickly. Alerts are sent out locally via buzzers and LCD screens. IoT connectivity makes it possible to monitor and send alerts from afar, giving you rapid access to important information on web platforms. This smart technology is powered by a regulated power supply and helps miners and authorities by giving them accurate and timely environmental data. It also speeds up emergency response times, lowers the danger of accidents, and makes mining safer.

Keywords: CO, DHT11, Arduino Micro Controller, Lcd, Buzzer

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1. INTRODUCTION

One of the most important and dangerous jobs in the world is mining coal. It is very important for making energy and growing the economy, especially in countries that rely significantly on coal for electricity and fuel for industry. But coal mining is dangerous for both people and the environment. For example, it can produce hazardous gases like carbon monoxide (CO), put workers at risk of high temperatures, spark fires, and even trigger earthquakes or other seismic activity because of the way mining is done underground. Not only do these dangers put miners' lives at risk, but they also do a lot of damage to mining infrastructure and the ecosystem around it. To keep workers safe and limit harm to the environment, there needs to be an efficient, real-time monitoring system that can find risky situations early and let the right people know so they can act quickly. Traditional safety systems in coal mines depend a lot on people checking things by hand and regularly inspecting them. These methods are not always good at finding changes in the environment that happen quickly. There is a higher chance of accidents and a longer wait for emergency responders because there is no continuous or automated surveillance. Modern technologies like the Internet of Things (IoT) have made it feasible to set up smart, automatic

monitoring systems that collect and analyze data all the time, in real time. IoT-enabled systems are made up of sensors and devices that are connected to each other. These systems can monitor environmental factors from afar, process data on-site or in the cloud, and send alerts through a variety of communication channels. Because of these properties, IoT technology is very useful in coal mines, which are dangerous and complicated places. The suggested IoT-based coal mine monitoring system uses a number of sensors to constantly check important environmental elements like temperature, carbon monoxide levels, seismic activity, and the existence of fire. An Arduino microcontroller collects data from sensors and processes it based on safety limits that have already been set. When dangerous situations are found, the system sends out local alerts utilizing buzzers and LCD screens and also sends real-time alerts to remote monitoring stations through IoT platforms. This dual alert system makes things safer by making sure that everyone knows what's going on right away, whether they're on site or not. This lets people make decisions and respond to emergencies faster.

The system also uses IoT technology to allow for long-term data logging and analysis, which can assist find patterns and trends that affect mine safety. This data-driven method helps with predictive maintenance and proactive safety management, which lowers the chance of accidents even further. The system is also scalable and affordable since it uses cheap sensors and microcontrollers that are easy to find. This means that mines of all sizes can use it, even in developing areas where mining safety infrastructure may not be as good. In short, the IoT-based coal mine monitoring system solves important safety problems in mines by constantly and automatically keeping an eye on dangerous environmental factors. Its ability to send alerts in real time, together with its flexibility to be accessed from anywhere and analyze data, makes it a complete solution for improving miner safety, avoiding accidents, and safeguarding mining infrastructure. The goal of this study is to develop, build, and test such a system, which will help make coal mining safer and more environmentally friendly.

2. LITERATURE SURVEY

Adding Internet of Things (IoT) technologies to coal mine safety monitoring systems has greatly improved their ability to find hazards in real time, communicate, and respond to emergencies. In the past, coal mine safety depended a lot on manual inspections and cable communication. These methods had a lot of problems with response time and the ability to keep an eye on dangerous circumstances that changed quickly. As the Internet of Things (IoT) has grown, it has become possible to set up a network of sensors that constantly check different environmental factors. This gives miners and authorities fast information to lower risks.

Early research, including the work of Thilagavathi and Arockiam (2023), showed that it was possible to use gas sensors, MEMS sensors, and light-dependent resistors (LDR) in an IoT framework to keep an eye on underground mining areas. Their technology put a lot of emphasis on tracking important things like gas leaks and fires in real time. These are the main causes of accidents in coal mines. The authors showed that automating the monitoring process could make it less necessary to do manual inspections and speed up responses. Maheswaran et al. (2023) made more progress

in this area by adding a wireless sensor network that used Arduino UNO and NodeMCU microcontrollers along with sensors for temperature, humidity, and gas. Their investigation showed how important it is to keep an eye on the environment all the time, especially in underground mines with limited ventilation, where dangerous gasses like carbon monoxide can build up quickly without being noticed right away. It was found that IoT systems' ability to broadcast alarms from afar using GSM or WiFi modules was a key aspect in making mines safer.

