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A Survey on Air Pollution Monitoring Using Internet of Things

R. Dhanusha[1], Dr. S. Rathi[2]

[1]PG Scholar, Department of Computer Science and Engineering, Government College of Technology/Anna University, Coimbatore, Tamilnadu, India

[2]M.E, Ph.D, Associate Professor, Department of Computer Science and Engineering, Government College of Technology/Anna University, Coimbatore, Tamilnadu, India

ABSTRACT

Internet of Things (IoT) consists of smart devices that can sense the environment and perform data interaction with the users. Air Pollution is increasing day-by-day, which is a harmful cause for the humans and the living environment. In order to monitor the air pollution, a real-time system which provides a high spatio-temporal resolution is required due to the limited data availability and non-scalability of conventional air pollution monitoring systems. The air pollution monitoring systems are rapidly changing due to the immense advances in the development of portable, lower-cost air pollution sensors which collect data in near-real time at a high-time resolution, increased computational and visualization capabilities. It is possible that these advances can support traditional air quality monitoring by supplementing ambient air monitoring and enhancing compliance monitoring using various sensors. In this paper, we review the state-of-the-art low-cost air pollution sensors, identify their major impacts in various sessions and comprehensively surveying the validation of the sensing strategies suited for different deployments. And, different sensing applications in different domains such as IoT, Cloud and Edge Computing are also surveyed.

Keywords: Internet of Things, state-of-the-art, MQ Sensors

I. INTRODUCTION

Internet of Things is a system of interconnected information processing system equipped with specific identifiers and has the ability to transfer information over a web without demanding human-to-human or human-to-computer interaction. The internet of things broadens internet connectivity beyond traditional devices like personal computers and laptop, smart phones and tablets towards various ranges of devices.

Today, the IoT plays a major role especially in the collection of real time sensor data and intimating the user about the level of pollution in a particular area. Real time collection of data from various IoT devices enhances the data generated as it produces accurate values. The MQ sensors act as the IoT devices in order to collect the real time data from the polluted and non-polluted areas. The various MQ sensors are listed in Table-1.

Data collected from these sensors can be distributed through IOT technology and accessed using web-based technology. MQ-2 and MQ-6 sensors are used to observe gas [1] leakage in domestic security systems, if the gas range is greater than the predetermined boundary, the system will render data using notifications in the form of short message services (SMS), then the gas pressure can be reduced

to avoid the occurrence of fire [2].

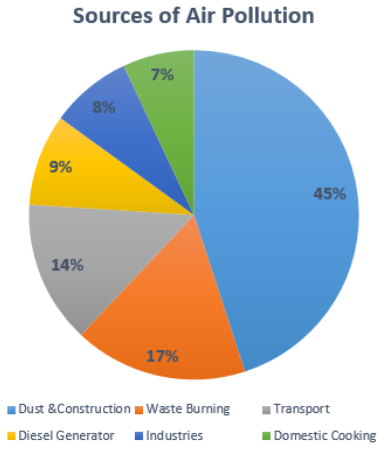
MQ sensors	Gas Detected
MQ2	Methane, LPG, alcohol, Propane, Hydrogen
MQ7	Carbon monoxide
MQ135	NH3, alcohol, smoke, benzene, carbon dioxide
MQ3	Oxygen, alcohols, aromatic compounds
MQ138	Hydrogen gas, Benzene, Toluene, Formaldehyde gas

Table 1. MQ Sensors

Likewise, the MQ-5 sensor is used to observe a assortment of harmful gases such as propane, butane, carbon monoxide (CO), cigarette smoke, alcohol and so on, the subsequent system can find harmful gases [3] and generate an advance cautionary system in the form of buzzer notification in urban environment. The MQ-7 and MQ-135 sensors[4] are used to sense the concentration of Carbon monoxide, NH3, NOx, alcohol, benzene, smoke and carbon dioxide which aims at monitoring the parameters from anywhere within the wifi-access. The state-of-the-art low cost air pollution sensors identify their major impacts in various sessions and survey the validation of the sensing strategies which can be suited well for different deployments.

Air pollution in India is a serious health issue, of which the most polluted cities in the world, 22 out of 30 were in India. The important problem of this pollution is decreasing air quality and one of the major threats in mega cities comprises outdoor pollution. The different sources of air pollution can be figured as below:

The recent advances in the system of air pollution monitoring helps to improve the traditional air quality monitoring system.



II. RELATED WORK

In this section we perform the analysis and identify the issues related to the designing and implementation of real-time air quality monitoring systems. In order to overcome the defects of existing monitoring systems we consider the two metrics: computational time and memory requirement.

