Internet of Thing (IOT) based Air Pollution Mapping

Amit Sharma
Department of Electronics and Communication Engineering
Faculty of Engineering, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

ABSTRACT: Air pollution, particularly carbon monoxide, is dangerous for our health. Inhaling carbon monoxide may lead to trigger cough, runny nose, eye irritation and even death. Carbon monoxide is a colorless, odorless, tasteless gas created by burning gasoline, wood, propane, charcoal or other fuel. Improperly ventilated appliances and engines, especially in a tightly sealed or enclosed room, can allow carbon monoxide to accumulate to dangerous levels. The main goal of this research is to create a tool capable of detecting levels of carbon monoxide emissions by using mobile sensors and projecting the findings into overlaid heat maps on Google Maps. This paper have introduced an integrated pollution monitoring and mapping network consisting of MQ-7 sensor, GPS, GSM, display panel, Arduino board, and web-server. This paper also examined two methods of sampling: time-based and distance-based sampling. Based on our experiments, the distance-based sampling method provided well-distributed data compared with the time-dependent method and closer to the predicted inter sample distances. It is also shown that our device can work to track the levels of carbon monoxide emissions in real time.

KEYWORDS: CO pollution; Pollution sensor; Pollution mapping; Mobile sensor; Internet of things.

INTRODUCTION

With an ever-increasing number of environmental observations being available through methods such as crowd sourcing, citizen science, and participatory sensing, one of the big emerging challenges is how best to make sense of the vast amount of collected observations and how to provide a meaningful value-added product to people and other end users. For many countries around the world, air pollution is a major environmental issue, with severe effects on public health and the economy. Bad air quality is of particular concern to many large urban areas. Detailed observation-based large-scale air quality maps are therefore very scarce as the conventional highly accurate observation network is very expensive and the resulting low number of air quality monitoring stations with reference equipment typically cannot accurately capture the small-scale spatial variation of air pollutants in the urban environment.

Recent technical advancements related to sensor technology have led to comparatively low-cost and lightweight air quality monitoring devices. Using various elements from Citizen Science and crowd sourcing, a high-density network of these low-cost air quality sensors has considerable potential to enhance spatial mapping in general and in urban areas in particular. Nevertheless, most observation databases within a crowd sourcing system involve substantial data gaps and observations are typically extremely erratic point measurements. This presents a major challenge for mapping applications using these observations. One way to solve these problems is to combine these crowdsourced information with data from the model, which has complete spatial coverage.

Data fusion techniques, as a subset of data assimilation, allow for the mathematically accurate combination of observations with model data (through the best linear unbiased estimate) and thus provide a way of adding value to both the observations and the model. The holes in the observations are filled up, and the observations limit the model. The model also offers detailed spatial structures in places where there are no observations. As such, data fusion of observations from high-density low-cost sensor networks together with models can dramatically enhance air quality mapping on an urban scale.

Since it was only fairly recently feasible to use low-cost micro sensors for air quality applications, not many studies have been performed to use this knowledge to measure air quality on an urban scale. While there are already numerous studies using these sensors for general monitoring and assessment of personal exposure, the number of studies using such sensor devices specifically for urban air quality map-ping is very low. The related ones include mainly those examining the use of mobile air quality sensors to produce average longer-term maps along the street network and areas where mobile measurements are representative. Some experiments used a network of fixed passive samplers to establish long-term averages of urban air quality, e.g. using generic additive models or using techniques of land-use regression. While observations from official air quality monitoring stations and not low-cost sensor data were used, it showed that data assimilation of air quality observations from 9 fixed sites into an urban air quality model is feasible and can account for up to 50 per cent reduction in high-station density root mean squared errors.

LITERATURE REVIEW

Monitoring the air quality is highly important because air pollution directly affects human health. This paper presented a low-power, low-cost mobile sensing device for participatory monitoring of the air quality. Unlike conventional stationary air pollution monitoring stations and presented a Gas-Mobile design, implementation and evaluation, a compact and portable measuring device based on o-the-shelf components and suitable for use by a large number of people. High data quality is vital to the success of participatory sensing applications [1]. This paper collects the measurements over a span of more than two years using mobile sensor nodes mounted on top of public transportation vehicles in the Swiss city of Zurich. Based on these results, this paper is developing land-use regression models to construct maps of pollution with a high 100 m/100 m spatial resolution. It compare the accuracy of the derived models over different time scales, and note a rapid decline in accuracy for maps with temporal resolution sub-weekly.

