International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 3, pp 307-313, March-2025

https://doi.org/10.47001/IRJIET/2025.903044

Evaluating the Impact of IoT Sensors placement on Air Quality Detection Accuracy

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***Abstract* - The proliferation of Internet of Things (IoT) sensors has revolutionized air quality monitoring, enabling real-time detection of pollutants. However, the accuracy of air quality detection is heavily influenced by the placement of IoT sensors. This study investigates the impact of IoT sensor placement on air quality detection accuracy, with a focus on identifying optimal deployment strategies. Using a combination of simulations, field experiments, and machine learning algorithms, we evaluate the effects of sensor placement on air quality detection accuracy. Our results show that strategic placement of IoT sensors can significantly improve detection accuracy, while suboptimal placement can lead to inaccurate readings. This research provides valuable insights for policymakers, urban planners, and environmental monitoring agencies, highlighting the importance of careful IoT sensor placement in air quality monitoring applications. Our findings have significant implications for the development of smart cities and the mitigation of air pollution- related health risks.**

Keywords: ESP 8266, Gas Sensors, Wi-fi, Internet of Things.

I. INTRODUCTION

Air quality has worsened over the years due to rising emissions from vehicles industries and burning activities the who reports over four million annual deaths from air pollution-related diseases with numbers increasing due to covid-19 air pollution exacerbates respiratory issues raising the risk of severe covid-19 cases and deaths studies show links between air pollution and covid-19 severity one study found that a 1 gm increase in raised the covid-19 mortality rate by another detected sars-cov-2 in particles suggesting pollutants might aid virus transmission if confirmed air quality monitoring will be vital to controlling the pandemic.

Think of it as a personal air quality detective, always on the job. These sensors can measure pollution levels and send real-time updates right to your phone. It's like having a tiny guardian angel, keeping an eye on the air you breathe. The best part? This isn't just for techies or big corporations. Anyone can use it – from schools and hospitals to homes and workplaces. It's a powerful tool that can help us build smarter, healthier cities. During the pandemic, this kind of technology could have been a lifesaver.

By understanding the air quality in our surroundings, we could have taken extra precautions to protect ourselves and our loved ones. They're also fine- tuning their system to make it even more reliable and user-friendly. It's exciting to see how technology can make a real difference in our lives. By empowering us with information, we can take control of our health and our environment.

II. GOALS OF RESEARCH

The below are the main key factors that are to be concerned:

- Assessing the data and taking required actions.
- Getting a knowledge on the placement of the sensor's location and the changes it actually requires.

Forming an opinion on effectiveness of sensors for monitoring air quality in urban areas researchers employ a rigorous experimental approach under controlled conditions these experiments systematically investigate various aspects of sensor performance key areas to be focused include data transmission evaluating reliability and efficiency of different communication protocols used to send sensor data environmental influence analysing how factors like temperature humidity and precipitation impact sensor accuracy and stability sensor positioning determining optimal placement strategies to ensure accurate and representative air quality measurements within urban environments calibration developing and testing calibration methods to maintain consistent and accurate sensor readings over time through these controlled experiments researchers gain valuable insights into the strengths and limitations of IoT sensors for urban air quality monitoring this knowledge is crucial for optimizing design improving data ultimately enhancing our ability to effectively manage it.

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III. RELATED WORK

The need for air quality monitoring networks stimulates the development of systems devices and techniques for measuring and analyses the concentrations of air pollutants as part of the work this section presents state-of-the-art research on the object of study that will be presented below. The application that is in the cloud receives the MQTT packages extracts the data collected by the sensors and stores them in a time series database a service was also implemented to make information available on a web interface using the application.

The availability of information in real time is not enough to minimize the possible damage to health it is necessary to implement informative notifications and alerts when the concentrations of pollutants exceed the acceptable limits the hardware design is compact and the device has an elegant design which appears to be a product ready for large scale production and commercialization. The evidence that the proposed device is accurate in its measurements can be seen in the sensor calibration methodology that has been described and, in the results, presented the monitoring platform was designed for the device to collect sensor data the system was designed. To reduce energy consumption both for terrestrial and spatial monitoring energy consumption is controlled by the server that manages the devices that can act to request more measurement data when the concentration is high or increases the time to send information when conditions are favourable allowing the IoT device to operate in idle mode with minimal energy consumption. Perhaps due to the premise of low energy consumption sensors were not shipped to monitor other pollutants harmful to health leaving the solution limited to monitoring only two pollutants.

