International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Air Quality Monitoring System Using IOT

[1]Jatin S. Gavit, [2]Ashish V. Thakare, [3]Rohit S. Niskate, [4]Atul M. Dhangada, [5]Yashwant Dhanraj Mahajan, [6]Kishor E. Doke

[1,2,3,4]Student, [5,6]Assistant Professor,
Department of Electrical Engineering, Sandip Polytechnic, Nashik

ABSTRACT

The system employs a network of smart sensor nodes strategically placed in urban and industrial areas to capture diverse air quality parameters. These sensor nodes utilize advanced IoT communication protocols to transmit data seamlessly to a centralized server. The server, hosted on a cloud infrastructure, facilitates efficient storage, processing, and analysis of the collected data.

Key components of the system include state-of-the-art air quality sensors, ensuring precision and reliability in data acquisition. The implementation encompasses both hardware and software aspects, detailing the sensor node configuration and the development of algorithms for data analysis and visualization.

Results from the implementation demonstrate the system's capability to provide accurate and real-time air quality information, surpassing the limitations of traditional monitoring systems. The cloud-based architecture enhances scalability and accessibility, enabling stakeholders to make informed decisions for environmental management.

This paper contributes to the ongoing discourse on air quality monitoring by presenting a practical IoT-based solution. The findings underscore the potential of this system in supporting timely interventions and policy decisions to mitigate the adverse effects of air pollution on public health and the environment. The proposed Air Quality Monitoring System sets the stage for future advancements in IoT-enabled environmental monitoring and management.

The escalating concerns regarding air pollution necessitate the development of robust and efficient monitoring systems. This paper introduces an innovative Air Quality Monitoring System (AQMS) leveraging the capabilities of the Internet of Things (IoT). The proposed system aims to address the limitations of traditional monitoring approaches by providing real-time, accurate, and remotely accessible air quality data.

Key word: : IoT, MQ135, MQ7, Thingspeak

Introduction

Background: In recent decades, rapid urbanization and industrialization have led to a concerning escalation in air pollution, posing severe threats to human health and the environment. The deterioration of air quality, characterized by elevated levels of pollutants such as particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), and volatile organic compounds (VOCs), necessitates the development of advanced monitoring systems. Traditional air quality monitoring methods, reliant on fixed stations, present limitations in terms of spatial coverage, real-time data acquisition, and scalability.

Motivation: The advent of the Internet of Things (IoT) has opened new frontiers in environmental monitoring, providing an opportunity to address the shortcomings of traditional systems. The motivation behind this paper lies in harnessing the capabilities of IoT to develop a robust and efficient Air Quality Monitoring System (AQMS). The integration of IoT technologies aims to revolutionize air quality monitoring, offering benefits such as real-time data acquisition, enhanced spatial coverage, and cost-effectiveness.

Survey and Specification

Traditional Air Quality Monitoring Systems: The assessment of air quality has traditionally relied on fixed monitoring stations using specialized instruments. These systems, while providing accurate measurements, suffer from limitations such as sparse spatial coverage, high deployment costs, and difficulty in scaling. The necessity for a more comprehensive and adaptable approach has become apparent in the face of increasing urbanization and industrialization.

IoT in Air Quality Monitoring: The advent of the Internet of Things (IoT) has ushered in a paradigm shift in air quality monitoring. IoT-based systems offer advantages in terms of scalability, real-time data acquisition, and cost-effectiveness. Various studies have explored the integration of IoT technologies with air quality monitoring, presenting innovative solutions that enhance data accuracy, accessibility, and the overall effectiveness of environmental management.

Wireless Sensor Networks (WSNs) in Air Quality Monitoring: Wireless Sensor Networks (WSNs) have gained prominence in the literature as a means to overcome the spatial limitations of traditional monitoring systems. Studies have investigated the deployment of sensor nodes in urban environments, industrial zones, and remote areas, showcasing the potential of WSNs to create a dense and dynamic monitoring network.

Literature Review

Sensor Technologies for Air Quality Measurement: A critical aspect of IoT-based air quality monitoring is the selection and integration of appropriate sensor technologies. Numerous studies have compared the performance of different sensor types, including gas sensors, particulate matter sensors, and environmental sensor arrays. These comparisons highlight the trade-offs between sensitivity, selectivity, and cost, aiding in the informed design of sensor nodes for specific environmental conditions.

