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Original Article

Design and Development of Web Application Using AI Based Sensors for Improving Air Quality Index

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Abstract - *This paper presents a Web-based platform for monitoring air quality that consists of a web server and the "Smart-Air" Air quality sensor. This platform uses cloud computing and the Internet of Things to track air quality everywhere, at any time, through seamless connectivity and powered AI through an LTE modem. Based on IoT technology, Smart-Air was created to effectively monitor air quality and send data to a web server through LTE in real time. A microprocessor, sensors for pollutant detection, and an LTE modem make up the device. In order to monitor the quality of the air, the research equipment was created to detect the concentration of aerosol, VOC, CO, CO_2, Particulate Matter, SO_2, NO_2, and temperature-humidity. The device was then successfully reliability tested by adhering to the Pollution Control Board's recommended protocol. In order to identify and visualise air quality in accordance with the Pollution Control Board and regulatory standards, Ubiquitous computing has also been integrated into a web server for data analysis from the device. To aid in tracking the air quality, an app was created. Consequently, authorised staff can use the web server or the application to check the air quality at any time and from anywhere. Artificial Intelligence (AI) plays a significant role in improving the Air Quality Index (AQI) through various applications and processes. The backend server stores all data which is accumulated from different sources and provides resources for further analysis of indoor air quality.*

Keywords - *Web server, LTE modem, Artificial Intelligence, Air Quality Index, Sensor.*

1. Introduction

These days, air pollution is a serious issue. Air pollution results from an undesired substance, contaminant, or agent being present in the air. The Air Quality Index, or AQI, is used to describe the air around us. The government uses a figure called the Air Quality Index (AQI) to inform the public about the state of the air. It was known as the Pollution Standards Index (PSI) before being renamed as AQI [1]. The higher the AQI, the air pollution is the more serious. the body feels more uncomfortable [2, 3]. Pollutant concentration rises together with a decline in air quality. For average people, the Air Quality Index measures how bad the pollution is. AQI provides valuable information about the quality of the air we breathe. Poor air quality can have serious health effects, especially for vulnerable populations such as children, the elderly, and individuals with pre-existing respiratory or cardiovascular conditions. Monitoring AQI helps people make informed decisions to protect their health, such as staying indoors on days with high pollution levels or using masks when necessary. Monitoring AQI helps track the impact of various pollutants on the environment. Poor air quality can harm ecosystems, damage vegetation, and contribute to acid rain. It can also harm aquatic ecosystems when pollutants like nitrogen oxides and sulphur dioxide are deposited into water bodies. Many countries and regions have established air quality standards and regulations to limit pollutant concentrations in the air. The AQI is used to assess compliance with these standards. Governments can use AQI data to identify areas with persistent air quality problems and develop policies and regulations to improve air quality.

The AQI is a simple and easy-to-understand tool that can raise public awareness about air pollution [4, 5]. Providing a clear and standardized way to communicate air quality information encourages individuals and communities to take action to reduce pollution and protect their health. Poor air quality can have significant economic consequences. It can lead to increased healthcare costs due to the treatment of pollution-related illnesses and decreased worker productivity. Monitoring AQI can help governments and businesses assess the economic impact of air pollution and take steps to mitigate it. In cases of severe air pollution events, such as wildfires or industrial accidents, the AQI can provide critical information for emergency response efforts. It can help authorities make decisions about evacuations, public health advisories, and the deployment of resources to protect public safety. According to the American Lung Association, air pollution-related diseases cost the United States about 37 billion dollars per year [6].

Scientists and policymakers use AQI data to conduct research on air quality trends, identify sources of pollution, and assess the effectiveness of pollution control measures. This information is crucial for developing evidence-based policies to reduce air pollution and its associated health and environmental risks.

2. What is the Air Quality Index (AQI)?

These days, air pollution is a serious issue. Air pollution results from an undesired substance, contaminant, or agent being present in the air. The Air Quality Index, or AQI, is used to describe the air around us. The government uses a figure called the Air Quality Index (AQI) to inform the public about the state of the air. Pollutant concentration rises together with a decline in air quality. For average people, the Air Quality Index measures how bad the pollution is.

