Indoor Air Pollution Monitoring System

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Abstract:
This work presents an investigation of indoor air pollution using a combination of biomedical engineering (BME) sensors and indoor air sensors. Indoor air quality is a significant factor affecting human health, and monitoring and controlling indoor air pollution have become essential for indoor environ- mental quality management. In this study, BME techniques are employed to analyze indoor air pollutants, and an indoor air sensor is used to measure and monitor the indoor air quality in real-time. The study involves the deployment of a network of sensors in an indoor environment, data collection, and analysis using machine learning algorithms. The results show that the combination of BME and indoor air sensors is an effective approach for detecting and mitigating indoor air pollution, and provides valuable insights for the development of indoor air quality management systems. This study contributes to the growing body of research on indoor air quality and provides new strategies for improving indoor air quality and safeguarding human health.

Index Terms: Indoor Air Pollution, AQI, Real-time monitor- ing, Data analysis.

I. INTRODUCTION

Indoor air pollution refers to the presence of harmful pollutants and contaminants in the air inside a building or enclosed space. These pollutants can come from various sources, including outdoor air, building materials, furnishings, cleaning products, cooking, and smoking. Indoor air pollution can lead to various health problems, including respiratory issues, allergic reactions, and other chronic illnesses.

Indoor air pollution has become a significant concern in recent years, as people spend a significant amount of time indoors. In fact, studies show that people spend up to 90% of their time indoors, making indoor air quality a critical factor in human health and well-being. Poor indoor air quality has been linked to various health problems, including asthma, allergies, respiratory infections, and even cancer.

The sources of indoor air pollution can vary depending on the building, the occupants, and the surrounding environment. For example, indoor air pollution in homes can be caused by poor ventilation, smoking, cooking, and cleaning products, while in workplaces, it can be caused by poor air circulation, chemical emissions from building materials, and cleaning products.

To mitigate indoor air pollution, various strategies can be employed, such as improving ventilation, using air purifiers and filters, and reducing the use of toxic chemicals. Addition- ally, monitoring and measuring indoor air quality using sensors can help identify potential sources of pollution and allow for timely interventions.

Overall, indoor air pollution is a critical issue that affects human health and well-being, and its mitigation requiresa concerted effort from building designers, occupants, andpolicymakers.

II. RELATED WORK

Indoor air pollution has been the subject of extensive research, with many studies investigating the sources, effects, and mitigation strategies of indoor air pollution. In this section, we review some of the relevant research in the field of indoor air pollution.

Real-time monitoring of indoor air pollution using sen- sors[1] has been a popular research topic in recent years. Many studies have focused on developing low-cost and portable sensors for measuring various pollutants, such as particulate matter, volatile organic compounds, and carbon monoxide. These sensors can provide real-time data on indoor air quality, allowing for timely interventions to improve indoor air quality. Machine learning has also been used in indoor air pollution research to analyze sensor data and identify patterns and trends in indoor air quality. For example, a study by Shikha Jain. (2022)[2] used machine learning algorithms to identify the sources of indoor air pollution in a classroom setting. Thestudy found that cleaning activities, cooking, and outdoor air pollution were the primary sources of indoor pollutants.

Several studies have investigated the health impacts of indoor air pollution. A study by Salonen et al. (2019)[3] found that exposure to indoor air pollution was associated with an increased risk of respiratory infections in young children. Another study by Young-Chul Lee. (2020)[4] found that exposure to indoor air pollution was associated with an increased risk of cardiovascular disease in older adults.

Various strategies for mitigating indoor air pollution have been proposed and investigated in the literature. For example, a study by Raghavendra Kumar. (2023)[5] investigated the effectiveness of using indoor plants to remove indoor pollu- tants. The study found that certain types of indoor plants can significantly reduce the concentration of indoor pollutants.

In addition to sensor-based monitoring, some studies have investigated the use of building design and ventilation systems to improve indoor air quality. For example, a study by Shunichi Hattori (2022)[6] investigated the impact of ventilation sys- tems on indoor air quality in residential buildings. The study found that well-designed ventilation systems can significantly reduce the concentration of indoor pollutants.

Overall, indoor air pollution is a critical issue that has been extensively researched, with many studies investigating the sources, effects, and mitigation strategies of indoor air pollution. Further research is needed to develop effective strategies for mitigating indoor air pollution and to better understand the health impacts of indoor air pollution.