In 2025, Rokade et al. looked into the idea of wearable IoT devices for miners. They created a smart helmet with several sensors that could keep an eye on both the miners' health and the environment at the same time. This method used built-in accelerometers to find gas exposure, extreme temperatures, and falls or impacts in order to offer customized safety measures. The smart helmet might send real-time alarms to a central monitoring system, which would make it possible to quickly evacuate and get help in an emergency, which would save a lot of lives. Machine learning (ML) and artificial intelligence (AI) have also been used to make coal mine safety systems more accurate and better at predicting problems. Luo and Pan (2024) came up with a safety early warning system that uses a genetic algorithm (GA-BP) and a three-layer feedforward backpropagation artificial neural network. By looking at complicated patterns in sensor data, their technology made it easier to find possible hazards. This made it possible to take safety steps before risky circumstances got worse. This combining of AI with IoT sensors is a big step toward making safety systems that are smart and can work on their own.

Another important part of mine safety that has used AI in new ways is keeping an eye on dust levels. Trubicina et al. (2024) created an autonomous system that uses AI to check dust levels in real time in mine atmospheres. Dust is a big health risk in coal mines since it can cause respiratory problems in miners. Their method was meant to do more than just find unsafe levels of dust; it was also meant to look at old data to figure out long-term health risks. Researchers have recently looked into using wireless protocols like LoRaWAN for industrial IoT applications in mining. LoRaWAN is a long-range, low-power communication system that works well in underground or remote mining areas where regular cellular service is not reliable or not accessible. Industry experts talk about how hard it is to make sure that these networks perform well, manage electricity, and keep data safe when they are set up in rough mining areas.

There have also been reports of IoT being used in coal mines in real life. For instance, a system that used Arduino-based sensors and GSM modules was shown to keep an eye on and warn of excessive carbon monoxide levels and fires. It sent data to remote monitoring centers via SMS. Local alerts were also sent out using LCD screens and buzzer alarms to make sure that miners in the area got the warnings right away.

George and Thomas (2019) did more research that looked at a wide range of IoT designs used in mining safety. They compared different types of sensors, communication protocols, and data management platforms. Their research stressed how important it is for coal mine monitoring systems to be able to grow, be easy to set up, and process data in real time.

It is still hard to completely use these

technologies in all mining operations, especially in developing areas where resources and infrastructure may be limited. Power supply problems, sensor calibration, network interference, and data privacy are all ongoing difficulties that need more innovation and standardization.

In general, the material we looked at supports the idea that IoT-based technologies could make coal mines safer. These technologies assist keep miners safer, stop disasters from happening, and make mining operations more environmentally friendly by combining sensing of several environmental factors, real-time data transmission, smart data processing, and timely alerting systems. More research and development in sensor technology, AI integration, and communication networks will make the system even more reliable and popular in the coal mining business.

3. EXISTING SYSTEM

Environmental and safety parameters are measured by individual sensors that are coupled to a microcontroller in the current coal mine monitoring systems. The system mostly relies on manual oversight and simple alarm systems. With the Arduino microcontroller, sensors such the DHT11 (temperature and humidity), CO (gas detection), earthquake, and fire sensors are interfaced. Data from these sensors is continuously read by the controller, which keeps an eye on the surroundings.

Stable voltage is supplied to the microcontroller and sensors by a controlled power source. An LCD module locally displays the gathered sensor data, and in the event of a critical condition, a buzzer alert is activated to provide prompt on-site warnings. For remote data transfer, some systems come with a simple IoT module; nevertheless, the dependability and real-time data analytics are restricted.

All things considered, the current system concentrates on simple monitoring and alerting; it lacks sophisticated automation, predictive analysis, and strong real-time IoT connectivity—all of which are critical for enhancing miner safety and detecting hazards early.

