EAI Endorsed Transactions
on Internet of Things
Research Article EAI.EU

An IoT Implemented Dynamic Air Pollution Monitoring System

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Abstract

In recent years, pollution of air has become a critical concern in many urban areas, causing serious health problems and environmental damage. To address this issue, an Internet-of-Things (IoT)-based air pollution monitoring system was proposed. The mechanism was designed to measure various air quality parameters such as temperature, humidity, various gases, microbes, and light intensity in real time. The proposed sys-tem consists of sensor nodes, a gateway, WIFI module, an LCD display, and a cloud server. The sensor nodes were placed at different locations to measure air quality parameters, and the data were transmitted to the gateway via wireless communication. The gateway aggregates the data from the sensor nodes and sends them to the cloud server for further analysis and processing. The cloud server processes the data, and the system also includes a web interface that displays data on the pollution levels of the air in real time. The sys-tem can also send alerts to users when the air quality is poor, allowing them to take the necessary precautions. This system could assist decision-makers in taking appropriate measures to alleviate air pollution and safeguard the health of the community by providing real-time information about air quality. The system was evaluated in a real-world environment and the results demonstrated its effectiveness in providing accurate and reliable air quality information. The proposed system has the potential to be used in various applications, including public health and environmental monitoring, and can be integrated with other IoT devices to enhance their functionality.

Keywords: Internet of Things, Arduino Uno, Air Pollution, Cloud Environment

Received on 17 August 2023, accepted on 31 October 2023, published on 06 November 2023

doi: 10.4108/eetiot.v9i4.4316

1. Introduction

Air pollution-related dangers to the planet and human well-being are some of the most important problems confronting humanity today [3]. It is a global problem that affects people of different socioeconomic backgrounds. Environmentalists and climate change scientists are skeptical of contaminants in the air, climate change, along with their consequences on today's globalized environment [10]. Automobiles and industries produce a variety of hazardous gases into the environment, putting both terrestrial and marine life in danger [4]. Stroke, heart disease,lung cancer, and because of deteriorating quality of the air is making it more difficult to breathe and airway diseases are becoming more prevalent. The most fragile people are affected by bad air quality of the general population, including infants, persons suffering from airway diseases,expectant mothers, and senior citizens, at serious risk. Statistics from the World Health Organization (WHO) showthat airborne pollutants are responsible for millions of unexpected deaths.

Airborne pollutants are a major problem in most of the locations and its influence on the environment and human

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health is a growing concern. Therefore, there is a requirement for an efficient system for monitoring air pollutionthat can deliver precise and up-to-date data on air quality. The growth of the Internet of Things (IoT) in the past couple of years has revolutionized the way we interact with the world [1]. IoT-based systems are designed to keep an eye and manage various environmental factors. To address this issue, an air pollution monitoring system powered by the Internet of Things (IoT) using the Arduino Uno has been proposed. The proposed system was designed to measure various air quality parameters, such as temperature, humidity, various gases, microbes and light intensity, in real time using cost-efficient sensors [5]. Arduino Uno is a popular microcontroller board that is widely used in the IoT domain. It is easy to use, affordable, and can be programmed using the Arduino IDE. The proposed system uses the Arduino Uno as the main controller board to process the sensor information and uploadit to the cloud server. The system comprises sensor nodes, a gateway, WIFI module, an LCD display, and a cloudserver [6]. The sensor nodes were placed at different locations to measure the air quality parameters, and the data were transmitted to the gateway via wireless communication [16]. The gateway aggregates data from the sensor modules transmits them to the cloud server for further analysis and processing. The system can also provide real-time data to users through various interfaces such as mobile applications and web portals. The system also includes a web interface that displays statistics about the pollution level instantaneously, allowing users to keep an eye onpollution level in their area. The system can also send alerts to users when the air quality is poor, allowing them to take the necessary precautions.