IV. MONITORING OF AIR QUALITY

Imagine living in a world where you can't breathe easy. Where the air you inhale is a silent threat, slowly chipping away at your health. That's the reality for millions of people living in cities choked by pollution. Air pollution is a sneaky enemy. It doesn't announce its arrival with a drumroll. Instead, it creeps into our lives, causing a range of health problems, from asthma to heart disease. And now, with the added threat of COVID- 19, the stakes are even higher. But what if we could fight back? What if we could equip ourselves with the knowledge to protect ourselves and our loved ones? That's where air quality monitoring comes in. It's like having a watchful eye on the environment, keeping track of the invisible pollutants that could harm us. By setting up a network of sensors in cities, we can get a real-time picture of the air quality in different neighbourhoods. With this information, we can make informed decisions. We can avoid areas with high pollution levels, especially during peak hours.

We can choose routes that are less polluted. And we can even take steps to improve the air quality in our own homes. But the benefits of air quality monitoring go beyond individual health. It can also help policymakers make better decisions about urban planning and transportation. By identifying pollution hotspots, cities can take steps to reduce emissions and create healthier environments for everyone.

Air quality monitoring can help cities identify pollution hotspots, implement targeted solutions, and create healthier, more sustainable urban environments. It's a powerful tool that can help us protect our planet and safeguard our future.

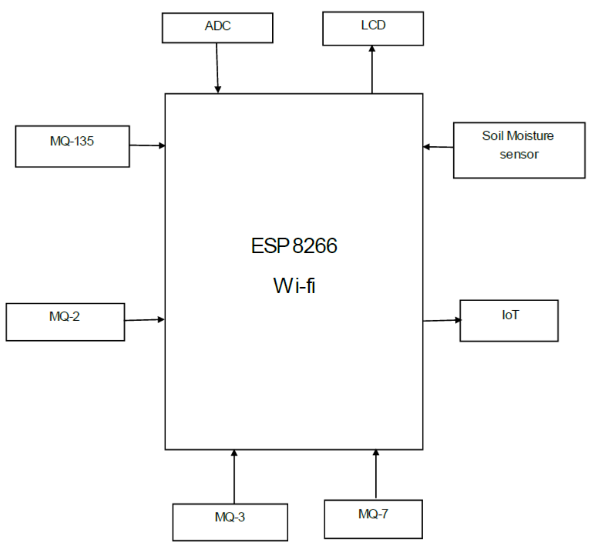
V. LITERATURE REVIEW

- Using IoT sensors to monitor urban air quality.
- Obstacles in the Monitoring of Urban Air Quality.
- The impact of Environmental Factors on Sensor Performance.
- Positioning of sensors and variability of data.
- Reliability of data transmission methodologies.

VI. ADVANTAGES OF USING SENSORS

- Continuous Monitoring.
- Remote Data Access.
- Scalability.
- Affordability.
- Actionable Insights.
- Reliability.
- Accuracy.
- Safety and Compliance.
- Energy Saving.
- Environmental Monitoring.

VII. BLOCK DIAGRAM



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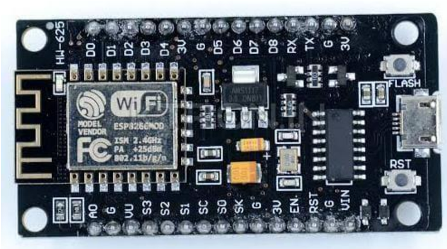
VIII. COMPONENTS

The major and key factor that contribute to the overall performance of the device is choosing of correct components. So, one need to be very clear and defined towards the required action and based on that one can choose the components. To get the required output in a efficient way the developer needs to use the perfect components with less rate of error. Not only using the good components one need to make sure that he shouldn't give scope for errors to take place at any cost.

An ADC is like a translator that takes that smooth line and converts it into a series of numbers that a computer can understand and process. In other words, it can also be defined as the device which converts the analog signal into digital signal. In today's digital world, ADCs are crucial components in many electronic devices. They allow us to interface with the real, analog world and process information digitally.

8.1 Wi-fi Module



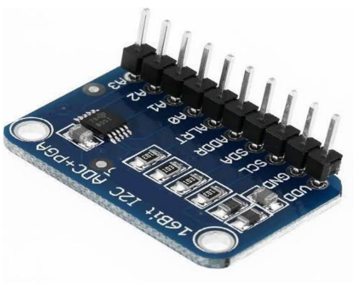
The ESP8266 is a versatile and cost- effective solution for adding Wi-Fi connectivity to various projects. Its affordability, ease of use, and wide range of applications have made it a popular choice in the world of electronics and the Internet of Things.

Key features:

- Wi-Fi Connectivity.
- Microcontroller Functionality.

8.2 ADC

ADC stands for Analog-to-Digital Converter



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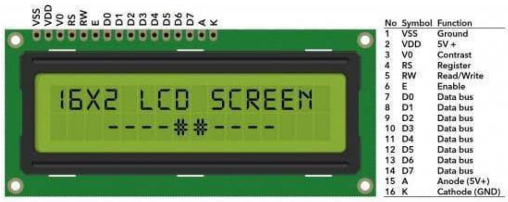
Key features:

- Resolution.
- Sampling Rate.