III. LITERATURE SURVEY

Indoor air pollution has become a significant concern in re- cent years, with many studies investigating the sources, effects, and mitigation strategies of indoor air pollution. This literature survey aims to provide an overview of the current research on IOT-based indoor air pollution monitoring systems, including the sources of pollutants, their effects on human health, and the strategies for mitigating their impact.

A. Development of an IoT-Based Indoor Air Quality Monitor-ing Platform[7]

In this paper, an IoT-based indoor air quality monitoring platform consisting of an air quality sensing device called "Smart-Air" and a web server is demonstrated. This platform relies on IoT and cloud computing technology to monitor indoor air quality anywhere, anytime. Smart-Air was devel- oped based on IoT technology for effective monitoring of air quality and real-time transmission of data to a web servervia LTE. The device consists of a microcontroller, pollutant detection sensors, and an LTE modem. In the research, the device was designed to measure aerosol concentration, VOC, CO, CO2, and temperature humidity for air quality monitor- ing. After that, the reliability of the device was successfully tested according to the prescribed procedure of the Ministry of Environment in Korea. Cloud computing has also been integrated into a web server for analyzing data from indoor air quality classification and visualization equipment according to ministry standards. An app has been developed to help monitor air quality. Approved workers can thus monitor air quality at any time and from anywhere, either via a web server or an application. The web server stores all data in the cloud to provide resources for further indoor air quality analysis. In addition, the platform was successfully implemented at Hanyang University in Korea to demonstrate its feasibility.

B. IoT enabled proactive indoor air quality monitoring system for sustainable health management[8]

Indoor air quality has recently attracted the attention of policymakers and researchers as an important counterpart to outdoor air pollution. In a sense, indoor air quality needs to be given more attention than outdoor air quality because people spend more time indoors than outdoors. The indoor environment is confined and closed compared to the out- door environment, providing fewer opportunities for pollutant dilution. As technology has advanced, jobs have become more automated, using machines to perform tasks that were previously done manually. During their operation, these devices release various solid substances and gases into the environment. These emissions contain many substances that are harmful to human health if exposed to them for a long time or above certain concentration levels. This paper proposes an IoT-based indoor air quality monitoring system for monitoring ozone concentrations near a copier. An experimental system with a semiconductor sensor capable of monitoring ozone concentrations was installed near the high-volume copier. The IoT device was programmed to collect and transmit data at five-minute intervals via a bluetooth connection to the gateway node, which in turn communicates with the processing node via a local WiFi network. The sensor was calibrated using standard calibration methods. As an additional capability, the proposed air pollution monitoring system can generate an alert when the pollution level exceeds a predetermined threshold value.

C. IMPLEMENTATION OF INDOOR AIR QUALITY MONI-TORING SYSTEM USING IOT AND GSM[9]

This paper present an IOT-based indoor air quality moni- toring system that monitors indoor air pollutants such as CO, NH3 gases, temperature, humidity and tiny dust particles using sensors and an Arduino. The collected information is displayed on the personal computer and together with Dust density is provided on the LCD screen and also the data can be accessed remotely through the IOT platform and warning messages can also be displayed sent to the administrator to alert the pollutant levels inside the building using a GSM modem.

IV. PROPOSED METHODOLOGY

1) **Selection of Study Area**: The first step is to select an appropriate study area, such as a residential

building or an office. The study area should be representative of the indoor air pollution conditions of the target population.

2) **Instrumentation**: Install BME (temperature, humidity, and air pressure) and indoor air quality sensors to measure various pollutants such as PM2.5, PM10, CO2, CO, NO2, and VOCs. The sensors should be placed in different locations in the study area to capture spatial variability.
3) **Data Collection**: Collect data from the sensors con- tinuously for a specific duration, preferably for several weeks, to capture the temporal variability of indoor air pollution.
4) **Data Pre-processing**: Pre-process the collected data to remove outliers and missing values. Perform data qualitychecks to ensure that the data is reliable and accurate.
5) **Data Analysis**: Analyze the data using statistical meth- ods to identify patterns and trends in indoor air quality. Use machine learning algorithms to develop predictive models for indoor air quality.
6) **Mitigation Strategies**: Based on the results of the data analysis, identify potential sources of indoor air pollution and develop appropriate mitigation strategies. For example, if the analysis shows that cooking activitiesare a significant source of indoor air pollution, suggest using ventilation systems or cooking with natural gas instead of propane or butane.
7) **Evaluation**: Evaluate the effectiveness of the mitigationstrategies using the same sensors installed in the study area. Compare the indoor air quality before and after implementing the mitigation strategies.
8) **Reporting**: Prepare a comprehensive report that in- cludes the methodology, data analysis, findings, and recommendations for improving indoor air quality. The report should be easily understandable and accessibleto the target audience, such as building owners, facility managers, and occupants.
9) **Continuous Monitoring**: Finally, suggest continuous indoor air quality monitoring to maintain a healthy indoor environment and ensure that the implementedmitigation strategies are effective.