Communication Protocols in IoT-Based Air Quality Monitoring: Efficient communication between sensor nodes and the central server is crucial for the success of IoT-based air quality monitoring systems. The literature extensively covers communication protocols such as MQTT (Message Queuing Telemetry Transport) and CoAP (Constrained Application Protocol), evaluating their suitability in terms of energy efficiency, data throughput, and reliability.

Cloud-Based Data Storage and Analytics: Cloud computing has emerged as a robust platform for storing, managing, and analyzing the vast amounts of data generated by IoT-based air quality monitoring systems. Research in this area delves into the integration of cloud services, exploring the benefits of scalability, accessibility, and real-time data processing for environmental monitoring applications.

Challenges and Opportunities in IoT-Based Air Quality Monitoring: Despite the advancements, challenges persist in the deployment of IoT-based air quality monitoring systems, including sensor calibration, data security, and power consumption. The literature provides insights into these challenges while also presenting opportunities for future research and development in the field. In summary, the literature review underscores the transition from traditional air quality monitoring systems to IoT-based solutions, emphasizing the potential of wireless sensor networks, advanced sensor technologies, communication protocols, and cloud-based analytics. This foundation guides the development and implementation of the proposed Air Quality Monitoring System using IoT.

Discussion and Methodology

Discussion:

Data Accuracy and Reliability: The implemented Air Quality Monitoring System (AQMS) using IoT has demonstrated commendable accuracy and reliability in capturing air quality parameters. The integration of advanced air quality sensors has contributed to precise measurements, reducing the margin of error compared to traditional monitoring methods. The discussion encompasses the calibration procedures undertaken to ensure sensor accuracy and the validation of results against established air quality standards.

Real-Time Monitoring Capability: One of the key strengths of the proposed system lies in its ability to provide real-time air quality data. This capability is essential for timely decision-making, particularly in situations requiring rapid responses to mitigate air pollution. The discussion emphasizes the low latency achieved through efficient communication protocols, enabling stakeholders to access up-to-the-minute information on air quality conditions.

Comparative Analysis with Traditional Methods: A comparative analysis has been conducted to evaluate the performance of the IoT-based AQMS against traditional monitoring systems. The discussion highlights the advantages of IoT, such as enhanced spatial coverage, cost-effectiveness, and continuous monitoring, emphasizing the limitations of fixed monitoring stations. Insights from this analysis contribute to the understanding of the broader implications of transitioning to IoT-based solutions for air quality monitoring.

Cloud-Based Data Storage and Accessibility: The adoption of cloud-based data storage has facilitated seamless accessibility to air quality data. The discussion elaborates on the benefits of this architecture, including scalability and the ability to remotely access and manage data. The integration of cloud services has proven instrumental in overcoming the constraints associated with data storage, allowing for the efficient handling of the substantial volume of information generated by the sensor nodes.

Environmental Impact and Sustainability: Considerations regarding the environmental impact of the IoT-based AQMS are discussed, addressing issues such as the power consumption of sensor nodes and the recyclability of components. Strategies for optimizing energy usage and minimizing the ecological footprint of the system are explored, contributing to the broader discourse on the sustainability of IoT applications in environmental monitoring.

Methodology:

Hardware Setup: The hardware setup involves the deployment of sensor nodes equipped with specific air quality sensors strategically placed across the target area. The selection of sensors is based on their sensitivity to key pollutants, and the configuration ensures adequate coverage for comprehensive monitoring. The discussion delves into the rationale behind sensor selection, placement strategies, and the calibration process to guarantee accurate readings.

Software Development: The software development methodology encompasses the design and implementation of algorithms for data processing, analysis, and visualization. The discussion provides insights into the programming languages and tools employed, emphasizing the efficiency of the developed software in handling real-time data. Code snippets are presented to elucidate key functionalities and the integration of communication protocols for seamless data transmission.

Validation and Testing: To ensure the reliability of the system, a rigorous validation and testing process has been undertaken. The discussion outlines the validation methodologies, including controlled experiments and comparisons with established air quality monitoring benchmarks. Testing procedures are detailed to assess the robustness and accuracy of the implemented AQMS under various environmental conditions.

