SUBTERRA SENSE: HARNESSING ADVANCED IOT FOR PURE AIR IN UNDERGROUND REALMS

PROJECT SYNOPSIS

OF MAJOR PROJECT

Masters of Computer Applications

Branch

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INTRODUCTION

As mining contributes to a large part of the economy in the world hence this sparks a vast amount of interest for researchers on how to improve the harsh conditions that miners have to face as they enter the mining tunnels .

Around 15 000 miner are dying each year due to mining accidents and around 50 percent of these are due to air pollution in mines including gas explosions and dust-related incidents, are significant contributors to these fatalities .In the recent years WHO has also recorded a large number of individuals diagnosed with Pneumoconiosis (Black Lung Disease)and silicosis due to air pollution .

Most of the previous technologies lack the concept of real time and this means that they can not detect the issue in real time but only after the issue has cropped up then they give a warning and this is where the Internet of things (IOTs) comes into place we can integrate the old system with real-time data transmission.

PROBLEM STATEMENT

In many developing nations as well as developed nations , poor air quality control remains a significant issue due to how expensive it is to implement and execute for the organisations as well as lack of knowledge on how to implement these systems , leading to a high rate of fatalities and chronic health conditions among miners.

OBJECTIVE

There have been many air quality control systems developed however this project is different from all the others due to its focus on real time data transmission which is a problem in most systems . It also focus on dust sensor which is normally overlooked as not important while researcher look at gases but dust is equally important and contribute to death fatalities

LITERATURE REVIEW

In the paper "Air Quality Management: A Mining Perspective," Schwegler (2006) focused on the multifaceted challenges of air quality management in the mining sector, mainly emphasising on the critical need for comprehensive strategies to mitigate air pollution and protect worker health. He highlighted the importance of integrating technology, regulatory frameworks, and community engagement in developing effective air quality control measures. Schwegler discusses the roles of various pollutants typically found in mining operations, including dust and gaseous emissions, and presents case studies illustrating successful air quality management practices. The paper provides valuable insights into best practices for monitoring and assessing air quality, making a significant contribution to the literature on environmental management in mining contexts .

Singh and Gupta (2023) also reviewed various technological solutions for air pollution control, including advanced filtration systems, electrostatic precipitators, and catalytic converters. Their review outlined the mechanisms of these technologies and assessed their efficacy in different industrial applications however it focused more more on other industries leaving the mining industries in its pursuit for knowledge . The authors highlighted that while investing in such technologies can be costly, the long-term benefits in terms of health outcomes and environmental sustainability justify such investments.

A comprehensive study on the effectiveness of air quality monitoring systems in urban areas was conducted by Gao et al. (2020) . Their research highlighted the use of low-cost sensors as an emerging technology for real-time monitoring of hazardous pollutants, including PM2.5 and NO2. The study found that these sensors, when calibrated correctly and used in conjunction with traditional methods, could provide valuable data to inform policy decisions and improve public awareness about air pollution levels .

The impact of policy measures on urban air quality has been a topic that many researchers have looked at, however Lee and Kim (2021) gave a new insight to this study . Their analysis focused on Seoul, South Korea, where strict vehicular emissions regulations were implemented. The article concluded that while such policies significantly reduced pollutants, public engagement and education were essential for their long-term success. The authors emphasised the need for ongoing assessments to adapt regulations to changing urban dynamics.

Miller et al. (2019) investigated the role of green infrastructure in air quality improvement. Their research illustrated that urban green spaces, such as parks and gardens, play a crucial role in reducing air pollution by absorbing airborne particulates and acting as carbon sinks. The longitudinal study showed that cities incorporating green infrastructure not only improved air quality but also enhanced residents' quality of life.

FEASIBILITY STUDY

This project aimed to provide real-time data to miners , promote awareness, and facilitate actions for improving air quality.

Technical Feasibility:

Hardware Availability: The project relied on readily available sensors (such as MQ series for gas detection and DHT 11 that can be interfaced with the Arduino Uno.