To address this issue, this paper propose a novel modeling approach which integrates past metadata-annotated measurements into the modeling process [2]. This paper addresses a pilot study where it measured urban air pollution with mobile carbon monoxide (CO) sensors. Our goal is to use inexpensive Global Positioning System (GPS) receivers to monitor the sensors and explore fine geographic scale CO variations. The main problem in data processing is the management of the imprecise GPS logs. Through using knowledge of the route and layout of the buildings, author are able to greatly improve the precision of the location, while at the same time demonstrating that certain phenomena, such as CO profiles, can be identified with a high degree of accuracy while crossing roads [3]. This paper developed a Exposure Sense, a rich participatory mobile sensing network combining the two independent sensing paradigms.

Exposure Sense can track the everyday activities of people, as well as measure a fair estimation of the exposure to pollutants in their daily lives. In addition to using external sensor networks, Exposure Sense also supports pluggable sensors (e.g., O_3) to further enrich data on air quality through mobile participatory smartphone sensing[4]. The main goal of this research is to create a tool capable of detecting levels of carbon monoxide emissions by using mobile sensors and projecting the findings into overlaid heat maps on Google Maps. It also proposed a built-in pollution monitoring and mapping system consisting of MQ-7 sensor, GPS, GSM, display panel, Arduino board, and web server and have tested two types of sampling, time dependent sampling and distance dependent sampling. Based on our experiments, the distance-based sampling method provided well-distributed data compared with the time-dependent method and closer to the predicted inter sample distances. This paper have also shown that our device can work to track the levels of carbon monoxide emissions in real time. This paper uses the OpenIoT1 middleware to implement an approach to sensor data analytics; for this reason, real time event processing and clustering algorithms were used. The OpenIoT platform has been extended to support stream processing and thus demonstrates its versatility in allowing on-demand application domain analytics in real time.

For analyzing and inferring air quality conditions, this paper used a mobile crowd-sensed data generated in real time from wearable sensors. This experimental evaluation was carried out using the design principles and methods for interoperability of IoT data as defined by the OpenIoT project [5]. This paper describes a framework for tracking the ambient air quality in real time. The network consists of many distributed monitoring stations, which use machine-to-machine communication to communicate wirelessly with a backend server. Each station is fitted with gaseous and meteorological sensors, as well as capacity for data logging and wireless communication. The backend server gathers data from the stations in real time and translates it via web portals and mobile apps into information transmitted to users. In the pilot phase the device is introduced and four solar-powered stations are installed over an area of 1 km2 [6]. This paper demonstrates a low-power, sensitive and selective multiplexed gas sensing system using this platform by detecting H2S, H2, and NO2 at ambient temperature for the oil and gas industry, providing major advantages over established system.

In addition, the device mentioned here can be easily integrated with mobile electronics in environment pollution mapping and personal air quality monitoring for distributed sensor networks. This paper introduces an experimental study that uses wireless sensors on public transport vehicles to track air pollution in real-time. The research is part of Sweden's GreenIoT project, which uses the Internet-of-Things to calculate air pollution rates in downtown Uppsala. More fine-grained and real-time air pollution rates can be obtained at different locations through the deployment of low-cost wireless sensors. The sensors on public transportation vehicles complement the readings from stationary sensors and Uppsala's only ground level monitoring station. This study examines the views, expectations, attitudes and behavioral intentions of 12 participants who used a real-time NO2 sensor in Barcelona's metropolitan area over a span of 7 days and contrasts them with 16 participants who did not have access to the system but to documentary information instead. The design of the study is focused on recombined focus groups which met at the beginning and end of a seven-day event. The results indicate that the interaction with the sensors generates greater motivation among participants as compared to traditional knowledge [7].

