**Dynamic Air Pollution Monitoring Using IoT**

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**ABSTRACT *–*** Air quality detection for the bus system was designed based on the Arduino platform to get specific air quality information. The proposed system can detect atmospheric pollutants like PM2.5 (Fine Particulate Matter), formaldehyde, CO, etc. Also, the data was uploaded to the mobile terminal via Bluetooth communication, and then it gets stored in the SQLite database. It provides reliable data for the analysis of environmental conditions. When the measured data exceeds the safety threshold, a warning message was sent to the user. Experimental results show that the mean square error of the predicted value of the system was low, and accurate air pollution data can be detected in indoor and outdoor environments.

**Keywords** *–Accurate, Safety, Dynamic, Pollution Monitoring*

1. **INTRODUCTION**

Air Quality monitoring is nowadays a major issue and it is a community-based initiative. It is a major concern for many cities. In urban areas, the quality of air has become poor which causes various health problems for those who are exposed to air in their day-to-day life. The main cause for the above-said problem is vehicle exhausts and industrial sites located nearer to urban areas. Many cities installed a small number of expensive monitoring systems for monitoring the quality of air. However, the deployment of monitoring systems increases city infrastructure costs. Due to the increase in costs, only a few numbers of stations are deployed to provide limited coverage in the city. Recently, much research has been conducted to investigate low-cost sensors so that they can be deployed in many areas to monitor the quality of air. Green IoT project has developed a test bed with wireless and stationary sensors to monitor the quality of air in the cities of Uppsala [7]. Mobile sensors are allowed to measure the quality of air at different locations in the city without any constraints and extra costs. The first thing is to identify a set of bus routes that provide good coverage of the town and pass through the highly polluted areas. To select bus routes, route planning is studied in this work that can acquire measurements from important locations. Route planning is conducted through image analysis on a bus route map provided by the local bus company named Upplands Lokaltrafik (UL). The second thing is to deploy the sensor on a public vehicle that evaluates the capability of a moving sensor in comparison with the stationary sensor. The final thing is to evaluate the sensor performance and data quality. Evaluation of sensor performance is based on the data collected on public vehicles over a long period. And data quality is evaluated by comparing the measurements with those from other sensors deployed in the cities of Uppsala.

Due to the occurrence of severe atmospheric pollution phenomena such as smog, hoping to be able to grasp the specific data of atmospheric pollution in the monitored living environment that reduces the harm as much as possible caused by air pollution[1]. The national environmental monitoring department publishes regional air quality in real-time, but due to the limited number of monitoring points, fixed locations, and limited monitoring data, this cannot accurately display the quality of air and cannot meet the needs of ordinary users for air quality monitoring. To solve the above-mentioned problems, an Arduino-based air quality detection system is proposed that can upload data to the mobile APP in real-time with Bluetooth communication to realize the monitoring of indoor and outdoor air pollutants. The proposed system can accurately detect and display the air quality information of the user’s current location and upload the data to the mobile terminal.

1. **OBJECTIVES**

The main objective of the designed system is to detect and analyze the pollution observed at various places effectively using a single dynamic device. As the system is incorporated with the public road transports. Buses, the periodic locomotion of the devices into the major places of a city takes place, thereby the instantaneous information on the pollution rate of the places can be monitored. As the system comprises sensor modules and microcontrollers, the pollution caused by various factors like transportation, road traffic, industrial emissions, and other local anthropic actions results in the major sources of toxic gases like O3, SO2, NH3, and volatile compounds like benzene, toluene and also the greenhouse gases (CO2, CH4, N2O) can be detected. The declaration of sensor-based real-time data can be viewed on an application that is integrated with the device.

1. **EXISTING SYSTEM**

Bus powered by fossil fuels is major contribution of air pollution. Transportation emits more than half of the nitrogen oxides in air and this is a major source of global warming emissions. Studies that have linked pollutants from vehicle exhaust to adverse impact on every organ system in the body. While this air pollution carries significant risks to human health and the environment, through clean vehicles and fuel technologies, we can significantly reduce emissions and help transform transportation.

Several research projects have been conducted to measure air quality using the IoT or wireless sensor networks. This project includes measurements of different types of pollutants in the air using stationary or mobile sensors. For example, the University of Patras evaluated the power consumption of the Waspmote platform in 2015. The waspmote platform was developed by a company called Libelium, which provides different types of sensors, radio technologies, open-source SDK (Software Development Kit), and API (Application programming interface) for sensor network development. The paper focused on identifying critical operations and implementing a setup for power consumption measurements in the wireless sensor network.

