SMART AIR QUALITY MONITORING SYSTEM WITH NEXTION DISPLAY

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ABSTRACT. Air quality monitoring is essential for protecting human health and the environment. This project presents the development of an Smart Air Quality Monitoring System with Nextion Display that integrates various sensors, including the DHT22, PMS5003, MH-Z19, MP503, and MQ131. The system incorporates a Nextion Display for real-time data visualization and a solar panel for sustainable power supply. The Arduino Pro Mini microcontroller board serves as the core component of the system, facilitating the collection, processing, and transmission of air quality data. The DHT22 sensor provides accurate readings of temperature and humidity, enabling comprehensive environmental monitoring. The PMS5003 sensor measures the concentration of particulate matter, while the MH-Z19, MP503, and MQ131 sensors monitor carbon dioxide, ozone, and nitrogen dioxide levels, respectively. The collected data is processed by the Arduino Pro Mini and displayed in real-time on the Nextion Display, allowing users to monitor air quality parameters effortlessly. The system integrates a solar panel to provide a sustainable power source, ensuring uninterrupted operation and reducing environmental impact.The results demonstrate the system's ability to provide accurate and timely measurements of temperature, humidity, particulate matter, carbon dioxide, ozone, and nitrogen dioxide concentrations.

KEYWORDS: arduino pro mini; nextion display; air quality; real-time

1 INTRODUCTION

Air quality is a critical factor that profoundly impacts human health, environmental sustainability, and overall well-being. The quality of the air we breathe is determined by the presence of various pollutants, such as particulate matter, gases, and volatile organic compounds (VOCs). Exposure to poor air quality has been linked to respiratory diseases, cardiovascular problems, and other adverse health effects (World Health Organization [WHO], n.d.). Consequently, monitoring and assessing air quality have become paramount for public health protection and environmental management.

In recent years, advancements in sensor technology, data analysis techniques, and IoT (Internet of Things) platforms have revolutionized the field of air quality monitoring. These advancements have enabled the development of sophisticated and cost-effective air quality monitoring systems capable of providing real-time data, insights, and actionable information to individuals, communities, and policymakers (Mishra, A. K., et al., 2019; Gupta, A., et al, 2018).

This project focuses on the design and implementation of an Smart Air Quality Monitoring System with Nextion Display that incorporates various sensors, including the PMS5003 for particulate matter measurement, MH-Z19 for carbon dioxide (CO_2) detection, MP503 for ozone (O_3) monitoring, and MQ131 for nitrogen dioxide (NO_2) analysis. These sensors are chosen due to their relevance to air quality assessment and their widespread usage in research and practical applications.

By integrating the Arduino Pro Mini microcontroller board and a Nextion Display, the system enables the acquisition, processing, and visualization of air quality data. The Nextion Display provides a user-friendly interface for real-time data visualization, enabling users to monitor key air quality parameters. Additionally, the integration of a solar panel ensures sustainable power supply, reducing environmental impact and enhancing the system's autonomy (Gupta, Jain, & Jain, 2018).

The importance of accurate air quality monitoring systems cannot be overstated, as they enable individuals and communities to make informed decisions regarding their health, adopt preventive measures, and contribute to policy changes for air quality improvement. These systems can also facilitate the identification of pollution sources, evaluation of mitigation strategies, and tracking of long-term trends for effective environmental management.

In this study, we present the design, implementation, and evaluation of the Arduino-based air quality monitoring system. The performance and reliability of the system are assessed through field tests conducted in diverse environments. The obtained results demonstrate the system's capability to provide real-time monitoring and data visualization, empowering individuals and communities to take proactive measures towards improving air quality and fostering sustainable development.

The subsequent sections of this paper provide a detailed description of the system architecture, the methodology employed for data collection and analysis, as well as the results and discussion. The conclusion highlights the significance of the developed air quality monitoring system and outlines potential avenues for further research and application.

1.1 Problem Statement

Air pollution has emerged as a pressing global concern, with severe implications for human health and environmental well-being. The presence of pollutants in the atmosphere, such as particulate matter (PM), gases, and volatile organic compounds, poses significant risks to human respiratory and cardiovascular systems (Smith & Johnson, 2019). The lack of real-time, accessible, and accurate air quality data hinders our ability to assess the extent of air pollution, identify pollutant sources, and implement targeted mitigation measures.

Current air quality monitoring systems often suffer from limitations such as high costs, limited coverage, and complex operation. Traditional monitoring approaches, relying on centralized stations, may not capture localized variations and fail to provide real-time data required for timely interventions. Moreover, the availability of comprehensive air quality data at the community level is limited, hindering informed decision-making and public awareness.