OPERATIONAL METHOD

The architecture of the detection system for air pollution may be seen in Fig. 1. The proposed air pollution monitoring system consists of several components, including air pollution sensor, internet access, database, and electronic devices such as Desktop, laptop, and cell phone. Air pollution sensor comprises a module aimed at collecting data from CO pollution that occurs in a given location. If the emission data is read, the data will then be sent over the internet network to the MySQL database. The MySQL database contains tables that are used to store data on CO pollution. The data stored are the date and time of the MySQL server, the pollution value (in ppm), the pollution location coordinates (latitude and longitude) and the date and time of the GPS. Collective data on CO pollution can be viewed and analyzed through a web portal that can be accessed from a PC, laptop or mobile phone.

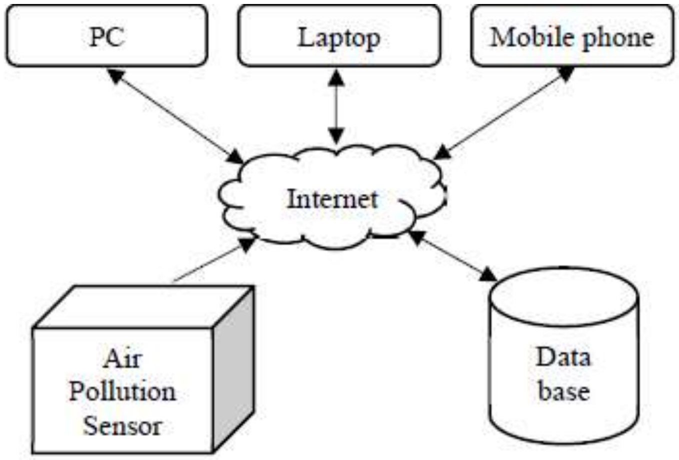

Fig. 1. Design of air pollution detection system.

FIGURE. 1. Air pollution sensor diagram.

The diagram for the air quality sensor appears in Fig. 1 and the list of air pollution control components can be seen in Table 1. Arduino Mega's input data comes from both the MQ-7 gas sensor and the GPS module. Meanwhile, Arduino Mega's output data is sent to both the LCD and GSM module. The MQ-7 gas sensor obtains the emission data for carbon monoxide (CO) in ppm (parts per million) form. In addition, the GPS module obtains the data sample date, time, and position (in latitude and longitude form). The data collected is then forwarded to the LCD module and to the GSM network. The LCD module is useful to view the MQ-7 gas sensor readings so that the value is explicitly known. Although GSM module is useful for the transmission of pollution value, location, date and time to MySQL database server.

The air pollution control system is then used to perform air quality measurements by moving a car along various routes. In addition, the program periodically sends the measurement of air pollution levels and their location over the internet, which is stored in the MySQL database. GSM module is used to submit sensor system reading data. In addition, it also uses a GPS module to get measurement position. The data is then processed and analyzed based on their time and location.

No.	Part Name	Specification	Qty
1.	Arduino Mega 2560	R3 CH340	1 pc
2.	MQ-7 Gas Sensor		1 pc
3.	LCD Module	20x4 with I2C	1 pc
4.	GSM Module	SIM 800L	1 pc
5.	GPS Module	Ublox Neo-6M	1 pc
6.	Breadboard	MB-102	1 pc
7.	Car Power Inverter	150W,220V	1 pc
8.	Breadboard MB-102 Power Supply		1 pc
9.	Cable	Male to Female	As needed
10.	Cable	Male to Male	As needed
11.	USB Cable		1 pc
12.	Adapter	220V to 9V	1 pc

Table 1. List of Air Pollution Detection Components.

It is then possible to view and analyze data that has been stored in the MySQL database through a web browser installed in a Desktop, laptop, mobile phone or other electronic devices. The data shall be separated by pollutant sampling date. In addition, the data is clustered again based on the time period for the sampling. The clustered data can then be shown in table form or in graph form. The air quality control device is mounted on the car dashboard, while the MQ-7 gas sensor is positioned outside the car near to the rear view mirror, making the measurement results more reliable.

RESULT

Information entered in the MySQL database can then be analyzed, and the results can be described as follows:

(1) Distance-based sampling

Distance-based sampling is done upon travelling over a certain route. The road condition had been very congested. The spacing between points is fairly consistent with each other and implies that the algorithm for distance calculation works well. The chart uses varying shades of green and yellow to reflect different levels of emissions, where a dot of green hue shows a lower level of pollutants.