Similarly, the University of the Armed Forces developed a wireless monitoring system for air quality measurement. The study attempts to deliver a system with hardware, software, and firmware solutions to measure air quality. This system is developed on an Arduino platform using the network gateway to connect the sensor nodes to the Internet. It measured carbon monoxide (CO) and carbon dioxide (CO2) concentrations in the city of Quito, Ecuador. In stationary sensor networks, mobile sensors are investigated to support air pollution monitoring.

OpenSense was a project conducted in Zurich, Switzerland. In the OpenSense project, a tram is used as a moving platform for carrying the sensors. Communication between the sensors and the cloud are done by using GPRS (General Packet Radio Services). In this paper, deploying sensors on city buses was done, which provide wider coverage in the city and more options and flexibility in the selection of bus routes. City buses have different installation infrastructures, more dynamic speeds, and moving patterns.

In Another project , which air quality was monitored in autonomous wheeled rover was conducted on 2016 by Sapienza University of Rome. The sensor measured methane (CH4), ethylene (C2H4), ammonia (NH3), benzene (C7H8), LPG (C4H10), CO2, CO, and nitrogen oxides (NOx). The rover was developed by the Sapienza University with GPS sensors, three-axis gyros, accelerometers, and magnetometer so that it can able to navigate and avoid obstacles on the path to scan the pollution status over the large area.

The Green IoT project aims to research an energy-efficient IoT platform for the public to develop innovative applications based on open data provided by the Green IoT testbed. A case study for the Green IoT is implemented in Uppsala, the fourth largest city in Sweden. It includes IoT testbed deployed in the city centre for monitoring air pollution. Uppsala occasionally exceeds the EU standards on particulate levels, especially in winter and spring, which gives an objective for the project to reduce air pollution through active monitoring, traffic management, and better city planning.

Another project focussed on monitoring urban pollution through public transportation-based opportunistic mobile sensor networks. The objective of the paper was to report on new developments in mobile sensors-based opportunistic urban pollution monitoring networks. This work follows from the implementation of a single pollution sensor-based sensing node prototype which was used for testing an opportunistic communication network and which was reported elsewhere. They concentrated on the extension of the basic sensing system and its modular conversion into a multi-pollutant sensing system able to additionally provide temperature, humidity, and geo-position information as well as on the software architecture developed around it to process the huge amounts of data the system produces.

The different prototypes were tested on the public transportation system of the city of Vigo and multiple test runs around the city of A Coruna in the northwest of Spain produced very promising results.

The data regarding to the air pollution particles such as emission, smoke, and other pollutants will be collected via sensors on the public transport bus and the data is aggregated and transmitted to sink node. Using the concept of the Internet of Things (IoT) the collected data will be uploaded to the cloud server also called the IoT cloud where a large amount of the data is stored. This data can then be accessed at any point to analyze and accurate measures can be taken to map air pollution.

1. **PROPOSED SYSTEM**
2. ***Description***

The system structure of the portable air quality detection system which includes the microcontroller, sensor module, LCD module, noise sensor, communication module, and other parts. The controller chooses the Arduino Uno control platform. Arduino Uno is a development platform based on ATmega328P. It consists of 14 digital IO pins and 6 analog input pins. It can virtualize multiple soft serial ports and can realize multiple analog and digital sensor Access [2]. The Arduino micro-control platform processes and analyses the air pollutant signals collected by the air sensor in real-time, and sends the processing results to the LCD dispLCDand mobile phone terminal for display. At the same time, the processing results are compared with the preset threshold in real time, and the system sends a warning message to the user when the threshold is preset. The system can accurately detect and display the air quality of the user's current location, and upload the data to the mobile terminal. The sensor module mainly includes a PM2.5 acquisition circuit, a carbon monoxide acquisition circuit, a formaldehyde acquisition circuit, and a temperature and humidity acquisition circuit.