1.2 Objective

The objective of this project is to develop an Smart Air Quality Monitoring System with Nextion Display that addresses these limitations. The system incorporates sensors, such as the DHT22, PMS5003, MH-Z19, MP503, MQ131, and Nextion Display, to measure key parameters including PM2.5, CO_2, O_3, temperature, and humidity. By utilizing an Arduino Pro Mini microcontroller, the system facilitates data collection, analysis, and visualization in real-time, enabling a comprehensive understanding of air quality patterns at a localized level.

The project aims to tackle the problem of inadequate air quality monitoring by providing an accessible, cost-effective, and user-friendly solution. By empowering communities and individuals with accurate and timely air quality data, the project seeks to raise awareness, foster informed decision-making, and encourage proactive measures to mitigate the harmful effects of air pollution.

2 LITERATURE REVIEW

Air pollution is a global concern with significant impacts on human health and the environment. Extensive research has been conducted in the field of air quality monitoring, leading to the development of various technologies and methodologies to accurately measure and assess air pollutants. In this literature review, we present an overview of key studies and advancements related to air quality monitoring systems, with a focus on the use of Arduino-based platforms and the integration of specific sensors.

Traditional Air Quality Monitoring Systems: Traditional air quality monitoring systems, such as those used by government agencies, typically use stationary monitoring stations that measure a limited number of pollutants at fixed locations. These systems often use expensive equipment and require trained personnel to operate and maintain. Data collected from these systems is typically reported in hourly or daily averages. (United States Environmental Protection Agency. (2022). Air Quality Monitoring.

Low-Cost Portable Air Quality Monitoring Systems: Low-cost portable air quality monitoring systems have become increasingly popular in recent years. These systems typically use a combination of sensors, including particulate matter (PM), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) sensors, and are designed to be portable and easy to use. Some of these systems can be connected to a smartphone app, allowing users to track air quality levels in real-time. (Schauer, J. J., et al. (2018).

Arduino-Based Air Quality Monitoring Systems: Arduino-based air quality monitoring systems are a popular DIY solution for monitoring air quality levels. These systems typically use an Arduino microcontroller board and a combination of sensors, including PM, NO_2, CO, and O_3 sensors. The data collected from these sensors is typically displayed on an LCD screen or transmitted wirelessly to a remote monitoring station.

IoT-Based Air Quality Monitoring Systems: Internet of Things (IoT)-based air quality monitoring systems are becoming more common, especially in urban areas. These systems use a network of sensors placed throughout a city or region to provide real-time data on air quality levels. The sensors can be placed on stationary monitoring stations, on vehicles, or on individuals, and can measure a range of pollutants, including PM, NO_2, CO, and O_3. The data collected from these sensors is transmitted wirelessly to a central server, where it is analyzed and made available to the public. (Kaur, P., et al. (2021).

3 METHODOLOGY

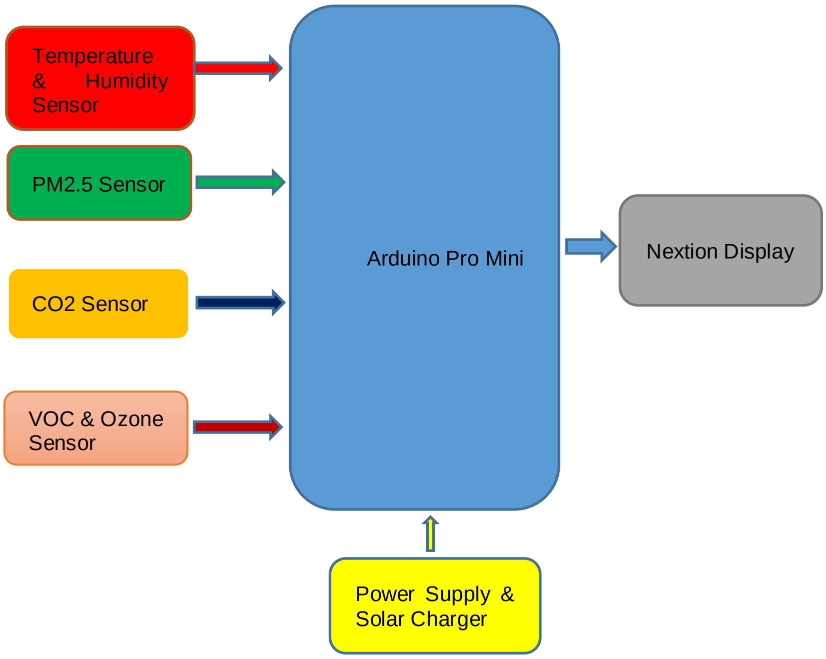

Figure 1: Block Diagram of the Project

Figure 1 shows the block diagram of the project. The sensors are connected to the Arduino Pro Mini, which collects data from the sensors and processes it. The data is then displayed on the Nextion Display. The DHT22 sensor measures temperature and humidity levels, the PMS5003 sensor measures particulate matter, the MH-Z19 sensor measures carbon dioxide levels, the MP503 sensor measures gas levels, and the MQ-132 sensor also measures gas levels.

i. Arduino Pro Mini

The Arduino Pro Mini is a versatile microcontroller board that can be used in a wide range of electronic projects, including air quality monitoring systems. In an air monitoring system project, the Arduino Pro Mini can be used as the main control board to process the data from the various sensors and display the results on a screen.

