A Review of a Crowd-sensing-Based Air Quality Monitoring System

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ABSTRACT: ***In the development of modern intelligent cities, correctly collecting data on air pollution is a significant issue for inhabitants. More sensors are being placed on mobile terminals, and several individuals are collaborating with the Internet to distribute sensing jobs and collect sensing data in order to complete large-scale and complex social awareness tasks; this process is known as crowdsensing. The traditional monitoring method, fixed base stations, is inflexible and inaccurate. On the other hand, crowdsensing provides new answers to those problems and enables more people to participate. Various air quality monitoring techniques have been proposed in many studies thus far. After reading and classifying these articles, it is assess the disadvantages as well as benefits of these systems, and also their similarities and variances. Finally, we address research challenges in order to provide resources for future researchers interested in the field.***

KEYWORDS: Air Quality, Monitoring, Crowdsensing, Pollution.

1. INTRODUCTION

Crowdsensing is a kind of Internet of Things (IoT) but also service-oriented computing that combines crowdsourcing with mobile device sensing to gather data. By establishing interactive, participatory networks of sensing via current mobile devices and posting sensing tasks to individuals or groups in the network, crowdsensing assists ordinary people and experts in collecting data, analyzing information, and sharing knowledge. Mobile crowdsensing people-centric sensing social sensing participatory sensing Despite the fact that these concepts are distinct, they are both ways for humans to help mobile devices with data gathering, information sorting, and knowledge finding. There is no precise definition of crowdsensing at the moment.

The crowdsensing process,

- Sampling.
- filtering.
- data transmission.
- data processing.
- Results display.

1.1.Different hardware components can perform all of these functions.

Numerous industries and automobiles have been releasing enormous quantities of exhaust and air pollutants into the environment since the industrial revolution. Humans, animals, and ecosystems are all harmed by these air pollutants. People are becoming increasingly concerned about environmental issues and their own health. Through pollutant detection rate score, toxic impact score, or population exposure score, a screening approach for atmospheric healthcare benchmark target pollutants has been developed. This technique is used to filter a list of candidates for the benchmark target pollutants for atmospheric health. Some research into the connection between key contaminants in the atmosphere, which will aid relevant departments in implementing targeted actions. Principal component analysis was used to evaluate and compute the data of six main atmospheric pollutants including such SO2, NO2, PM10, PM2.5, CO, and O3 in 16 cities using specific software. We typically use the air quality indicator (AQI) established by the US Environmental Protection Agency to assess air quality (EPA)[1], [2].

Crowdsensing is currently a novel paradigm for sensing the surroundings. Crowdsensing offers a number of benefits, including cost-effective deployment, multisource heterogeneity of sensing data, broad coverage, and high expansion and flexibility. As a result of these benefits, an unending stream of research on air quality monitoring has developed. The concentrations of CO and PM pollutants will be monitored by the WSN. The gathered data is transformed into a European Directive-defined data quality target format. a sensor kit that enables individuals to simply install gas sensors in their homes, monitor neighborhood air quality, and share monitoring data via social media. Because most mobile phones do not have built-in gas sensors, air quality research using mobile crowdsensing often uses external sensing equipment[3].

1.2.Various Air Quality Monitoring Crowdsensing Systems:

1.2.1. Camera-Based Systems:

Photographs taken with cameras may be used to estimate current partial environmental pollution indices as technology advances. To estimate the value of PM2.5, use the phone's camera to snap a photo. They developed a learning-based (LB) approach for correctly inferring PM2.5 concentrations by training the prediction model using data from adjacent reference sensors. The architecture of their suggested system is shown in Figure 1. To enhance data accuracy, fixed PM2.5 sensors will be linked to the server. Air Tick is a mobile software that transforms any camera-enabled smart mobile device into an air quality sensor for a range of air quality measurements. Air Tick generates reliable air quality assessments using image analysis and deep learning methods. the mobile Third-Eye app, which can transform a smartphone into a high-resolution PM2.5 monitor. They look at cluster search and web crawling as ways to effectively construct big data sets, such as weather and air pollution data for mobile phone pictures shot outside[4].