2.1. Indian AQI Range & Probable Impacts

0–50: According to this scale, high air quality has little to no negative effects on health.

51–100: This range of acceptable air quality can cause impacts like respiratory difficulties in vulnerable people.

101–200: This range exhibits intermediate air quality, which can have negative effects on persons with heart and lung conditions, children, the elderly, and those who already have breathing problems.

When the AQI falls at this level, it indicates that the air is of poor quality and that prolonged exposure to it can have negative health consequences on individuals. People with existing heart conditions may feel discomfort after brief exposure.

301–400: Exposure to the air in this range for an extended period of time results in respiratory sickness due to the extremely poor air quality.

401–500: The extreme range Real-time AQI monitoring of a city makes the people more concerned about the environment in which they are living and thus makes them avoid or minimize the use of pollutants in the air [10].

2.2. Air Quality Index Parameters

2.2.1. Particulate Matter (PM10 & PM2.5)

Particulate matter is made up of liquid droplets and airborne particles. PM 10 refers to particles that are less than or equal to 10 microns in size, while PM2.5 refers to ultra-fine particles that are less than or equal to 2.5 microns in size. Construction, smoking, cleaning, remodelling, demolition, natural disasters like earthquakes and volcanic eruptions, and emissions from companies like brick kilns, paper and pulp, etc. All emit particulate matter into the air.

2.2.2. Carbon Monoxide

It is a colourless gas that is emitted into the atmosphere as a result of car emissions, fires, industrial activities, gas stoves, kitchen chimneys, generators, smoking from wood burning, etc.

Both the Indian government and the US EPA use it as an AQI criterion. According to the US-EPA and the Indian government, the safe threshold of exposure is 0-9.4 ppm at 8 hours and 0-0.04 mg/m3 after one hour.

2.2.3. Ozone (O_3)

Three oxygen atoms make up the compound ozone. It creates a shield that stops dangerous UV rays from reaching the earth. The environment and people are greatly harmed by ground ozone. Various sources, including businesses, cars, petrol fumes, chemicals, and electrical equipment, give it off. Ground ozone generation is additionally aided by the formation of Nitrogen Oxides (NOx) and Total Volatile Organic Compounds (tVOCs).

2.2.4. Nitrogen Dioxide (NO_2)

One well-known highly reactive gas found in the environment is nitrogen dioxide. Automobile emissions, energy production, fuel combustion, fossil fuel combustion, and other industrial operations all release it into the atmosphere.

Table 1. Safe exposure limits

Indian AQI	Indian Range (24 hr)		US AQI	US-EPA Range (24 hr)	
	PM10 (ug/m3)	PM2.5 (ug/m3)		PM10 (ug/m3)	PM2.5 (ug/m3)
0-50	0-50	0-30	0-50	0-54	0-12.0
51-100	51-100	31-60	51-100	55-154	12.1-35.4
101-200	101-250	61-90	101-150	155-254	35.5-55.4
201-300	251-350	91-120	151-200	255-354	55.5-150.4
301-400	351-430	121-250	201-300	355-424	150.5-250.4
401-500	430+	250+	301-500	425-604	250.5-500.4