8.3 LCD

LCD stands for Liquid Crystal Display



LCDs work on the passage of light through liquid crystals. By controlling the alignment of the liquid crystals using electric fields, the display can selectively block or allow light to pass through, creating the visual image. It is very helpful for a user to have a better understanding about the output which he can actually look into through the LCDs.

Key features:

- Low power consumption.
- Flat-panel display.

8.4 MQ-135

The MQ-135 is a popular gas sensor used for detecting various air pollutants. The MQ-135 is a valuable tool for detecting various gases in the air. The main working of this gas sensor is, it has a semi-conductor material that changes its electrical resistance when exposed to certain gases. The change in resistance is measured and converted into an electrical signal, allowing for the detection and quantification of the presence of gases.

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Sensitive to:

- Ammonia (NH3)
- Sulphides
- Benzene
- Smoke
- Alcohol
- Carbon Dioxide (CO2)

8.5 MQ-2

The MQ-2 is a popular and low-cost gas sensor used to detect various combustible gases in the air. The MQ-2 is a widely used gas sensor due to its low cost and ability to detect various combustible gases.

Sensitive to:

- LPG (Liquefied Petroleum Gas)
- Methane (CH4)

8.6 MQ-3

The MQ-3 is a type of gas sensor specifically designed for detecting alcohol vapor.

Sensitive to:

- Alcohol vapour (especially ethanol).

8.7 MQ-7

This MQ-7 is specifically designed for detecting Carbon Monoxide (CO). It is a crucial component in CO detectors, helping to safeguard lives from the dangers of carbon monoxide poisoning.

Sensitive to: CO

IX. RESULT

Evaluating the impact of IoT sensor placement on air quality detection accuracy is a critical task, as the placement of sensors can significantly influence the data collected and, consequently, the quality of air quality assessments.

9.1 Sensor Placement Criteria

- Environmental Factors: The location of the sensor in relation to potential sources of pollutants (such as industrial areas, roads, or trees) matters. Sensors located near traffic will likely register higher concentrations of particulate matter (PM), nitrogen oxides, and carbon monoxide.
- Height and Exposure: Sensors placed at different heights (ground level vs. elevated locations) can yield varying readings. For instance, sensors placed at ground level might capture more local pollution, while sensors on higher ground could provide a broader picture of air quality.
- Spatial Distribution: Deploying sensors at multiple sites across an area (urban, suburban, and rural) helps capture variations in air quality. A single sensor in a specific location might miss crucial air quality fluctuations occurring elsewhere in the area.

9.2 Accuracy vs. Cost/Deployment Efficiency

- Calibration: Sensors need to be calibrated regularly. Sensor drift and environmental interference can affect accuracy, so the positioning strategy should account for ease of access for maintenance.
- Redundancy and Overlap: Overlapping sensor coverage in densely populated or high-risk zones could increase reliability and detection accuracy by ensuring that data anomalies can be cross-checked.
- Network Size: The more sensors you deploy, the higher the likelihood of detecting variations in air quality, but cost and infrastructure will be factors to balance with sensor precision.

9.3 Data Interpretation

- Interference Factors: Placement near heat sources, HVAC systems, or other equipment can lead to sensor interference. It's crucial to account for factors that may skew readings.
- Microclimates: Air quality can vary even in small geographical areas due to wind patterns, temperature, and terrain. Understanding local microclimates and

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adjusting sensor placement accordingly can significantly impact the accuracy of air quality data.

- Real-time vs. Long-term Measurements: If your objective is real-time monitoring, the placement will need to ensure constant, uninterrupted data flow. For long-term assessments, you may want a more diverse spread of data over extended periods.

9.4 Statistical Methods for Evaluation

Place	MQ-2	MQ-3	MQ-7	MQ-135	Soil Moisture
P-1	518	153	57	250	54
P-2	805	218	157	148	98
P-3	15,321	487	1,871	127	154
P-4	377	150	220	143	21
P-5	750	348	121	97	45

- Comparison of Data from Different Locations: By comparing air quality data from sensors placed at various locations (e.g., urban vs rural, or near a highway vs residential areas), you can assess the influence of placement on the accuracy of the readings.
- Calibration and Error Assessment: Statistical tools such as regression analysis, error propagation models, and machine learning algorithms can be used to analyse how sensor location affects the accuracy of measurements.
- Cross-referencing with Standards: Comparing IoT sensor data with reference- grade monitoring stations can help establish an accuracy benchmark. Sensors with greater spatial variability might be less reliable unless calibrated or cross-verified regularly.

9.5 Practical Application

- Dense Urban Areas: High pollution levels may require sensors placed closer to traffic, industrial zones, and other high-emission areas, but a balanced distribution will give a more comprehensive view.
- Rural or Remote Locations: Fewer sensors might be needed, but strategic placement in agricultural or natural areas is important to understand background air quality or identify specific pollution sources.

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