Moving average method based air pollution monitoring system using IoT platform

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Abstract. Researches show that almost seven million people worldwide are dying due to air pollution every year. Data given by World Health Organization observed that 9 out of 10 people breathe the air that contains significant proportions of poisons. Monitoring helps in evaluating the degree of contamination corresponding to the surrounding air quality benchmarks. In this work, a IoT based air quality monitoring system is developed using Raspberry Pi Internet of Things (IoT) platform. A MQ135 sensor is used to detect gases like CO, Ammonia, Smoke, Alcohol, etc., and the corresponding data is processed using moving average method to avoid the redundant data samples, stored in a database to do further analysis and future predictions of the air pollutants. This will help future generations to take precautions and stay safe.

1. Introduction
With an ever-expanding number of modern units and transport vehicles, the issue of air contamination is getting serious by each spending day. Nowadays, in the most developing countries 90% of the rural people and around 50% of the world's population uses unprocessed biomass for open fires and indoor cooking stoves. These poor cooking methods are liable for indoor air pollution (IAP). Due to this, health of women and young children weakens as they are exposed to a contaminated environment [1]. In this way, it has now gotten critical to keep the air contamination levels under check, particularly in urban focuses. To accomplish this objective, some kind of air quality monitoring framework should be created. To counter the issue of air quality monitoring, we propose a Raspberry Pi and IOT based air quality monitoring system project. To quantify the air contamination levels, the observing framework utilizes an MQ135 sensor by considering the sensor features and ranges mentioned in [2, 3]. The deliberate sensor information is then transmitted to a remote web server employing a Wi-Fi association. The most huge part of this Raspberry Pi based Air quality monitoring system is the IoT availability, which permits the remote and ongoing checking of air quality levels. By viable checking of contamination levels, measures can be brought to cut those levels down.

2. Previous Works
In [4], Matplotlib+ is used to plot real-time data. On the x-axis time is plotted and on y-axis quantity of the element and compound will be plotted. The RPi 3B+ is used, with different sensors connected to it. In [2, 5, 6], IoT concept is used to monitor air pollution using Raspberry Pi 3B+. Parameters such as Particulate Matter, Carbon Monoxide, Carbon Dioxide are observed
Figure 1. Block Diagram of the Air Quality Monitoring System

For network connectivity the arduino isn’t built directly. An extra chip which contains an Ethernet port will be used and it is connected to arduino board using coding to get the outputs. Whereas in the raspberry pi, to make the applications easier an inbuilt Wi-Fi port is available. Though web attachment is used to monitor [8], security and storage of data are problems unsolved in the previous researches.

3. Literature Survey
Principles are an administrative measure to set the objective for contamination decrease and accomplish clean air. Powerful checking assists with guarding against outrageous occasions by alarming individuals and start an activity. Late advancement of an almost flawless air quality checking framework utilizing raspberry pi was done yet it did exclude any continuous sensor for SO₂, NO₂, and ozone that makes a hole in the previous model. In our model, we have attempted to make an air quality estimating framework utilizing Raspberry pi 3 B+ microcontroller. By referring the properties of pollutants in [9] to estimate Carbon dioxide (CO₂), Carbon Monoxide (CO), smoke, alcohol, flammable gas, other minor contamination gases (like methane) and suspended particulate issue, we have utilized the MQ135 sensor.

4. System design and architecture
The popular IoT embedded platform Raspberry pi 3B+ is utilized, with a sensor associated with it. The framework needs to gather information through the sensor for a specific region to screen the air pollution. Here we have observed the values of Carbon Dioxide (CO₂), Carbon Monoxide (CO) and smoke using MQ135 gas sensor. The MQ135 sensor is with minimal effort and especially appropriate for air quality monitoring applications. The sensor is associated with the Raspberry pi 3B+, at that point dissected by Python language, and afterwards displayed on a monitor screen to comprehend the air nature of a specific area. The proposed system gives ease, low force, a conservative and exceptionally precise framework for observing the different parameters of the environment.

From Figure 1, the MQ135 sensor is connected to the Raspberry Pi 3B+ with sufficient power
Figure 2. System setup with LCD

supply. This will be connected to an IoT device. As the outputs obtained from the Raspberry pi are digital, we have used an MCP3008 Analog-to-Digital converter (ADC). LCD connections are made accordingly. When the code is analyzed using python language, outputs will be displayed on the monitor screen and the LCD. Graphs are obtained by calculating moving averages.

5. Implementation
Connections between MQ135 sensor, raspberry pi and LCD are made as shown in Figure 2

5.1. Moving averages
A moving average also called a rolling or running average. From a complete dataset, different subsets are taken and their averages are calculated to analyze the time-series data. As the datasets average over time is taken, it is also defined as moving mean or rolling mean.

5.1.1. Simple Moving Average (SMA)
For a set of periods to calculate the average, SMA uses sliding window. It is the mean weight average of the previous n data with equal weights. Old data will be discarded when new data is added.

5.1.2. Cumulative Moving Average (CMA)
In CMA all the previous data will be taken into consideration. It takes the average of all the previous data until the present data. It is not that good technique to observe changes and smooth the data.