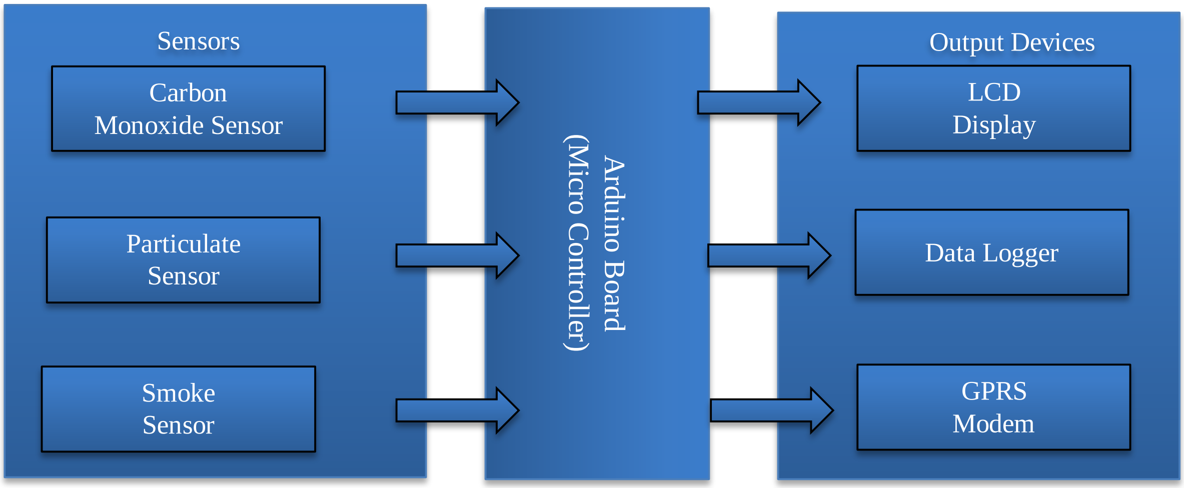

Fig. 1 Components of IOT AQI system

2.2.5. Sulfur Dioxide (SO_2)

A colourless gas with a burnt smell, sulphur dioxide has the chemical formula SO_2. The gas can combine with other substances in the atmosphere to produce sulfuric acid and other oxides of sulphur since it has an acidic and corrosive tendency. Sulphur dioxide enters the atmosphere as a result of emissions from vehicles, businesses, the burning of fossil fuels, the production of electricity, etc.

2.2.6. Ammonia (NH_3)

The Indian government is the only one to employ the colourless, reactive, soluble, and alkaline gas ammonia as a measurement of AQI. Agriculture, animal husbandry, fertilisers, different industrial operations, automotive emissions, volatilization from oceans and soil, etc. are the main sources of ammonia.

2.2.7. Lead (Pb)

Heavy metal group member lead is a blue-white lustrous metal. It is corrosive and robust by nature, but when exposed to air, it tarnishes fast. It is released through the processing of metal, the burning of garbage, the burning of fossil fuels, the burning of used batteries, automobile emissions, the burning of fossil fuels, etc. According to the Indian CPCB, 0-1.0 ug/m3 (24 hours) is the safe lead exposure threshold.

Figure 1 shows the sensors used to measure the air quality using IOT.

The formula to calculate AQI is the same as per the Indian CPCB and US-EPA.

$$Ip = [IHi – ILo / BPHi – BPLo] (Cp – BPLo) + ILo$$

3. Long Term Evolution Modem to Measure AQI

Using an LTE (Long-Term Evolution) modem to measure the Air Quality Index (AQI) is a feasible approach, particularly for remote monitoring applications where internet connectivity is not readily available through traditional means.

3.1. Air Quality Sensors

- Select appropriate air quality sensors to measure key pollutants like PM2.5, PM10, Carbon monoxide (CO), Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Ozone (O_3).
- Ensure the sensors are reliable and capable of providing accurate and precise measurements.

3.2. Data Logger

Connect the air quality sensors to a data logger or microcontroller (e.g., Arduino, Raspberry Pi) capable of collecting data from the sensors. Program the data logger to continuously read data from the sensors and store it locally.

3.3. LTE Modem

Choose an LTE modem or cellular module compatible with the chosen microcontroller or data logger. Ensure that the modem supports the LTE frequency bands used in your region or area of deployment.

3.4. Data Transmission

Develop software to transmit the air quality data from the data logger to a remote server using the LTE modem's cellular connection. Use MQTT (Message Queuing Telemetry Transport) or HTTP(S) protocols for data transmission, depending on your server setup.

3.5. Remote Server

Set up a remote server or cloud-based platform to receive, store, and process the air quality data.

Implement a database to archive historical data for analysis and reporting.