Software Development: Suitable libraries and resources are available for sensor interfacing and data collection. The Arduino IDE supports necessary programming for data acquisition and processing.

System Integration: The integration of sensors, Arduino, and output display (LCD or mobile app) is technically achievable, given the compatibility of the components.

Economic Feasibility:

Cost Analysis:The estimated cost of components (Arduino Uno, sensors, display, etc.) is relatively low, a little bit over ₹ 1000. This makes the project economically viable for educational institutions.

Operational Feasibility:

User Adoption: Growing concern over air quality issues in mines suggests that there's a clear demand for air quality monitoring systems. An easily deployable, user-friendly interface can attract users.

Maintenance Requirements: The system will require periodic sensor calibration and maintenance, but these processes are feasible and low-cost.

Need for the Project:

Air pollution remains a significant environmental health risk, affecting many miners globally. According to the WHO, millions die each year due to air pollution in mines . This project addresses the need for accessible air quality monitoring, enabling individuals to make informed decisions and measures to be taken to secure their health.

Significance of the Project:

Public Awareness: By providing real-time air quality data, the project raises awareness concerning air pollution and its effects on health and the environment.

Data for Research: The collected data can serve as a valuable resource for researchers and policy-makers to analyse trends and implement effective measures against air pollution.

In conclusion, this feasibility study indicates that the Air Quality Control Project using Arduino Uno is technically, economically, and operationally achievable, addressing a critical need for environmental monitoring and public health awareness.

METHODOLOGY

To develop an effective IoT-based air quality control system suitable for underground mining environments, the following structured methodology is applied. This methodology was designed to ensure accurate data collection, reliable communication, and practical usability in real-world mining conditions.

Problem Definition and Requirement Analysis

The project begins by defining the key air quality parameters to monitor , specifically identifying gases and particulates relevant to the underground mining environment .A literature review was conducted to understand existing systems and their limitations, helping refine requirements for sensor accuracy, response time, and operational resilience.

System Architecture and Component Selection

Based on the requirements, the system architecture was developed, detailing each component's function and interconnectivity. This architecture includes the Arduino Uno microcontroller, gas sensors MQ-135 , a DHT11 sensor for humidity and temperature, a 16x2 LCD display for real-time data visualisation. Each component was selected according to technical specifications, focusing on measurement accuracy, energy consumption, and cost effectiveness .

Sensor Calibration and Hardware Integration

Following component selection, the sensors are calibrated to ensure precise measurements of air pollutants. This involves testing each sensor one by one before combining them . After calibration, the components are integrated with the Arduino, where the wiring and configuration are verified for stability. The LCD display is added to provide immediate feedback on air quality for on-site personnel.

Software Development and Data Collection Protocols

Data collection protocols are designed to capture readings at regular intervals, ensuring consistency in real-time monitoring. The software also enables data transmission to a cloud storage platform or local database, facilitating remote monitoring and historical data access for analysis.