In an air quality monitoring system project that uses the PMS5003 particulate matter sensor, the MH-Z19 carbon dioxide sensor, the MP503 ozone sensor, and the DHT22 temperature and humidity sensor, the Arduino Pro Mini can be used to collect the data from each of these sensors and process it using programming code.

The code can be designed to perform various functions, such as calibrating the sensors, logging the data, and displaying the results on a screen. The Arduino Pro Mini can communicate with the sensors using various communication protocols, such as I2C, SPI, or UART, depending on the sensors used in the project.

The small size and low power consumption of the Arduino Pro Mini make it an ideal choice for an air quality monitoring system that requires a compact and low-cost microcontroller board. Additionally, the availability of various sensors and components that can be easily integrated with the Arduino Pro Mini make it a popular choice for air monitoring projects.

ii. DHT22

The DHT22 is a temperature and humidity sensor that is commonly used in air quality monitoring systems. It is an inexpensive and accurate sensor that provides digital output of temperature and humidity readings. The DHT22 sensor uses a capacitive humidity sensor and a thermistor to measure relative humidity and temperature, respectively. Aosong Electronics. (2015).

iii. PMS5003

The PMS5003 is a particulate matter sensor that is commonly used in air quality monitoring systems. It is a compact and low-cost sensor that provides accurate measurements of particulate matter (PM) in the air. The PMS5003 sensor uses a laser scattering technique to measure the concentration of particles in the air. The PMS5003 sensor can measure particles with a diameter of 0.3 µm to 10 µm, and can provide real-time data on PM1.0, PM2.5, and PM10 concentrations. The sensor can be interfaced with microcontrollers such as the Arduino, and can be powered by a 5V DC power supply. Plantower. (2016).

iv. MH-Z19

The MH-Z19 is a carbon dioxide (CO_2) sensor that is commonly used in air quality monitoring systems. It is an infrared-based sensor that provides accurate and stable measurements of CO2 concentrations in the air. The MH-Z19 sensor can measure CO_2 concentrations from 0 to 5000 parts per million (ppm). The MH-Z19 sensor can be interfaced with microcontrollers such as the Arduino, and can be powered by a 5V DC power supply. The sensor provides both digital and analog output, allowing for flexibility in data collection and analysis. Winsen Electronics. (2015).

v. MP503 and MQ131

The MP503 is a semiconductor gas sensor that is typically used to detect carbon monoxide (CO) in the air. The sensor is sensitive to CO concentrations from 10 to 500 ppm, and provides an analog output voltage proportional to the CO concentration. The MP503 sensor can be interfaced with microcontrollers such as the Arduino, and can be powered by a 5V DC power supply. Winsen Electronics. (2016).

The MQ-131 is a gas sensor that is typically used to detect ozone (O_3) in the air. The sensor is sensitive to O_3 concentrations from 10 to 1000 ppb, and provides an analog output voltage proportional to the O_3 concentration. The MQ-131 sensor can be interfaced with microcontrollers such as the Arduino, and can be powered by a 5V DC power supply. Winsen Electronics. (2016).

4 RESULT AND ANALYSIS

Figure 2(i) and 2(ii) show The Air Quality Monitoring System successfully collected data on various air quality parameters, including PM2.5, CO_2, O_3, temperature, and humidity.

The Arduino Pro Mini serves as the central microcontroller board in the air monitoring system. It initializes and coordinates the operation of all the connected components. The DHT22 sensor measures temperature and humidity, and the Pro Mini triggers the sensor to collect data. The PMS5003 sensor measures particulate matter (PM) concentrations, and the Pro Mini sends commands to retrieve PM data. The MH-Z19 sensor detects and measures carbon dioxide (CO_2) levels, and the Pro Mini initiates CO_2 measurements and captures the concentration values. The MP503 sensor measures ozone (O_3) levels, and the Pro Mini triggers the sensor to collect O_3 concentration data. The MQ131 sensor detects nitrogen dioxide (NO_2), and the Pro Mini retrieves NO_2 concentration readings. The Nextion Display serves as the user interface, receiving data from the Pro Mini and presenting real-time information on temperature, humidity, PM2.5, CO_2, O_3, and NO_2. The Solar Panel provides a sustainable power supply to the system, harnessing solar energy to charge the system's batteries and ensure continuous operation, even in areas without access to conventional electricity. This allows the system to function autonomously and facilitates long-term monitoring. The entire process involves the Pro Mini gathering data from the sensors, processing and analyzing the data, displaying it on the Nextion Display, and powering the system through the Solar Panel.