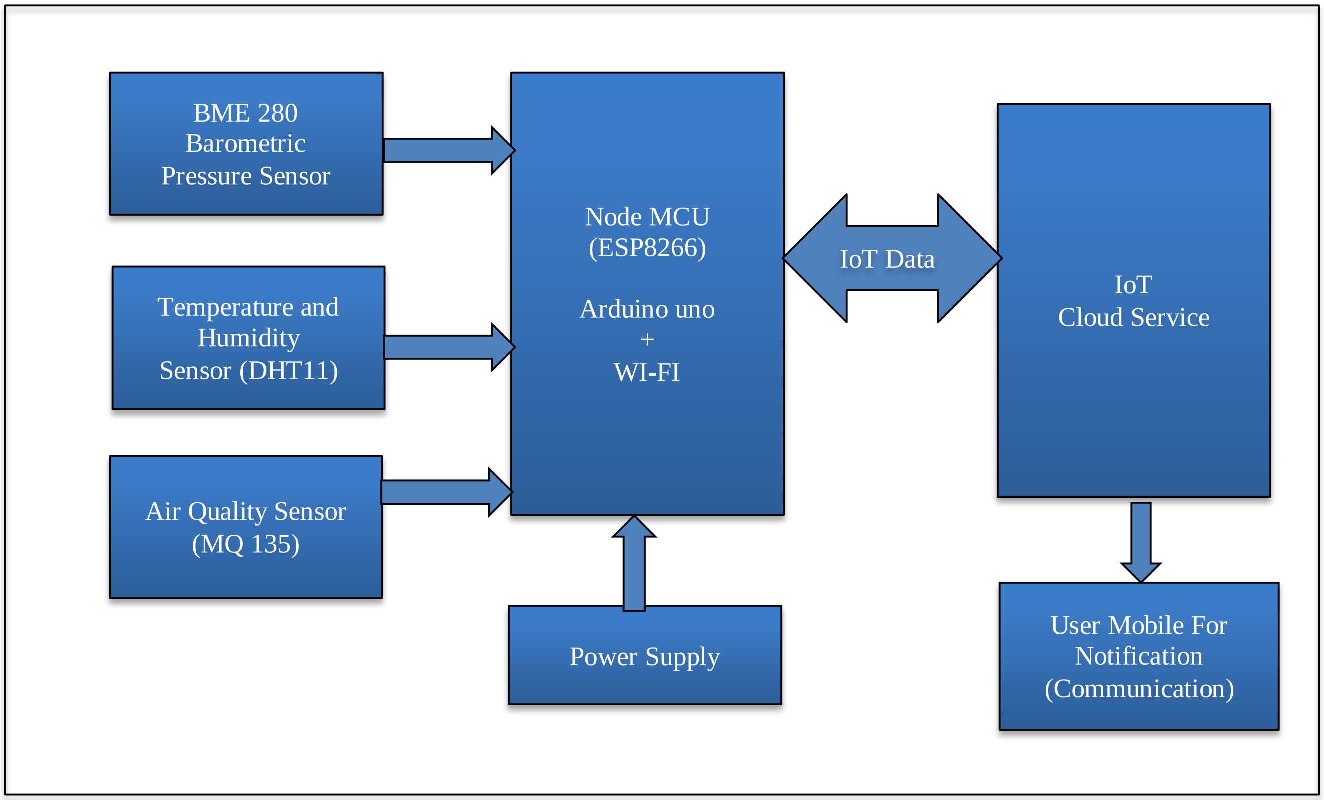

Fig. 2 Overview of AI-IOT web application components

3.6. Data Analysis and AQI Calculation

Develop algorithms to process the raw sensor data and calculate the AQI based on local air quality standards and guidelines. Ensure that the AQI calculations take into account the specific pollutants being measured and their corresponding concentration levels.

3.7. Visualization and Reporting

Create a web-based or mobile application for users to access real-time air quality data, historical trends, and AQI values. Develop data visualization tools such as graphs, charts, and maps to present the information in a user-friendly way. Implement an alerting system to notify users or authorities when AQI levels exceed predefined thresholds or when there are significant changes in air quality. Use email, SMS, or push notifications for disseminating alerts.