(2) Time-based sampling

Time-based sampling Routes traveled at certain route at the time of data collection; The assumption used is that the expected vehicle speed is 40 km / h, and each 9 seconds is the required sampling time. The road situation was very congested too. It can see that there is a very small gap between the lines. This is due to busy road conditions, such that the driving scenario is not done at a speed of 40 km / h.

The distance-based sampling approach is better than the time-based sampling method, based on the effects of measuring mean and standard deviation. The benefits of the distance-based sampling method are as follows:

(1) The distance between the samples is more regular;

(2) The standard deviation value is lower;

(3) Driving the vehicle more comfortable as the vehicle speed does not have to be constant, which just needs to be taken into account is that the vehicle speed does not exceed 40 km / h. And the distance-based sampling approach is more efficient, with the above stated advantages. The second test is conducted to determine the capabilities of the sensor to conduct measurement of the data in real time.

The functionality in real-time can be seen from the transmission of latency data between the sensor module and the MySQL database. The average latency from the collected data is 5.97 seconds, with a standard deviation value of 3.64 seconds.

CONCLUSION

This paper proposed a built-in pollution monitoring and mapping system consisting of MQ-7 sensor, GPS, GSM, display panel, Arduino board, and web server. The proposed system will deliver real-time pollution rates in an environment. From the experiments, it can be inferred that carbon monoxide pollution detector works properly in the air; from the method of reading carbon monoxide pollution value, sending it to MySQL server, until it is shown on Google Maps in the form of a heat map. This paper have tested two types of sampling, time dependent sampling and distance dependent sampling. It's clear that the distance-based sampling approach is stronger than the time-based sampling approach. The distance-based sampling system has a more normal distance from the sampling. This can be seen from the smaller value for standard deviation.

This work uses the MQ-7 sensor which focuses on detecting levels of carbon monoxide. This technology is planned to be improved in the future in order to be able to detect certain forms of contaminants in real time and portably. It may also be further developed to improve the quality of the mean value and the standard deviation produced in subsequent research. One potential solution is to use a cellular operator which has the widest range of GPRS networks to solve this problem. The data transfer method can also be carried out more efficiently, as it depends completely on the reliability of GPRS mobile network operators. In addition to choosing a good mobile operator and can also build a device that can store the sensor readings in a memory card. And the emission data stays well maintained when the GPRS network is volatile and can still be sent to the MySQL server when the GPRS network is stable again. It can boost both the quality of the mean value and the standard deviation value. The effect is a clearer view of the heat map in Google Maps, since there is no blank space.

REFERENCES

[1] D. Hasenfratz, O. Saukh, S. Sturzenegger, and L. Thiele, “Participatory Air Pollution Monitoring Using Smartphones,” *2nd Int. Work. Mob. Sens.*, 2012.

[2] D. Hasenfratz *et al.*, “Deriving high-resolution urban air pollution maps using mobile sensor nodes,” 2015, doi: 10.1016/j.pmcj.2014.11.008.

[3] R. Milton and A. Steed, “Mapping carbon monoxide using GPS tracked sensors,” *Environ. Monit. Assess.*, 2007, doi: 10.1007/s10661-006-9488-y.

[4] B. Predic, Z. Yan, J. Eberle, D. Stojanovic, and K. Aberer, “ExposureSense: Integrating daily activities with air quality using mobile participatory sensing,” 2013, doi: 10.1109/PerComW.2013.6529500.

[5] H. Hromic *et al.*, “Real time analysis of sensor data for the Internet of Things by means of clustering and event processing,” 2015, doi: 10.1109/ICC.2015.7248401.

[6] A. Kadri, E. Yaacoub, M. Mushtaha, and A. Abu-Dayya, “Wireless sensor network for real-time air pollution monitoring,” 2013, doi: 10.1109/ICCSPA.2013.6487323.

[7] C. Oltra, R. Sala, À. Boso, and S. L. Asensio, “Public engagement on urban air pollution: an exploratory study of two interventions,” *Environ. Monit. Assess.*, 2017, doi: 10.1007/s10661-017-6011-6.