Real-time information transfer between devices for online air quality monitoring can be seen using an Android application. It is responsible for gathering data from multiple sensors using an inbuilt Wi-Fi module and deliveringcaptured information to ThingSpeak, a publicly accessible cloud environment where information may be saved and retrieved over the internet via using a hypertext transfer protocol (HTTP) [15]. The instant information from sensors was stored on the ThingSpeak platform was employed to produce plugins, apps, and visualizations for use with social networks, web resources, and other application programming interfaces (API) [7]. Overall, the proposed device is an effective tool for monitoring and managing air pollution in urban areas. By providing real-time data on air quality, the system can help decision-makers take appropriate activities to lower air pollution and safeguard community health. The main objective of the suggested system is to give accurate and updated information on air quality to address the increasing problem of air pollution and its associated health risks. The system has the potential to be used in various applications, including public health and environmental monitoring,and can be integrated with other IoT devices to enhance their functionality.

2. Literature Review

2.1. IOT Enabled Air Pollution Monitoring and Awareness Creation System.

Yamunathangam1, K. Pritheka2, P. Varuna3

This study describes a cost-effective air pollution monitoring device that makes use of Arduino chip microcontrollers the design and construction of a sensor network made up of Arduino boards coupled with gas and particulate matter sensors are described by the authors. Processing and transmission of the gathered data to a central server for analysis and visualization. The system's performance was validated by the authors through field tests, and the outcomes were evaluated against those of standard measuring devices. The paper shows that using Arduino for air pollution monitoring is feasible and efficient, making it suitable for mass use [19]. Ghosh et al. (2023) embarked on a comprehensive study to assess water quality through predictive machine learning. Their research underscored the potential of machine learning models in effectively assessing and classifying water quality. The dataset used for this purpose included parameters like pH, dissolved oxygen, BOD, and TDS. Among the various models they employed, the Random Forest model emerged as the most accurate, achieving a commendable accuracy rate of 78.96%. In contrast, the SVM model lagged behind, registering the lowest accuracy of 68.29% [21].

Alenezi et al. (2021) developed a novel Convolutional Neural Network (CNN) integrated with a block-greedy algorithm to enhance underwater image dehazing. The method addresses color channel attenuation and optimizes local and global pixel values. By employing a unique Markov random field, the approach refines image edges. Performance evaluations, using metrics like UCIQE and UIQM, demonstrated the superiority of this method over existing techniques, resulting in sharper, clearer, and more colorful underwater images [22].

Sharma et al. (2020) presented a comprehensive study on the impact of COVID-19 on global financial indicators, emphasizing its swift and significant disruption. The research highlighted the massive economic downturn, with global markets losing over US $6 trillion in a week in February 2020. Their multivariate analysis provided insights into the influence of containment policies on various financial metrics. The study underscores the profound effects of the pandemic on economic activities and the potential of using advanced algorithms for detection and analysis [23].

2.2. Air pollution control model using machine learning and IoT techniques.

Chetan Shetty1, B.J. Sowmya2, S. Seema3, K.G. Srinivasa4

This research investigation presents air pollution monitoring system that combines machine learning and Internet of Things (IoT) technology. The authors created a network of sensor nodes in urban areas that are fitted with gas and particulate matter sensors. Wirelessly relayed to a central server, the collected data is then analyzed by machine learning algorithms to forecast air pollution levels [20].

3. Background

According to research, pollution is accountable for 50,000 to 100,000 premature deaths every year. in the U.S. Compared with 3,000 to over 30,000 worldwide in the EU. Various pollutants are released into the atmosphere. These pollutants undergo reactions that ultimately lead to the development of more recent pollutants, which are also known as secondary pollutants. Effective pollution monitoring is crucial for raising public awareness and enhancing public health. According to previous research, almost every person spends 90% of their time indoors. In recent decades, the outdoor air quality of industrialized countries has improved significantly. In comparison tothe present, air quality has deteriorated by an equal amount because of several factors that contribute to indoor air pollution. Therefore, a better air quality monitoring system is required. Governments worldwide are developing innovative cities to address these problems, while establishing a healthy environment and life for those that live there. By 2050,the Indian government plans to build 100 smart cities. WSNs, intelligent systems, and advanced communication networks are used in these cities to address present problems and provide new services. Although Delhi and othermetropolitan cities have deployed an equipment that continuously monitor the air quality. The future of the world'snext smart cities lies in inexpensive IoT-capable Future smart cities throughout the world will use WSN technology [11].