IoT Based Air Pollution Monitoring System monitors the Air Quality over a web server using the internet and will trigger an alarm when the air quality goes down beyond a certain level, which means when there are several harmful gases present in air such as CO2, smoke, alcohol, and benzene, NH3, NOx, and LPG. The system will show the air quality in PPM on the LCD and as well as on the webpage so that it can be monitored very easily. Temperature and Humidity are detected and monitored in the system. LPG gas is detected using the MQ9 sensor and the MQ135 sensor is used for monitoring Air Quality as it detects the most harmful gases and can measure their amount accurately. This IoT project can monitor the pollution level from anywhere using your computer or mobile. This system can be installed anywhere and can also trigger some devices when pollution goes beyond some level like we can send alert SMS to the user.

A picture containing graphical user interface

Description automatically generated

Fig 1: Block Diagram

1. ***Working***

Arduino Uno and the sensor, and the Bluetooth communication transmit the collected data to the mobile phone APP to realize display of the air quality data storage, alarm, and other functions, to complete the real-time monitoring of the air quality and the detection of the air quality. The liquid crystal display can achieve PM2.5, carbon monoxide, formaldehyde, temperature, and humidity information. After opening the APP, Bluetooth module detection is carried out first, and then Bluetooth is searched and connected. After a successful connection, the page will display the connect page. After connecting the Bluetooth module successfully, the current air temperature, humidity, PM2.5, CO (carbon monoxide), and TVOC (formaldehyde) values detected by the hardware system in the current air will be received in turn. When the value is greater than the predetermined value, there will be a buzzer alarm and an alarm prompt dialog box will pop up on the app.

1. ***Advantages***

* Ease of handling
* Easy to Install
* Updates On mobile phones directly
* Accurate Pollution monitoring
* Remote location monitoring
* It can be used at home, in public areas, and in rural and urban areas wherever the network is available
* Vital parameters can be constantly monitored and kept under check
* Better access to healthcare
* The system is user friendly
* Improved quality of healthcare
* Cost of this device is affordable
* An alert message will be sent to the mobile phone if any abnormality is detected at the Pollution level.

1. ***Disadvantages***

* It requires continuous power supply. If the battery is used, battery discharges quickly
* Limited amount of parameters can be monitored
* Susceptible to network hackers
* The cost of the system will be increased if large air quality sensors increases

1. ***Application***
   * Industrial perimeter monitoring
   * Indoor air quality monitoring.
   * Site selection for reference monitoring stations.
   * Making data available to users.
2. **RESULT**

The system implementation was done, and the system worked successfully. First, the power supply was given to the system, and it was stepped down to 15V by a step-down transformer. After turning the device ON, the CO2 sensor, CH4 sensor, noise sensor, temperature sensor, and humidity sensor start to measure the corresponding parameters in the environment. The output from these sensors is processed in an Arduino UNO ATMEGA328P. The temperature, CO2 level, Methane, and humidity of the corresponding environment is displayed on a 2x16 LCD.

The measured values can also be viewed in the app as a Bluetooth module is used in the product. The parameters like temperature, CO2 level, methane level, noise, and humidity can be viewed as separate numerical values in the app. The app displays a set value or the nominal value and also the measured status of the particular sensors. The app also displays the mobile number to which the SMS will be sent in case of any abnormality. SMS can be enabled/disabled with the click of a button in the app. The location where the bus is present can be viewed on the app using GPS.

When any abnormality is detected in the noise level, methane level, CO2 level, humidity level, or temperature level in the environment where the kit is present, an alert message is sent to the registered mobile number. This can be used to alert the person that the environmental condition at that place is not safe.

Important parameters like temperature, humidity, methane level, CO2 level, and noise level in the surrounding atmosphere of any location can be measured and monitored using this product. Connecting the device to Bluetooth will enable us to send an SMS and the exact location of the device to the mobile number registered in the app.

If any measured parameters exceed the nominal value, the alert SMS is sent to the mobile number indicating which quantity has surpassed the nominal value. Thus, this device can help in monitoring the pollution level of any location as it is mounted on a bus.

**Graphical user interface

Description automatically generated with medium confidence**

Fig 2: Output shown in Mobile App

Text

Description automatically generated

Fig 3: Alert Message

Graphical user interface

Description automatically generated

Fig 4: LCD Output

1. **CONCLUSION**

Real-time detection in air quality is an important issue in the current air pollution monitoring. This paper has designed an air quality detection system based on Bluetooth communication. It uses a variety of low-cost air sensors to detect indoor and outdoor air quality in real time. The data is sent to the mobile APP in real time, which facilitates the user's query. Experimental results show that the system can accurately detect and display the air quality of the user's current location, which has certain significance for low-cost air quality detection.

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