The real time collection of sensor data are collected and stored in cloud storage such as the firebase database, and the computational time is calculated by considering the processing time that is required to classify the sensor data according to the level of pollution and the memory requirement shows the amount of memory used for the storage.

2.1 IoT-MobAir

The leading problem in the enforcement of air pollution monitoring and detection constitutes that the sources of pollution may be controlled at sporadic time interval and when the pollutant is in the form of gases or vapors which are inconspicuous, the problem becomes even additionally difficult.

Sensors are the electronic components used for fundamental interaction with the outer environment. MQ sensors are used to execute the environmental perception [5] based cognitive process to check the air quality. This sensor comprises of a sensing element, mainly aluminum-oxide based ceramic, surfaced with

Tin dioxide, enveloped in a stainless steel mesh. Sensing element features six linking legs attached to it. Two leads are accountable for warming the sensing chemical element; the other four are used for output signals.

The IoT devices such as the sensors collect data from the surrounding and send it to the cloud. The Firebase cloud-hosted database is configured to collect the data from various sensors in various time periods through the Arduino IDE which is used to transmit the data to the cloud via the Wi-fi module. The correlation and Spatio-temporal correlation between the data is identified by applying the statistical analysis to determine the linear relationship between the sensed values and the Boundary threshold algorithm is utilized to differentiate the significance of currently sensed values based on the Air Quality Index (AQI)[6].

2.2 Air Pollution Detection Based on Genetic algorithm

The Genetic algorithm is used to create the possible combination of air concentration for various gases which will improvise the classification strategy, in which it uses the cloud as storage. The developed system [7] for air quality monitoring collects the presence level of the pollutant gases. The gas sensor nodes distributed in the outdoor environment based on the region of interest is identified using the genetic optimization algorithm. In the process of the genetic algorithm, the initial chromosomes are generated from the random input.

- The solution taken is encoded as 0 and 1 using node encoding scheme that forms initial chromosome.
- The objective value of the chromosome is calculated using fitness function and the best chromosomes are selected based on the objective value.
- In the generation phase new population are generated using crossover and mutation, in crossover two chromosomes are selected and the n point random crossover is applied and in mutation individual chromosomes are given as input. If the bit is zero then it exchanged as 1, and vice versa with respect to random bit exchange with specified mutation rate.
- After formation of new chromosomes again the process of chromosome fitness evaluation, selection and new population generation is applied until the specified iterations are met.

Now the selection operation is applied by sorting the chromosome based on the objective value in descending order and the same process is repeated until the final iteration is reached.

After specified iterations the final best chromosome is selected as optimal solution based on optimal fitness value. After selection of final chromosome, decoding is applied to get the solution.

Based on the generated solution from genetic algorithm, the data collection and the communication between the devices in the sensor network is established. During the sensing process, the gas sensitive substantial used in the MQ gas sensor which determines the concentration of the pollutant gases present in the clean atmosphere is determined by the low electrically conductive material. When there is ignitable gas in the surrounding air, the electric conductivity of the detector will increase with the higher intensity level of the combustible gas.

2.3 Edge Computing based IoT Architecture for Air Pollution Monitoring System

In an effort to tackle the issues of the cloud computing, edge computing [8] has been developed as a new methodology for computing and information processing near data sources. This system is designed using the sensors MQ2, MQ135, MQ7 and MQ3 to detect the concentration of pollutants such as carbon monoxide, methane, LPG, smoke, propane, benzene, hydrogen and NH3. Edge computing allows logical

estimation and validation to be executed at a level of an edge router by deploying any computing infrastructures along the route between end-devices and data centers in the cloud environment. Edge computing expressively reduces the data volume, which has to be interchanged with the cloud and thus reduces latency. The adaptable architecture of edge computing can render higher scalability compared to the present cloud architectures.

The fog processing [9] system seamlessly incorporates the two computing prototypes to effectively use edge devices and cloud infrastructures. This new paradigm provides location-aware and other related services to users with a better quality of service (QoS) in terms of response time, real-time response, information traffic control between the edge and cloud in many IoT applications. The fog system provides low latency and instant responses.

The sensing element collects the air quality information instantly and communicates it to the edge information processing system that performs necessary computations and analysis process. The entire infrastructure & prototype for evaluation is developed with the Arduino board and IBM Watson IoT platform. Our system is integrated in such a way that it decreases the computational overhead over sensing nodes which are battery powered and proportionated it with edge computing device that has its internal database and can be powered up directly as it is deployed indoor.