Air pollution is a global problem and its impact on medical conditions and the environment is a growing concern. In non-rural areas, air pollution is caused by various elements including traffic congestion, Industrialization as well as the use of petroleum and coal. The harmful pollutants released by these sources can cause respiratory problems, heart diseases, and even cancer [12]. Therefore, there is a need for an effective system that must continuously check the quality of the air and take steps as needed to lower air pollution [9]. The Internet of Things (IoT) is used extensively in environmental monitoring. IoT devices can be used to monitor various environmental parameters, including temperature, humidity, and air quality. These devices can be connected to the internet, allowing remote monitoring and control. Arduino Uno is a popular microcontroller board that is widely used in the IoT domain. This is an affordable open-source platform that can be easily programmed using an Arduino IDE. Arduino Uno has a big population density of developers and enthusiasts, which makes it simple to locate information and assistance. For efficient real-time air quality monitoring, consider employing an IoT-based air pollution monitoring system using an Arduino Uno. The device can measure various environmental pollution parameters such as temperature, humidity, various gases, microbes and light intensity using low-cost sensors [2]. The sensor information can be processed by an Arduino Uno and transmitted to a cloud server via wireless communication. The cloud server can then process the data using machine-learning algorithms to provide insights into air quality. The proposed mechanism can be applied by decision-makers to monitor and manage air pollution in urban areas. By providing real-time data on air quality, the system can help decision-makers take appropriate reduction measures for air contamination and safe-guard the well-being of the community.

4. Methodology

4.1. Procedure

An IoT-based air pollution monitoring system is a powerful tool that can help governments, organizations, and individuals monitor and manage quality of air in day-to-day life. The system uses sensors to measure pollutants in the air and transmits data to a cloud server in real time. The data were then analyzed and visualized according to environmental standards, and an application was made available for approved personnel to monitor air quality from anywhere.

Step-1: Developing an IoT-based air pollution monitoring system to identify the parameters to be measured. Typically, air pollution monitoring systems measure temperature, humidity, light intensity, and pollutants. Once the parameters and types of pollutants have been identified, sensors can be installed to measure the levels of these pollutants in the air.

Step-2: Set up the Arduino Uno, install the necessary libraries, and connect the sensors to it. Appropriate pins are used to check the datasheets of the sensors to ensure correct wiring, display it on the LCD display, and sends the data from the sensors to the cloud server [13].

Step-3: Once the sensors and Arduino Uno are designed and installed, the system can be tested and calibrated. This involves comparing the readings from the sensors to those from a reference instrument to ensure that the system provides accurate and reliable data. The system can also be tested to ensure that it operates under different environmental conditions, such as extreme temperatures or high humidity.

Step-4: After the system has been tested and calibrated, the information can be sent to the server located in cloud environment in real-time. The information can also be stored in a database and analyzed using statistical methods.

In this system, the power source is connected to the Arduino Uno, which connects all the sensors. Within a few minutes, the device monitors the surrounding environment and shows each of the readings on the LCD screen. The Arduino Uno, using the ESP8266 Wi-Fi module, connects with the cloud server (Thing speak), where all readingsand graphs are generated. The Arduino Sketch is in the driver's seat handling data collection and transmission viathe Wi-Fi module to the Thing speak server. With the help of the Arduino IDE, the Arduino sketch is developed,compiled, and uploaded to the Arduino board. The buzzer is also connected to the system if the gas sensor value exceeds 200 PPM, which means that air is polluted and the buzzer rings.