4. PROPOSED SYSTEM

The suggested IoT-based coal mine monitoring system is meant to keep an eye on important environmental factors all the time and in real time to keep miners safe and stop accidents. The Arduino microcontroller connects a lot of different sensors, such as temperature and humidity sensors (DHT11), carbon monoxide (CO) gas sensors, earthquake shaking sensors, and fire detection sensors. The Arduino is the main processing unit. It gathers data from sensors, analyzes it, and decides whether there are any dangerous conditions depending on set criteria. A controlled power supply makes sure that all parts work properly. This multi-sensor array lets you keep an eye on the deep mine environment in great detail. It may also provide you early warnings about possible threats including toxic gas buildup, fires, earthquakes, and extreme temperature changes.

The system uses both local and remote notification methods to make sure that safety alerts are sent out on time. An LCD panel shows real-time information about the environment, and a bell goes off when harmful levels are found, which alerts miners right away. At the same time, the system links to the Internet through IoT modules and sends data to a cloud platform that mine operators and safety professionals may access from anywhere. This lets people keep an eye on things from

wherever, which makes it easier to make quick decisions and respond to emergencies. The suggested system improves standard safety measures by adding automation, real-time data visualization, and remote access. This makes mining operations safer and lowers the danger of accidents.

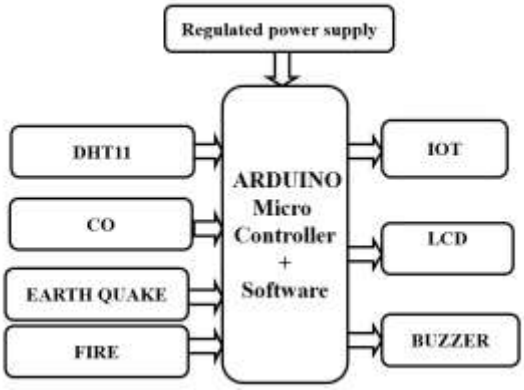
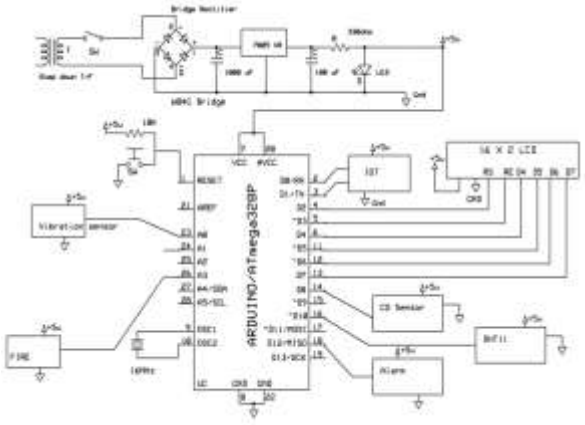


Fig.1. Proposed block diagram

WORKING MODEL:

The block diagram of the IoT-based coal mine monitoring system shows how the system is put together and how data moves through it. It also shows the main parts and how they work together. The Arduino microcontroller is the brain of the system. It collects and processes data from the sensors. The Arduino is connected to several sensors that keep an eye on important environmental factors in the coal mine. The DHT11 sensor measures temperature and humidity, the carbon monoxide (CO) sensor finds hazardous chemicals, the earthquake sensor finds seismic waves or tremors beneath, and the fire sensor finds smoke or fire. The sensors keep sending real-time data signals to the Arduino.



The microcontroller then compares these values to safety limits that have already been defined. When the Arduino finds a dangerous situation, it turns on output devices to warn miners and supervisors. The LCD screen is a local visual interface that shows the current measurements for temperature, gas levels, and other important data. At the same time, a buzzer sounds an alarm that miners can hear right away to warn them of any risk, allowing them to quickly leave or take other steps.

The system has an IoT communication module (like WiFi or GSM) that sends sensor data wirelessly to an online cloud platform or web server for remote monitoring. This way of sending data from a distance lets mine managers and safety workers keep an eye on things in real time from anywhere, so they can always be on the lookout, even when they're not at the mine. A controlled power supply powers the whole system, making ensuring that all the parts work without interruption and that the voltage stays consistent. These modules work together to make a whole safety monitoring network that makes it easier to find and talk about dangerous situations in the coal mine.