When the aforementioned techniques are compared, it is clear that the structure of these systems is similar. The difference is in the technological processing of these images, which includes integrating network monitoring data to validate the sensor, fine-grained monitoring range to enhance accuracy, and so on. Finally, the map is accompanied with a numerical representation of the PM2.5 value. You may go to the original articles for those particular system designs[5].

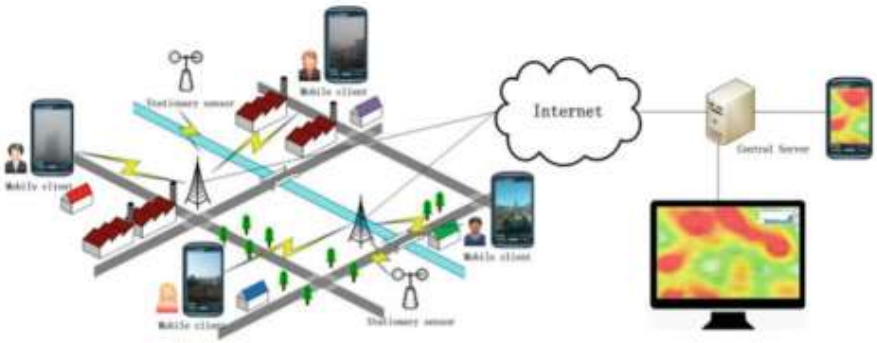

Figure 1: Illustrate the System architecture.

1.3.Wearable Computing Systems:

Commercial and off-the-shelf gas sensors will be integrated into wearable devices such as wrist straps, belts, and backpacks for personal air pollution monitoring. Previous research, on the other hand, lacked a thorough examination of the accuracy of air pollution detection for wearable devices. The application is built on the Open IoT platform and makes use of sensors to collect data on pollutant gas concentrations and weather conditions. the creation of a wearable sensor node with two electrochemical gas sensing device , temperature, relative humidity, or air pressure sensors, as well as a Bluetooth connection. W-Air is a personal multi-contamination monitoring platform for wearable devices that use a sensor fusion calibration method to recover high-quality ambient pollutant concentrations that are free of human influence. It also employs a neural network with shared hidden layers to enhance calibration parameter training with fewer measurements and semi-supervised regression to

update calibration parameters with minimal human involvement. the contrast between these two kinds of wearable gadgets You may go to the original articles for those particular system designs[6].

In general, wearable-based systems have comparable architectures, and the mobile device interacts with the external sensor using Bluetooth. The challenge with this technology is figuring out how to minimize interference from the user's wearing posture and various user activities. This detection method has an advantage over camera-based systems in that additional sensors may be utilized to monitor various gases in order to account for air quality. Many contemporary wearable gadgets can track the user's heart rate, pace, sleep quality, and other vital signs. Users will be able to quickly know the ambient air quality and their health in the future if the gas sensor gets smaller and incorporated into these wearable devices[7].

1.4.Systems based on bicycles:

In the urban environment, mobility as well as environmental circumstances are important elements that influence one's well-being and quality of life. In this instance, sensors, smart mobility, networks, and connections may all play a key role in improving the data and information accessible to government officials and citizens alike. They will be able to get additional assistance for sustainable and aware conduct, as well as helpful information and services to help them with their everyday tasks. Bike Net is a scalable mobile sensing system for rider experience mapping that uses opportunistic sensor network concepts and technology. Bike Net is a multi-faceted sensor system that makes use of a bicycle network. The Smart Bike platform includes features such as real-time remote location of the user's bicycle, anti-theft protection, route information, and air pollution monitoring. Figure 3 depicts the Smart Bike's logic architecture. Canarin II, a smart electric bicycle prototype, included a mechanism for collecting data on particulate matter and then analyzing and sharing the information. Contaminant sensors may provide data via a variety of networks, including the city's wireless network and passenger cellphones[8].