4.2. Block Diagram

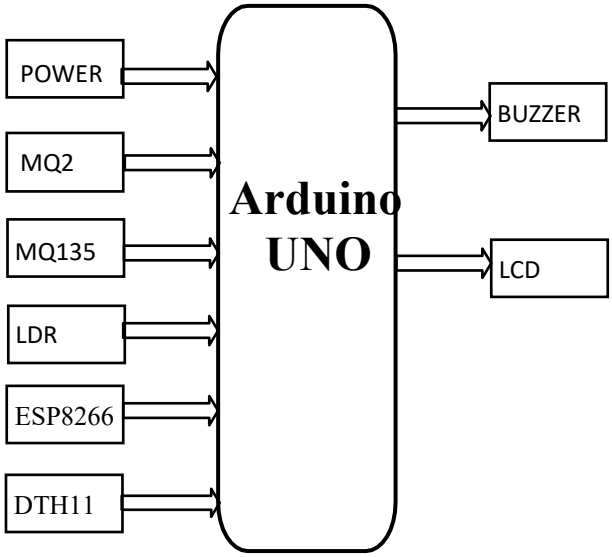

Figure 1. Block Diagram of the proposed architecture

4.3. Components

1. Arduino UNO
2. DTH11-Temperature and humidity sensor
4. MQ2 Gas sensor
5. LDR-Light intensity
6. ESP8266-Wifi module
7. Buzzer 8.LCD screen

5. Results and Discussions

The IoT-based air pollution monitoring system using the Arduino Uno successfully collected data on various air pollutants. The sensors used in this study were sensitive enough to detect changes in air quality over time, and the data were transmitted to the cloud platform without any issues. The collected data were analysed using appropriate visualization and analysis tools, and the results are presented below. The data showed significant fluctuations in air quality over time, with pollution levels varying according to time of day, weather conditions, and location. For example, particulate matter levels were highest during rush hour traffic, whereas ozone levels were highest during periods of high sunlight. Carbon monoxide levels were highest in areas with heavy traffic congestion, while sulphur dioxide and nitrogen dioxide levels were highest in industrial areas [14].

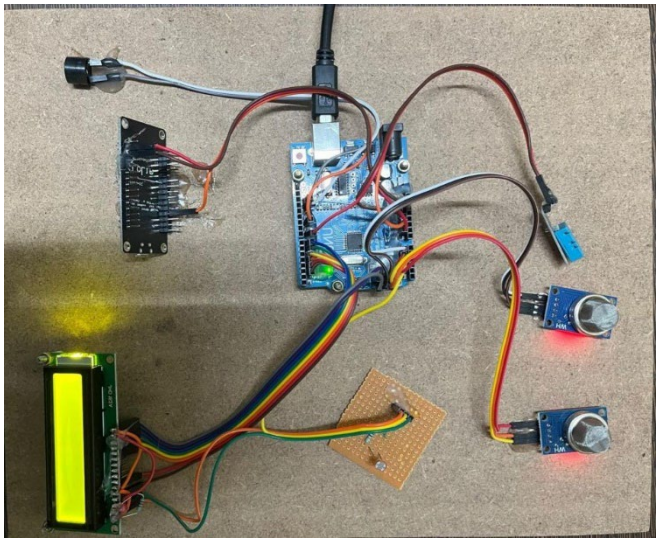

Figure 2. Air pollution monitoring device

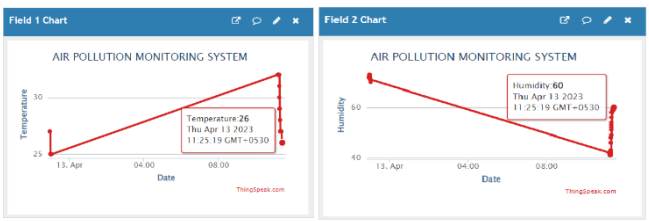

Figure 3. Graph of temperature (x-axis) and time (y-axis) and graph of Humidity (x-axis) and time (y-axis)