Figure 2(i)

Figure 2(ii)

Figure 2(i) and 2(ii): Testing in Outdoor

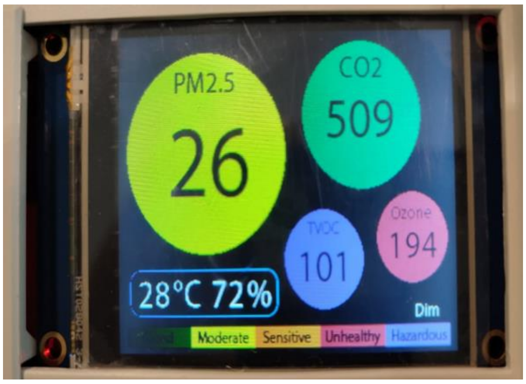

Figure 3(i)

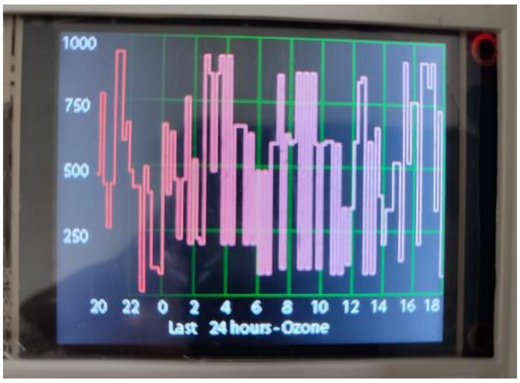

Figure 3(ii)

Figure 3(i) and 3(ii): Reading from Nextion Display

Figure 3(i) and 3(ii) show the reading obtained from Nextion Display. The PM2.5 reading of 26 indicates a moderate level of particulate matter pollution. This concentration suggests the presence of fine particles in the air, which may arise from various sources such as vehicle emissions, industrial activities, or dust particles. It is important to monitor this parameter closely, as prolonged exposure to high PM2.5 levels can have adverse effects on respiratory health.

The CO_2 level of 509 parts per million (ppm) indicates a moderate concentration of carbon dioxide in the environment. Elevated CO_2 levels can be attributed to poor ventilation or indoor air quality. While this reading falls within acceptable limits for general indoor environments, it is worth considering measures to improve air circulation and ventilation.

The O_3 measurement of 194 suggests a relatively low ozone concentration. Ozone is an important component of the atmosphere's protective layer but can be harmful at ground level. This reading indicates that the ozone level is within a safe range for human exposure.

The recorded temperature of 28°C indicates moderately warm conditions. It is essential to consider temperature variations as they can influence comfort levels and certain chemical reactions in the atmosphere.

With a humidity level of 72%, the air can be characterized as moderately humid. High humidity can contribute to a range of factors such as mold growth, discomfort, and potential impacts on respiratory health. Monitoring humidity levels is crucial for maintaining a healthy and comfortable indoor environment.

To further analyze the results, it is essential to compare the obtained measurements with relevant air quality guidelines and standards. Additionally, considering the trends and variations over time, geographical factors, and potential sources of pollution can provide a more comprehensive understanding of the air quality conditions.

It is important to note that the interpretation of the results should be contextualized within local air quality guidelines and standards. The obtained measurements can serve as a baseline for ongoing monitoring and inform decisions related to improving air quality and implementing necessary interventions.

5 CONCLUSION

The Arduino-based air quality monitoring system described in this project provides a cost-effective and flexible solution for monitoring air quality in various environments. The system incorporates multiple sensors, including the PMS5003, MH-Z19, MP503, MQ-131, and DHT22, to measure different types of pollutants and environmental parameters such as particulate matter, carbon dioxide, carbon monoxide, ozone, temperature, and humidity. The system also utilizes a Nextion Display to display real-time air quality data.

One of the advantages of using an Arduino-based system is its ease of use and flexibility. The Arduino platform is easy to learn and use, making it accessible to a wide range of users with varying levels of technical expertise. Additionally, the system can be customized to meet the specific requirements of different users and environments, such as indoor or outdoor air quality monitoring, or monitoring of specific pollutants.

Another advantage of the system is its cost-effectiveness. The Arduino microcontroller and sensors used in the system are relatively inexpensive, making the system accessible to individuals and organizations with limited budgets.

However, there are also some limitations to the system. One limitation is the accuracy of the sensors. The accuracy of the sensors can be affected by factors such as temperature and humidity, and regular calibration checks are necessary to maintain the accuracy of the system over time. Additionally, the use of low-cost sensors may not provide the same level of accuracy and precision as more expensive professional-grade sensors.

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