1.5.System based on automobiles:

The front-end bicycle-based system is a slow-moving system. A comparable mobile-based method involves mounting the sensor on a faster-moving vehicle. a car-based mobile device for monitoring CO2 gas concentrations in metropolitan areas Each vehicle has four components: a CO2 sensor, a GPS receiver, a GSM module, and a Jennic board. The GSM module then regularly sends the monitoring data to a nearby GSM base station using GSM short messages, integrating the location information from the GPS receiver with the sensing data from the CO2 sensor. In the Haze Watch design, a driver may choose between mounting an inexpensive but less sensitive oxide sensor or a more costly sensor. Additionally, roadside commercial monitors that offer more accurate pollutant detection are placed to calibrate the results of the car's sensors. The communication protocol, network bandwidth, sensor type, server type, and sensor accuracy are all altered. This technology, in comparison to bicycle systems, has to remove the interference of vehicle exhaust and focus more on air movement. In general, the vehicle wireless sensor network is used in conjunction with GSM, 3G, and other communication techniques to send data about contaminated gas concentrations to a mobile device, which is subsequently sent to a server through the mobile device, and the result is shown on a map for the user[9], [10].

1.6.Challenge:

In air quality monitoring, there are many applications of crowdsensing, the majority of which are achieved by integrating mobile sensor technology, data mining technology, machine learning technology, image processing technology, and other technologies. The difficulties faced include those posed by the technology themselves. We must address user involvement problems, hardware devices, and software design issues as part of the overall challenge. From the five stages of crowdsensing processing, the article will highlight the difficulties of technology implementation.

- The sampling method. The sensor's inaccuracy, sensor power consumption, volume, and sensor calibration techniques are the major difficulties. Various manufacturers' sensors have different inaccuracies, but the overall error range is acceptable. The range of usage will be influenced by the sensor's power consumption, size, and cost.

- The filtration procedure. It's possible that the data gathered contains an excessive amount of worthless information. Data reference at the same place over a length of time, for example, is comparable and does not require complete transmission. Furthermore, the data gathered may be erroneous and must be filtered.
- Data transmission. The balance between real-time and opportunistic is mostly solved through data transfer. The issue of high data volumes must also be taken into account. To account for bandwidth and latency, data compression technologies may be used. There are various issues with data uploading format and data transfer techniques.
- Data manipulation. The majority of the study at this point is focused on storing background data in the cloud, with data processing referring to the interpolation method used to rebuild the pollution map.
- Presentation of the findings. The way the findings are displayed to the system administrator is called the result display. The graphical mapping of the target region is the most usable depiction. It's difficult to keep up with the structure's presentation pace.

2. DISCUSSION

In addition, several studies focus on estimating air quality using data provided by users in social networks. However, the technique is prone to mistake, and determining the validity of data is challenging. Another study proposes using Unmanned Aerial Vehicles with pollution sensors to monitor air quality in major industrial regions or rural areas where transportation facilities are inadequate or non-existent. Common Sense, a handheld-based technology that was launched more than a decade ago, allows users to see current ozone readings in real time. Citi sense is able to monitor NO2, O3, CO, temperature, humidity, and pressure. Air Sense is a crowdsensing-based opportunistic air quality monitoring system that collects and aggregates sensor data to track air pollution in local and metropolitan regions. You may learn how they function by reading the original articles. Furthermore, many different designs are comparable to Air Sense, and various applications alter the technique used at each phase to better embody the concept of crowdsensing. However, in the typical system described above, sensors are used to gather data and an overall system architecture is built using various collection techniques. These architectures are similar and were taken from several publications mentioned above. The sensors and the users' mobile devices gather data, interact through Bluetooth or other communication protocols, and then send the data to the users' mobile devices. The data may be analyzed on the phone itself, or it can be sent to a server in the background through Wi-Fi, 3G, 4G, and other methods to be processed and then displayed. Through internet access devices, users may see the air quality of their own area as well as the air quality of other users who have participated in or not engaged in the event.

2. CONCLUSION

Air pollution is a worldwide issue that has an impact on everyone's health. As a consequence, people are becoming more concerned about environmental monitoring. However, conventional air quality monitoring relies on permanent base stations, that is not only expensive but also inflexible. The development of crowdsensing has the potential to address the aforementioned issues. It can collect real-time air pollution data or contributes to air quality monitoring when combined with the power of the people. In this article, humans look at a variety of popular air quality monitoring methods, including camera-based, wearable-based, bicycle-based, and car-based data collecting systems. In addition, researchers compare such systems and summarize the research challenges to serve as a resource for academics, allowing them to rapidly learn about the study area and identify research issues, as well as contribute to public air quality monitoring.

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