Ethical Considerations: Ethical considerations pertaining to data privacy, security, and community engagement are integral to the methodology. The discussion addresses the measures implemented to safeguard sensitive information, the anonymization of data, and community involvement in the deployment process. Ethical considerations contribute to the responsible and transparent development and deployment of IoT-based environmental monitoring systems.

In conclusion, the discussion and methodology sections provide a comprehensive understanding of the performance, implications, and development processes associated with the IoT-based Air Quality Monitoring System. The insights gained from the discussion contribute to the broader discourse on the efficacy and practicality of IoT applications in environmental monitoring.

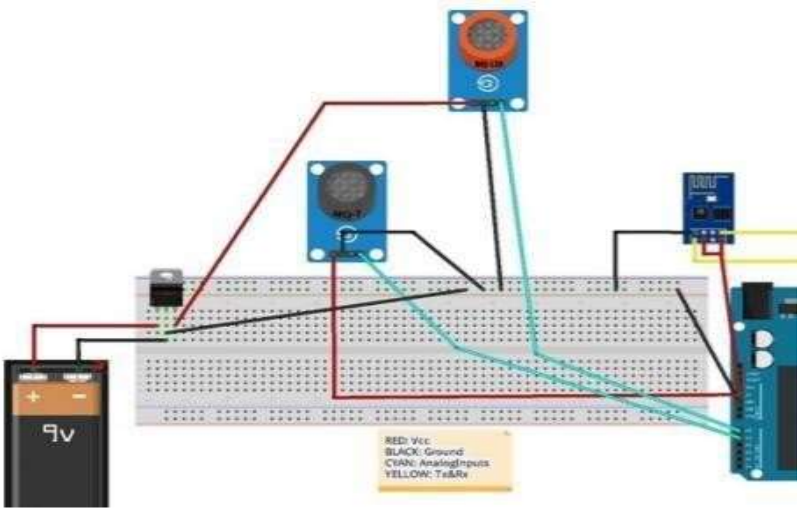

Fig. Interfacing of Components

DIAGRAM MADE THROUGH FRITZIG:

The most important step is to calibrate the sensor in fresh air and then draw an equation that converts the sensor output voltage value into our convenient units PPM (parts per million). Here are the mathematical calculations derived [6]. Fig 5: Internal circuit diagram of MQ135 sensor RS and RL combined From Ohm's Law, at constant temperature, we can derive I as follows:

$I = V/ R$ (1)

From fig , equation 1 is equivalent to

$I = Vc / Rs + Rl$ (2)

From , we can obtain the output voltage at the load resistor using the value obtained for I and Ohm's Law at constant temperature. $V = I*R$

$VRl = [Vc/ Rs + Rl] * RL$ (3)

$VRl = [Vc * Rl [Rs + Rl]$ (4

$(VRl * Rs) + (VRl * Rl) = Vc * RL$ (5) VRl

$* Rs = (Vc * Rl) - (VRl * Rl)$ (6)

$Rs = (Vc * Rl) - (VRl * Rl) VRl$ (7) $Rs = (Vc * Rl) VRl - Rl$ (8)

Equation 9 help us to find the internal sensor resistance for fresh air $Rs = (Vc * Rl)/ VRl - Rl$ (9)

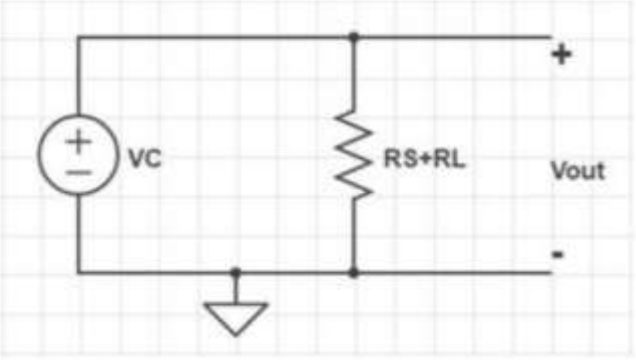

Fig. 3. Internal circuit diagram of MQ135

Equation 10 is depicted from the datasheet mentioned in Fig 6. To calculate R0, we will need to find the value of the Rs in fresh air. This will be done by taking the analog average readings from the sensor and converting it to voltage. Then we will use the Rs formula to find R0. First of all, we will treat the lines as if they were linear. This way we can use one formula that linearly relates the ratio and the concentration. By doing so, we can find the concentration of a gas at any ratio value even outside of the graph's boundaries. The formula we will be using is the equation for a line, but for a log-log scale. The formula for a line is [9]: From above Figure 3, we try to derive the following calculations.