5.1.3. Exponential Moving Average (EMA)
In EMA, it gives more priority to the recent data. So that it becomes the better technique to observe the changes in data trends than those in SMA and CMA. It is directly related to the data pattern.

6. Experimental results and analysis
By referring the air quality ranges shown in Table 1, we monitored the values in LCD as shown in Figure 3. In our project, when the outputs were displayed the data is collected and stored. We have calculated different moving averages with our output data. Here, Python language
Table 1. WHO recommended levels of pollutants [10]

| Name of the Pollutant       | Limit Value (ppm) |
|-----------------------------|-------------------|
| Nitrogen Dioxide (NO₂)     | 0.21 (24 hr)      |
| Sulphur Dioxide (SO₂)      | 0.02 (24 hr)      |
| PM2.5 [11]                 | 0.025 (24 hr)     |
| PM10 [11]                  | 0.050 (24 hr)     |
| Ozone (O₃)                 | 0.1 (8 hr)        |
| Carbon Monoxide (CO)       | 9 (8 hr)          |
| Carbon Dioxide (CO₂)       | 1000              |

is used to analyze them. Various graphs are obtained to differentiate Simple, Cumulative and Exponential moving averages with varying window sizes and intervals.

It is observed from Figure 4 and Figure 5 that the nature of the EMA means that it turns faster than the SMA. So choosing one over the other depends on what it will be used for. The key difference is the SMA weights all inputs equally and the EMA gives greater weight to recent inputs. From Figure 6, it is noted that a particular point both Cumulative and Exponential moving averages varies similarly with a slight variation.
7. Conclusion
From the graphs obtained by calculating moving averages, we have concluded that it is useful to separate out random variations. It is easy to understand and compute. These are used for forecasting data, goods or commodities with constant demand, where there is slight trend or seasonality. It gives constant forecasts. It can be used in an area where air pollution levels are considerably high. At a place where contamination levels are more than the standard levels, this method is performed to identify the pollutants. A website may also be developed to continuously monitor the changes in contamination values of the pollutants so that the authorities may take required measures to reduce the amount of pollution. As each molecule has its own features, it would be difficult to collect the data of each gas and recording the continuous change of data values which changes depending upon the environment.

8. Future work
The sensor (MQ135) used in our work, can also be used in diverse types of applications. Few of them are drones, air quality monitoring devices, vehicles etc, so that the pollution level may be detected very early and can be controlled easily to save the environment.
References

[1] Jagriti Saini, Maitreyee Dutta, and Gonçalo Marques. A comprehensive review on indoor air quality monitoring systems for enhanced public health. *Sustainable Environment Research*, 30(1):6, 2020.

[2] Somansh Kumar and Ashish Jasuja. Air quality monitoring system based on iot using raspberry pi. In *Proceedings of International Conference on Computing, Communication and Automation (ICCCA)*, pages 1341–1346. IEEE, 2017.

[3] Bisnita Sahoo, Alanksha Maharana, Mayank Murali, Lavanya Shivani, G Suganya, and M Premalatha. Low-cost air sensing system. In *Proceedings of 3rd International Conference on Computing and Communications Technologies (ICCT)*, pages 258–267. IEEE, 2019.

[4] Indranil Banerjee, Rajarshee Naskar, Kamelia Deb, Debjan Saha, Sanchari Bhattacharjee, and Deb Kumar Roy. Advanced air quality monitoring system using raspberry pi. In *Proceedings of International Conference on Opto-Electronics and Applied Optics (Optronix)*, pages 1–4. IEEE, 2019.

[5] Gagan Parmar, Sagar Lakhani, and Manju K Chattopadhyay. An iot based low cost air pollution monitoring system. In *Proceedings of International Conference on Recent Innovations in Signal processing and Embedded Systems (RISE)*, pages 524–528. IEEE, 2017.

[6] Kavi Kumar Khedo and Vishwakarma Chikhooreeah. Low-cost energy-efficient air quality monitoring system using wireless sensor network. In *Wireless Sensor Networks-Insights and Innovations*. IntechOpen, 2017.

[7] B Sivasankari, CA Prabha, S Dharini, and R Haripriya. Iot based indoor air pollution monitoring using raspberry pi. *International Journal of Innovations in Engineering and Technology*, 9:16–21, 2017.

[8] A Mari Kirthima and Aravind Raghunath. Air quality monitoring system using raspberry pi and web-socket. *International Journal of Comput. Appl*, 975:8887, 2017.

[9] John H Seinfeld and Spyros N Pandis. *Atmospheric chemistry and physics: from air pollution to climate change*. John Wiley & Sons, 2016.

[10] Priya Venkatesan. Who report: air pollution is a major threat to health. *The Lancet Respiratory Medicine*, 4(5):351, 2016.

[11] Abderrahim Nemmar, Jsrn A Holme, Irma Rosas, Per E Schwarze, and Ernesto Alfaro-Moreno. Recent advances in particulate matter and nanoparticle toxicology: a review of the in vivo and in vitro studies. *Bio Medical research international*, 2013, 2013.