5. RESULTS

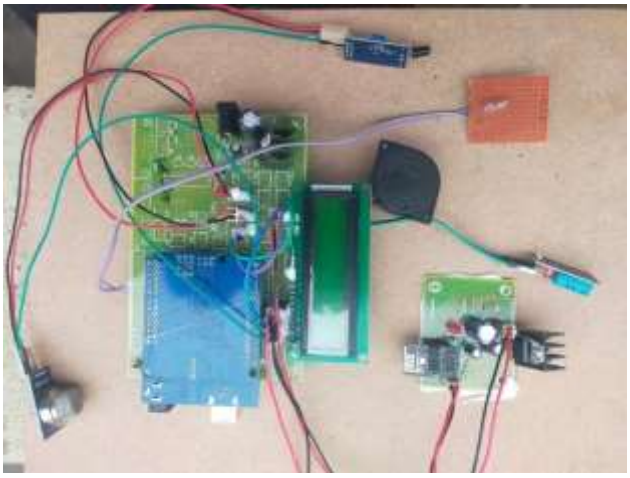


Fig.3. Proposed Output model

A 12-volt regulated power source powers the system. This power supply is stepped down and turned into a stable 5-volt direct current (DC) that powers all the circuit parts. When the system is turned on, an LED indicator connected to the 5V line instantly lights up, showing that the voltage is correct. This regulated 5V supply makes sure that all of the hardware modules, such the sensors and the microcontroller, have a steady and reliable power source so they can work correctly.

In the planned system for monitoring coal mines, the vibration sensor is a key switch that picks up on seismic activity or tremors underground that could mean an earthquake or a building that isn't stable. When the vibration sensor picks up on strange movement, it sends this information to the microcontroller to be processed and sent. The processed data is then delivered to an IoT server over a WiFi network, which lets mine safety workers keep an eye on things from a distance. The technology uses a piezoelectric buzzer that makes a loud noise on site to let miners know right away. At the same time, the IoT server updates the coal mine safety data on a separate webpage every 5 seconds. This gives you real-time information about things like gas levels, temperature, and seismic activity. This regular updating of data keeps managers and emergency responders up to date so they can act quickly when needed. So, the buzzer and IoT server make up the system's output modules. They turn sensor data into audible warnings and remote messages, making sure that miners are safe by sending them alerts on time and keeping an eye on the surroundings at all times.

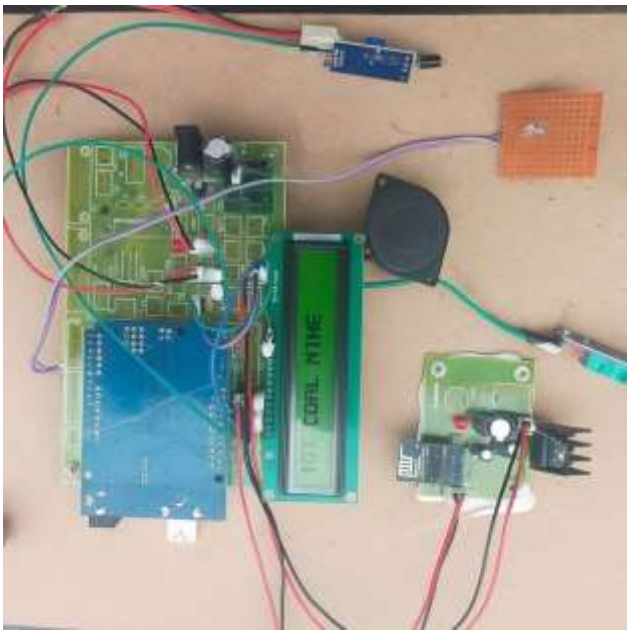


Fig.4. LCD Output

Fig.5. Web server Output

Table.1 Results comparison Table

Parameter	Existing Model	Proposed Model
Microcontroller	8051	Arduino
Speed	Low	High
Complexity	High	Low
Efficiency	LOW	HIGH

5. CONCLUSION

This IoT-based coal mine monitoring system works well with a variety of sensors, such as the DHT11 for temperature and humidity, the CO sensor for gas detection, the vibration sensor for structural integrity, and the fire sensor for hazard identification. The LCD shows real-time data, which makes it easy for workers and managers to spot dangerous situations right away. This solution uses IoT technology to enable for remote monitoring, which makes dangerous places like coal mines safer and lowers the chances of accidents. In the end, the prototype shows how sensor fusion and the Internet of Things may make industrial safety requirements better. With more work, these systems can be made bigger and used in real mines to send out early warning warnings, stop accidents, and make sure that emergency responders get there on time. This combination of hardware and IoT connectivity is a good sign for the future of smart safety management in businesses with a lot of risk.