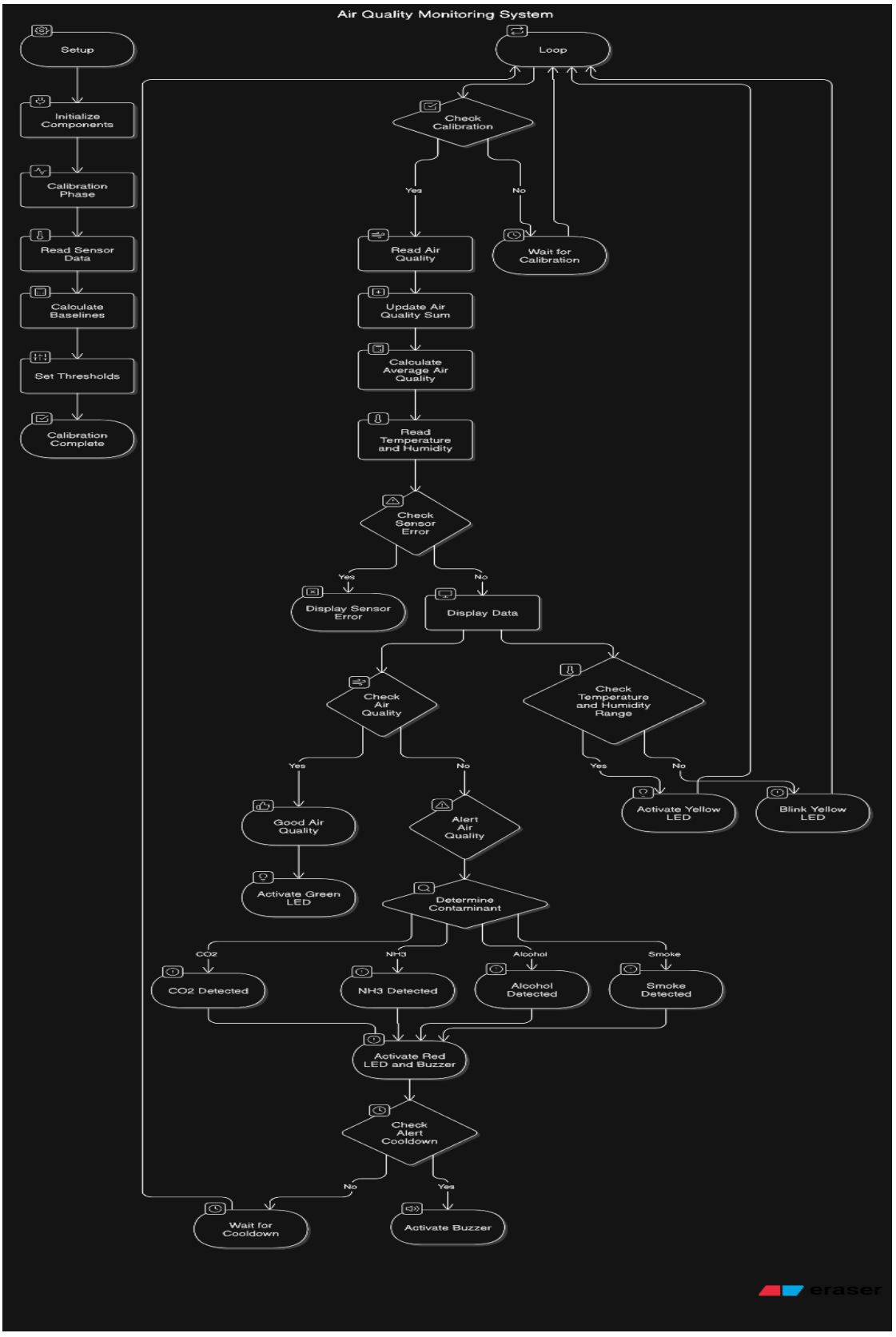
Data Analysis and Visualization

The collected data was analysed using data visualisation tools (Power BI) to interpret air quality trends and pollutant levels over time.This data analysis also helps in assessing system effectiveness over extended periods.

Evaluation and Iterative Improvement

The final step involves evaluating the system's overall performance, focusing on data accuracy, power efficiency, and durability in mining conditions. Feedback from testing phases is used to refine sensor calibration, software algorithms, and system integration.

A working flowchart of the air quality system



FACILITIES REQUIRED FOR AIR QUALITY CONTROL

In these projects the researcher used an arduino uno board as a microcontroller .Air quality sensors were also used like MQ-135 so as to detect the dangerous gases that might be lurking in the tunnel of the mine . SD card was also used and this gave us storage facility for real time clock module for timestamping data.An OLED was used for real time data visualisation . We also used the sensors calibration and housing , this was used so as to protect the sensors from dust and any moisture that might come in contact with our sensors .Arduino IDE was the software development environment that was used for coding and this provides a wide range of libraries and this has helped us come up with the best code for the air quality control .There are some instances that the miners can not always be at the led all the time hence they need some gadget to notify them as soon as there is a problem hence to solve this we installed the buzzer for alert since this does not need constant monitoring