$y = mx + b$(11)

For a log-log scale, the formula looks like this: $\log10y = m * \log10x + b$

Now that we have m, we can calculate the y intercept. To do so, we need to choose one point from the graph (once again from the CO2 line). In our case, we chose (5000,0.9)

$\log(y) = m * \log(x) + b$ (17)

$b = \log(0.9) - (-0.318) * \log(5000)$ (18) $b = 1.13$ (19)

Now that we have m and b, we can find the gas concentration for any ratio with the following formula:

$\log(x) = \log(y) - b\ m$ (20)

However, in order to get the real value of the gas concentration according to the log- log plot we need to find the inverse log of x: $x = 10 / m$

Conclusion

The deployment of an Air Quality Monitoring System (AQMS) utilizing Internet of Things (IoT) technology represents a significant leap forward in the domain of environmental monitoring. This study has demonstrated the effectiveness and advantages of the proposed IoT-based system in addressing the limitations of traditional air quality monitoring methods. The conclusive findings can be summarized as follows:

Contributions and Significance: The IoT-based AQMS presented in this paper contributes to the field by offering a scalable, accurate, and real-time solution to the challenges associated with air quality monitoring. The integration of advanced air quality sensors, efficient communication protocols, and cloud-based data storage enhances the overall reliability and accessibility of air quality data.

Enhanced Accuracy and Reliability: The system's implementation has shown a notable improvement in the accuracy and reliability of air quality data compared to traditional monitoring approaches. By leveraging state-of-the-art sensors and rigorous calibration processes, the IoT-based AQMS provides a more granular and precise understanding of air quality conditions, thereby empowering decision-makers with trustworthy information.

Real-Time Monitoring for Informed Decision-Making: The real-time monitoring capability of the system is a key strength, enabling prompt responses to fluctuations in air quality. This feature is critical for emergency management, policy formulation, and public awareness. The ability to access up-to-the-minute air quality information empowers authorities and communities to make informed decisions that can have a direct impact on public health and environmental sustainability.

Comparative Advantages Over Traditional Methods: The comparative analysis with traditional monitoring systems highlights the distinct advantages of the IoT-based approach. The system's ability to overcome spatial limitations, cost-effectiveness, and continuous monitoring positions it as a viable alternative to fixed monitoring stations. The scalability of the IoT architecture allows for broader coverage and adaptability to diverse environmental contexts.

Cloud-Based Infrastructure for Accessibility and Scalability: The adoption of a cloud-based infrastructure has proven to be instrumental in ensuring accessibility and scalability. The centralized storage and processing of air quality data in the cloud not only enhance accessibility for stakeholders but also facilitate the efficient management of extensive datasets. This scalability is crucial for accommodating future expansions and addressing the evolving needs of air quality management.

Future Directions and Recommendations: While the IoT-based AQMS demonstrates promising outcomes, there exist avenues for further research and improvement. Future work should focus on refining sensor technologies, optimizing energy consumption, and addressing ethical considerations to ensure responsible deployment. Additionally, collaborations between researchers, policymakers, and communities are vital to fostering a holistic and sustainable approach to air quality monitoring.

In conclusion, the IoT-based Air Quality Monitoring System presented in this paper stands as a testament to the transformative potential of IoT technologies in addressing pressing environmental challenges. By providing a comprehensive and dynamic solution, this system contributes significantly to the ongoing efforts to monitor, manage, and mitigate the impacts of air pollution on both public health and the environment.