V. SYSTEM REQUIREMENTS

A. *Hardware Requirements*

Raspberry Pi 3b+ can perform as a complete standalone system or as a slave device to a host MCU, reducing commu- nication stack overhead on the main application processor.

The **BME280** is a humidity sensor specially developed for mobile applications and wearables where size and low power consumption are key design parameters. The unit combines high linearity and high accuracy sensors and is perfectly feasible for low current consumption, long-term stability and high EMC robustness.

The **MQ-135** Gas sensors are used in air quality control equipment and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, and CO2. The MQ- 135 sensor module comes with a Digital Pin which makesthis sensor to operate even without a microcontroller.

The **RPi Cam** Web Interface is a web interface for the Raspberry Pi Camera module. It can be used for a wide variety of applications including surveillance, DVR recording and time-lapse photography. It is highly configurable and can be extended with the use of macro scripts.

B. *Software Requirements*

The **Thonny Python IDE** is an integrated developmentenvironment for Python that is designed for beginners. Itwas created by Aivar Annamaa, an Estonian programmer. Itsupports different ways of stepping through code, step-by-stepexpression evaluation, detailed visualization of the call stackand a mode for explaining the concepts of references and heap. **Blynk** is an IoT platform for iOS or Android smartphones that are used to control Arduino, Raspberry Pi and NodeMCU via the Internet. This application is used to create a graphical interface or human-machine interface (HMI) by compiling and providing the appropriate address on the available widgets.

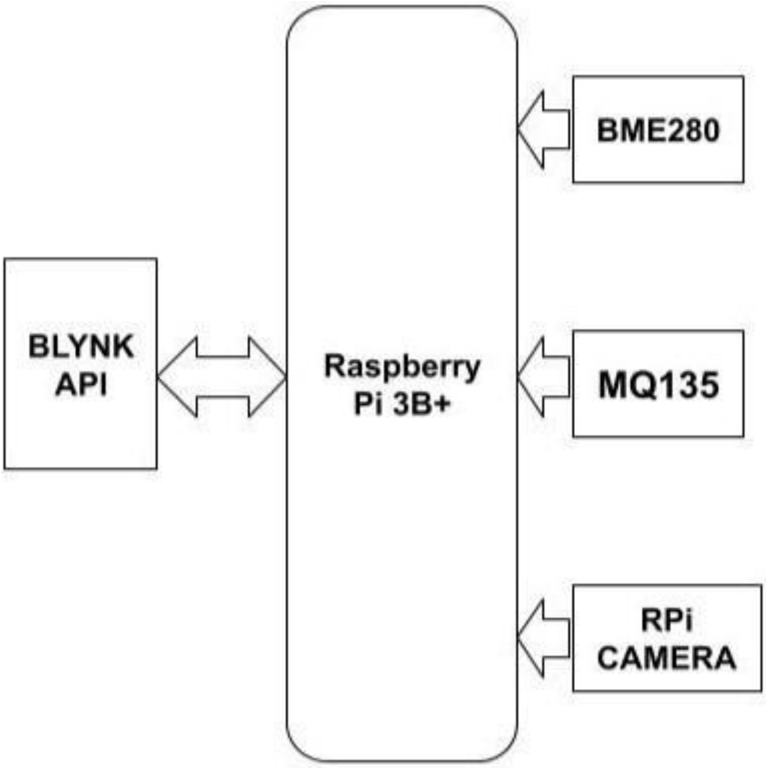

Fig. 1. Block diagram for Indoor Air Pollution Monitoring System

VI. SYSTEM FUNCTIONALITY

In this section, a description of the proposed system is provided. This system will monitor the Air Quality over an application using the internet and will trigger a notification when the air quality goes down beyond a certain level, which means when there are sufficient amounts of harmful gases present in the air like CO2(carbon dioxide), smoke, alcohol, benzene and NH3(ammonia), LPG(liquefied petroleum gas). It will show the air quality in parts per million(PPM) on mobile applications that can be monitored very easily. The system will show temperature pressure and humidity, which are displayed on the Blynk app.