REFERENCES

1. M. H. Ali — Improving coal mine safety with Internet of Things (IoT) (IoT-DSICS). A proposed IoT dynamic sensor information/control system for mine microclimate and gas monitoring. ScienceDirect
2. D. (authors) — Underground Coal Mine Monitoring with Wireless Sensor Networks (WSNs). Early/seminal WSN design and prototype for environmental and structural mine monitoring. ResearchGate
3. (ACM) — On IoT based Underground Mine Environment Monitoring (conference/overview). Survey and examples of LoRa/IoT solutions for underground coal mine monitoring. ACM Digital Library
4. H. Z. ul Hassan et al. — A wireless sensor network for coal mine safety powered by ... (ScienceDirect). WSN design addressing the harsh underground environment and energy issues. ScienceDirect
5. Wireless sensor-based monitoring of coal mine mechanical systems — continuous monitoring of mechanical stresses, gas levels and temperature using WSNs. Useful for vibration and structural monitoring strategies. ojs.sin-chn.com
6. G. Ramesh — An IoT System for Monitoring and Alerting Safety in Coal Mines (E3S Conf.). Practical IoT prototype and alerting workflow for mine safety. e3s-conferences.org
7. IoT Based Coal Mine Safety Monitoring and Controlling — design notes on underground localization, UWB/IMU fusion and monitoring/control architectures. ResearchGate
8. F. Molaei et al. — A Comprehensive Review on Internet of Things (IoT) and its applications in mining — an IoT-in-mining survey covering ventilation, personnel tracking, air quality, and WSNs. Good for literature context. Science Publications
9. C. H. Lee et al. — Development of IoT-Based Real-Time Fire Detection (Applied Sciences / MDPI). IoT fire detection design combining sensors and edge devices for real-time alerts. MDPI
10. A YOLO-based Approach for Fire and Smoke Detection in IoT Surveillance —

computer vision + IoT approaches for more reliable fire detection (useful if using camera-based detection alongside sensors). The Science and Information Organization

11. B. Miles — Carbon monoxide detection: an IoT application used for alerting/civil protection (ACM). Architecture for CO sensing + alerting to authorities. ACM Digital Library
12. Smart Monitoring of Carbon Monoxide using Internet of Things — prototype implementations with MQ-series gas sensors and IoT reporting; useful background for CO sensor selection and calibration methods. ResearchGate
13. IoT-based Vehicle Carbon Monoxide Monitoring, Alerting & Controlling — vehicle-focused, but contains helpful design patterns for MQ sensor interfacing, thresholds, cloud reporting. Warse
14. S. U. Rehman — A vibration-based IoT approach for remote real-time systems / Structural Health Monitoring — methods for vibration acquisition, feature extraction and remote reporting (applicable to tunnel / roof stability). ScienceDirect
15. S. U. Rehman (extended) — Advancing Structural Health Monitoring: vibration-based SHM — designs and algorithms for vibration-based damage/state detection (good for mining-structure monitoring). SSRN
16. M. Aruna et al. — Enhancing safety in surface mine blasting operations with IoT and ML — IoT ground vibration monitoring device and ML-based prediction of hazardous vibration levels (surface mining case). Nature
17. P. Nobahar et al. — Exploring digital twin systems in mining operations: A review — role of digital twins + IoT for predictive safety and monitoring (helps if you plan analytics/DT). ScienceDirect
18. IoT-Based Fire Detection Systems: Advancing Safety Through Intelligent Technology — review paper on IoT fire detection (algorithms, sensor fusion, cloud/edge). Good for design choices and tradeoffs. ResearchGate
19. Remote Environmental Monitoring System Using DHT11 (IJISRT / other). Practical implementations of DHT11 + ESP/NodeMCU for remote temp/humidity monitoring and IoT dashboards — useful for low-cost mine microclimate sensing. IJISRT
20. Monitoring the Temperature and Humidity using DHT11 (IoT based) — multiple case studies / student papers showing DHT11 integration, calibration notes, and ThingSpeak/Cloud upload patterns. Useful for rapid prototyping and understanding DHT11 limitations. ResearchGate