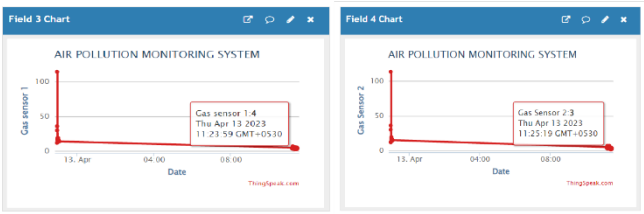

Figure 4. Graph of Gas sensor1 and time and graph of Gas sensor2 and time

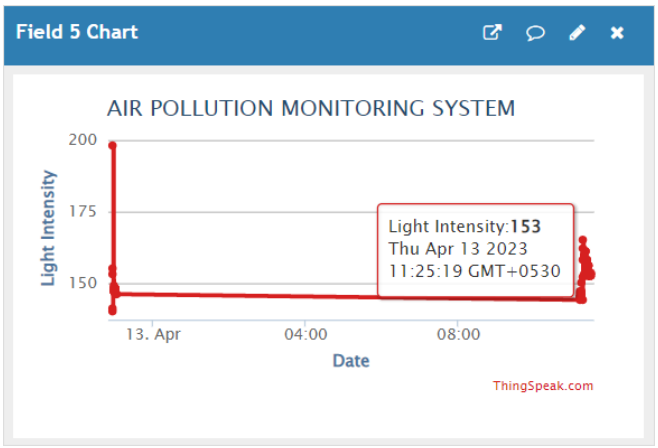

Figure 5. Graph of Light Intensity and time

6. Conclusion

In conclusion, the proposed IoT-based air pollution monitoring system using the Arduino Uno is an effective tool for monitoring quality of air in day-to-day life and provides insights into the sources of air pollution. The systemuses low-cost sensors to measure various air quality parameters and transmits the data to a cloud server for processing. The system was tested in a real-world environment and was able to detect changes in air quality and provide alerts when the threshold values crossed. The mechanism also offers information into the sources of air pollution, allowing decision-makers to implement reduction measures for air contamination and safeguard the well-being of the community. An IOT-based Air Pollution Monitoring System was presented in the study. A few sensors have been placed to track the temperature, humidity, gas values (CO, smoke, NH3, NOx and some other harmful gases concentrations in the air. In this, the non-commercial cloud environment and an Android application can only communicate in one direction. ThingSpeak has been developed. As a bridge to connect the hardware system, Arduino UNO has been used. Graphs are created based on the sensor information that has been collected in ThingSpeak.

This monitoring tool can assess the actual air quality. With the use of an Arduino microcontroller, this system aidsin improving air quality and monitoring the air environment. Perfect air quality sensing in specific locations requires the real-time compression of enormous low-cost sensors on a regular basis, because they travel from more precise and swift locations [18]. MQ135 gas sensors were used because of various dangerous gas types. Themain component of this project, Arduino, manages the entire process, and the LCD displayed is incorporated for the specified outputs. An automated system to manage can address the greatest threat. Overall, the system can be an effective tool for decision makers to monitor and manage air pollution in urban areas. With increasing concerns regarding air pollution and its impact on human health, such systems could have a vital impact in reducing air pollution and promoting sustainable development. Further research and development in this area can lead to more advanced and efficient air pollution monitoring systems that can contribute to healthier and cleaner environments. The main problem with the air monitoring system comes from the heavily polluted locations. This innovative technology helps us to live healthier lives.

7. Future Scope

The IoT-based air pollution monitoring system using the Arduino Uno has vast potential for future development and applications. Some areas of improvement and expansion are as follows.

1. Integration of advanced sensors: The system can be improved by integrating advanced sensors to measuremore air quality parameters such as ozone, sulfur dioxide, and volatile organic compounds. This providesa more comprehensive understanding of air pollution and its sources.

2. Data analysis using AI and machine learning: Collected information can be examined using AI and machine learning algorithms to recognize shifts and forecast air quality trends [17]. This will provide decision makers with valuable insights into the long-term impact of air pollution and help them developeffective strategies to combat it [8].

3. Development of mobile applications: This system can be integrated with mobile applications to providequality of air information in day-to-day life to the people. Air pollution affects crop yields and improvesthe health of rural communities.

The interfaces have a large number of sensors that can track the production of all airborne gases. Among the time and data, create all webpages or upload dates to which the

webpage connects to Secure Digital (SD) cards for data storage. Pollution is maintained by connecting a Global Positioning System (GPS) module at the ideal location and publishing the information to the webpage for the public. Overall, the IoT-based air pollution monitoring system using the Arduino Uno has vast potential for future development and applica-tions. With increasing concerns regarding air pollution and its impact on human well-being, such systems could have an essential part in promoting sustainable development and creating a healthier environment for future generations.

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