Fig.1 shows a block diagram of the system. The block diagram consists of Raspberry Pi 3B+, which collects the data from the given sensors and displays the data on the BLYNK platform. The various sensors which are used to build the project are the BME280, MQ135 and Rpi Camera. The MQ135 is used to check the air quality in the room, the BME 280 is used to measure the temperature And humidity of a room and the Raspberry Pi camera is used to count the no. of people present in the room.

VII. FLOW CHART DIAGRAM

Fig.2 presents a flowchart of the system. The hardware part of the system needs to get connected to power and then the sensors and devices present are initialized. If initialization is not done, hardware connections need to be checked once the connection is successful. The sensors start reading data and

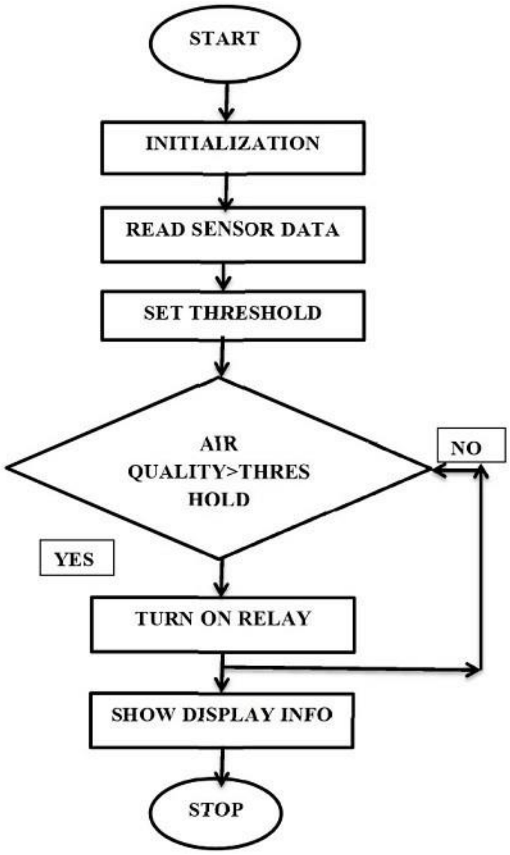

Fig. 2. Flow Chart of the proposed system

values are read. Next, when values are available the data is displayed and data is sent to the cloud through the Wi-Fimodule. Data is checked on the Blynk application retrieved from the Blynk server.

VIII. RESULT AND ANALYSIS

A. *Hardware Result*

Date	Time	No. of Persons	Temperature	Humidity	AQI
26/04/23	9.00	2	22	42	75
26/04/23	10.00	4	23	44	80
26/04/23	11.00	5	23	45	83
26/04/23	12.00	6	24	46	85
26/04/23	13.00	2	22	42	75
26/04/23	14.00	4	23	44	80

TABLE I
TEST RESULT

The experimental result is shown in TABLE 1

B. SOFTWARE RESULT

In this system, we used 3 sensors that capture the gases and collect data sent to Blynk and results in that application are shown in Fig.3

Fig. 3. Application output

IX. CONCLUSION

In conclusion, indoor air pollution is a major environmental health concern, with potential health impacts on the occupants of residential and commercial buildings. In recent years, there has been a significant increase in research efforts toward monitoring and mitigating indoor air pollution using various sensors and technologies.

Real-time monitoring of indoor air quality using sensors hasshown promising results in identifying the sources of indoor air pollution and developing effective mitigation strategies. Machine learning algorithms have also been used to analyze sensor data and identify patterns and trends in indoor air quality.

The mitigation strategies identified in the literature include using ventilation systems, natural gas for cooking, and indoor plants to remove indoor pollutants. It is crucial to continu- ously monitor indoor air quality to maintain a healthy indoor environment and ensure the effectiveness of the implemented mitigation strategies.

Overall, more research is needed to understand indoor air pollution's health impacts and to develop effective and sustainable strategies for mitigating indoor air pollution. With the rapid advancements in sensor technology and machine learning algorithms, we are hopeful that these efforts willcontinue to make significant strides in improving indoor air quality and promoting public health.

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