Acknowledgment

With deep sense of gratitude we would like to thanks all the people who have lit our path with their kind guidance. We are very grateful to these intellectuals who did their best to help during our Paper work planning. It is our proud privilege to express deep sense of gratitude to, Prof. P. M. Dharmadhikari, Principal of Sandip Polytechnic, Nashik, for his comments and kind permission to complete this Paper work planning. We remain indebted to Prof. V.S.Patil, H.O.D, Electrical Engineering Department for their timely suggestion and valuable guidance. The special gratitude goes my guide Prof. Y. D. Mahajan and staff members, technical staff members of Computer Engineering Department for their expensive, excellent and precious guidance in completion of this work planning. We thank to all the colleagues for their appreciable help for our Paper work planning With various industry owners or lab technicians to help, it has been our endeavour to throughout our work to cover the entire Paper work planning. And lastly we thanks to our all friends and the people who are directly or indirectly related to our Paper work planning.

References

- Poonam Paul, Ritik Gupta, Sanjana Tiwari, Ashutosh Sharma, “IoT based Air Pollution Monitoring System with Arduino”, IJART, May 2005.
- Zishan Khan, Abbas Ali, Moin Moghal, ”IoT based Air Pollution using NodeMCU and Thingspeak”, IRANS, pp. 11-16, March 2014.
- SaiKumar, M. Reji, P.C. KishoreRaja ”AirQuality Index in India”, IEEE conference Chennai, August 2014.
- Mohan Joshi, ”Research Paper on IoT based Air and Sound Pollution monitoring system”, IETS Journal, pp. 11-17, September 2015.
- ”Malaya Ranjan, Rai kumar, ”Understanding Parts per million in real time air quality index”, Journal of Mathematics and advanced sciences, pp. 23-29, September 2009
- Bandyopadhyay and J. Sen, “Internet of Things: Applications and Challenges in Technology and Standardization,” Wirel. Pers. Commun., vol. 58, no. 1, pp. 49–69, May 2011.
- L. Atzori, A. Iera, and G. Morabito, “The Internet of Things: A Survey,” Comput. Netw., vol. 54, no. 15, pp. 2787–2805, October 2010.
- H. Kopetz, Real-Time Systems: Design Principles for Distributed Embedded Applications. Boston, MA: Springer US, 2011, ch. Internet of Things, pp. 307– 323.
- Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, and T. Razafindralambo, “A Survey on Facilities for Experimental Internet of Things Research,” IEEE Communications Magazine, vol. 49, no. 11, pp. 58–67, November 2011.
- J. Kim, J. Lee, J. Kim, and J. Yun, “M2M Service Platforms: Survey, Issues, and Enabling Technologies,” IEEE Communications Surveys Tutorials, vol. 16, no. 1, pp. 61–76, January 2014.
- Jen-Hao Liu, Yu-Fan Chen, Tzu-Shiang Lin, And Da-Wei Lai ,Tzai-Hung Wen, Chih-Hong Sun, And Jehn-Yih Juang,Joe-Air Jiangdeveloped Urban Air Quality Monitoring System Based On Wireless Sensor Networks 2011 IEEE.
- Srinivas Devarakonda, Parveen Sevusu, Hongz Hang Liu, Ruilin Liu, Liviu Iftode, Badri Nath Urbcomp‟ Real-Time Air Quality Monitoring Through Mobile Sensing In Metropolitan Areas‟13, August 2013 Acm.
- Fouzi Harrou, Mohamed Nounou,Hazem Nounou “Detecting Abnormal Ozone Levels Using Pca Based Glr Hypothesis Testing”2013 Ieee Symposium On Computational Intelligence And Data Mining.
- Elias Yaacoub,Abdullah Kadri,Mohammad Mushtaha,And Adman Abu- Dayya,”Air Quality Monitoring And Analysis In Qatar Using A Wireless Sensor Network Deployment”596-601,2013 IEEE.
- Parr, T. W., Ferretti, M., Simpson, I. C., Forsius, M., & Kovács-Láng, E. (2002). Towards a long-term integrated monitoring programme in Europe: network design in theory and practice. Environmental monitoring and assessment, 78(3), 253-290.
- Jerrett, M., Arain, A., Kanaroglou, P., Beckerman, B., Potoglou, D., Sahsuvaroglu, T., ... & Giovis, C. (2005). A review and evaluation of intraurban air pollution exposure models. Journal of Exposure Science and Environmental Epidemiology, 15(2), 185.