EXPECTED OUTCOME

```
1:06:40 PM.290 Temp: 25.50 C, Hum: 73.90 %
1:06:46 PM.437 Temp: 25.50 C, Hum: 73.80 %
1:06:52 PM.346 Temp: 25.50 C, Hum: 73.80 %
1:06:58 PM.406 Temp: 25.50 C, Hum: 73.80 %
1:07:04 PM.427 Temp: 25.50 C, Hum: 73.80 %
1:07:10 PM.465 Temp: 25.50 C, Hum: 73.90 %
1:07:16 PM.490 Temp: 25.50 C, Hum: 73.90 %
1:07:22 PM.533 Temp: 25.50 C, Hum: 73.70 %
1:07:28 PM.556 Temp: 25.50 C, Hum: 73.60 %
1:07:34 PM.609 Temp: 25.50 C, Hum: 73.60 %
1:07:40 PM.649 Temp: 25.50 C, Hum: 73.50 %
1:07:46 PM.679 Temp: 25.50 C, Hum: 73.50 %
1:07:52 PM.703 Temp: 25.50 C, Hum: 73.50 %
1:07:58 PM.807 Temp: 25.50 C, Hum: 73.50 %
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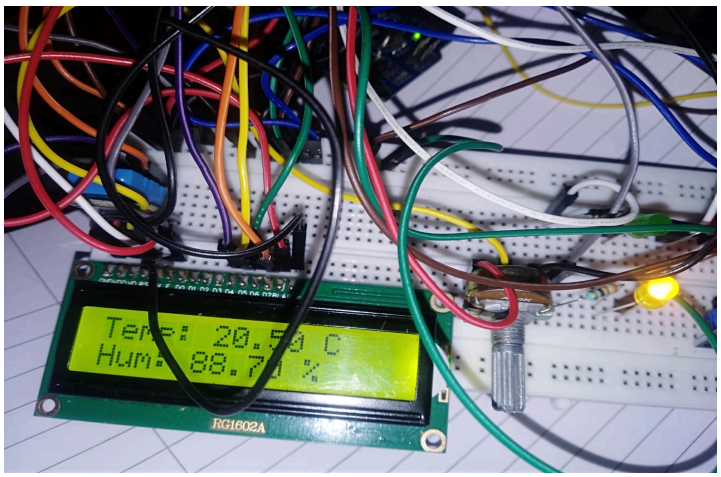
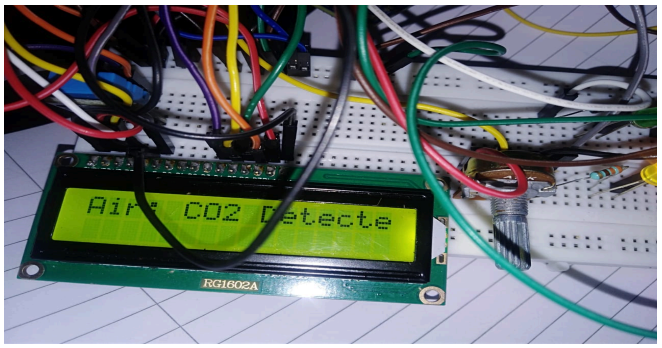
Fig 1.1 this is the results in the serial monitor with timestamp





The project is anticipated to yield a robust, real-time air quality monitoring system tailored to the specific challenges of underground mining environments. By accurately detecting hazardous gases and particulate matter, the system is supposed to facilitate improved occupational safety through continuous data collection and real-time alerts when pollutant concentrations exceed safe thresholds. This data will be transmitted to a cloud platform, enabling remote monitoring and historical data analysis for trend identification and long-term safety planning. Additionally, through comprehensive data visualisation, mine operators will gain actionable insights to optimise ventilation systems, enhance health and safety protocols, and support data-driven decision-making. The modular architecture of the system is designed for scalability, offering potential applicability in various subterranean contexts beyond mining, and laying the groundwork for future integration with predictive analytics, thereby advancing sustainable practices within industrial and environmental monitoring frameworks.

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