Fog communication architecture is configured in hierarchical manner with the set of sensor devices, Internet Gateway, Edge center with set of edge hosts, Cloud data center with cloud host devices and the user devices. The data fetching operation is initiated from user device to retrieve the data from the sensing environment. The sensor devices are configured to collect the environmental data in terms of pollutant gas concentration in the surrounding area. The sensed data is sent to the internet gateway using the connected AP of the sensing controller and the internet gateway forwards the data to the edge center which performs the data processing in the edge hosts. The designed model ensures to reduce the computational overhead over the sensing nodes and balances the total work load with the edge computing devices[10]. Though we receive large volume of data from the sensors placed, the useful information alone is generated and intimated to the users at the local level in order to create awareness and reduces the computational burden up to 70%.

III. Result Analysis

The data are collected from various sensors and maintained in the firebase database and the application interface is created using the android application. The values for the algorithm are fetched from the firebase database and stored in the local database of the android. The two metrics such as the computational time and memory overhead are evaluated by comparing the three systems above.

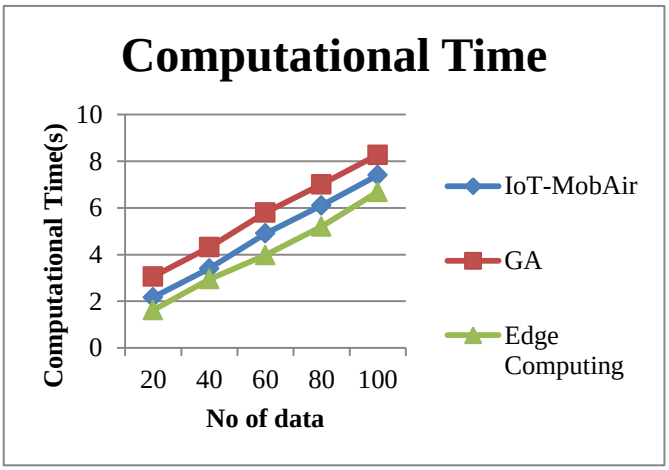


Figure 1. Computational time

The number of data fetched from the firebase database is varied from 20 to 100. It is analysed that the computational time for Genetic Algorithm(GA) is large and then followed by IoT-MobAir and Edge computing. The computational time required for edge computing is less and hence provides instance response to the user.

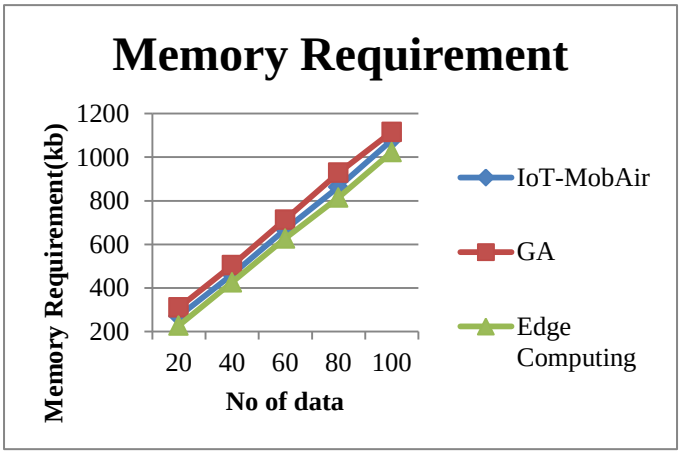


Figure 2. Memory Requirement

It is seen that during memory storage we require additional variables to be declared. In the case of GA and IoT-Mobair additional variables are created during the process of crossover, mutation which requires more memory storage whereas in edge computing while bringing the data from the cloud to the fog devices some variables are not needed thus reducing the memory requirement.

The input values are varied from 20-100 and the corresponding computational time and memory requirement are estimated and depicted in the following table :

No.of data	IoT-Mobair	GA	Edge-computing
20	2.17	3.06	1.62
40	3.4	4.31	2.94
60	4.9	5.8	3.98
80	6.1	7.01	5.2
100	7.4	8.27	6.68

Table 2. Computational Complexity

No.of data	IoT-Mobair	GA	Egde-computing
20	271	311	228
40	462	505	426
60	669	714	627
80	864	929	815
100	1079	1116	1024

Table 3. Memory Requirement

IV. Conclusion

In the living environment, the air pollution is increased day-by-day which causes the harmful effect to the inhabitants. In this survey, the various air pollution monitoring systems are analyzed along with the emphasized contributions. The air pollution monitoring system have been designed by using the cloud and fog computing based interface which utilize the storage and processing capability of the distributed system. It emphasizes that the edge routers and the fog nodes in the computational

environment performs the data management in both internal data servers as well as the remotely deployed cloud data storage. It further ensures that the fog computing system is also capable of aggregating the data at different server instead of storing and retrieving from one cloud data center using the single channel communication.

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