Ensure a stable power supply for the entire system, including the LTE modem, data logger, and sensors. Consider using backup power sources like batteries or solar panels for remote locations.

3.7.1. Maintenance and Calibration

Regularly calibrate and maintain the air quality sensors to ensure accurate measurements. - Monitor the system's connectivity and functionality to address any issues promptly. Ensure that the LTE system complies with relevant regulations and standards for air quality monitoring. - Implement data security measures to protect sensitive air quality data during transmission and storage.

3.7.2. User Interface and Access

Create user-friendly interfaces for accessing air quality data and provide appropriate access permissions for different user groups (e.g., public, government agencies, researchers). Make the air quality data available to the public or relevant authorities for transparency and decision-making.

Figure 2 shows the Overview of components used in the AI-IOT web application. By following these steps, you can set up an LTE-enabled air quality monitoring system that provides real-time AQI data and helps raise awareness, support decision-making, and protect public health in areas with limited internet connectivity.

4. Sensors to Measure AQI

Sensors used to measure Particulate Matter (PM) in the air for Air Quality Index (AQI) monitoring typically rely on various technologies to detect and quantify the concentration of these fine particles. The two most common types of PM sensors are:

4.1. Light Scattering Sensors (Optical Particle Counters)

- Principle: Light scattering sensors operate on the principle that when particles pass through a beam of

light, they scatter the light in different directions. The amount of light scattered is proportional to the size and concentration of the particles.
- Operation: A light source (usually a laser or LED) emits a beam of light into the air sample. Particles in the air pass through this beam, and detectors measure the scattered light. By analyzing the scattering pattern, the sensor can determine the size and number of particles in various size ranges, such as PM1, PM2.5, and PM10.
- Advantages: These sensors provide real-time data and are often used seamlessly.

4.2. Gravimetric Filters (Reference Method)
- Principle: Gravimetric filters are considered a reference method for PM measurement. This technique involves physically capturing particles on a filter and weighing them to determine their mass concentration.
- Operation: Air is drawn through a filter medium (usually a filter paper or membrane) for a specified period. After sampling, the filter is carefully weighed to determine the mass of collected particles. The difference in filter weight before and after sampling provides the PM concentration.
- Advantages: Gravimetric filters are highly accurate and are often used as reference instruments to calibrate other PM sensors.

In addition to these primary methods, there are other emerging technologies for PM measurement, including:

4.3. Beta Attenuation Monitors (BAM)
- Principle: BAM instruments use the attenuation of beta radiation by particles to measure their mass concentration.
- Operation: A beta radiation source emits beta particles through a sample of air. The particles in the air attenuate the beta radiation, and detectors measure the reduction in radiation intensity. This attenuation is used to calculate PM mass concentrations.
- Advantages: BAMs are widely used by regulatory agencies for PM monitoring due to their accuracy and reliability.

4.4. Microbalance Sensors
- Principle: Microbalance sensors use a microbalance to weigh particles in real time as they deposit onto a sensitive surface.
- Operation: Air containing particles pass over a surface, and particles are deposited on the surface. The microbalance measures the change in weight, allowing for continuous monitoring of PM concentrations.
- Advantages: These sensors offer high sensitivity and can detect very low concentrations of PM.

The choice of PM sensor depends on factors such as the application, accuracy requirements, and budget constraints. For regulatory monitoring and research purposes, reference methods like gravimetric filters and beta attenuation monitors are often preferred. However, for real-time monitoring in portable devices and indoor air quality applications, light scattering sensors are commonly used due to their convenience and affordability. Figure 3 is a Sample Block Diagram of AI -IOT AQI Monitoring System with various sensors, AI and cloud platforms.

5. Artificial Intelligence in Improving AQI

Artificial Intelligence (AI) plays a significant role in improving the Air Quality Index (AQI) through various applications and processes.

Data Fusion: AI can integrate data from various sources, including air quality sensors, weather stations, satellite imagery, and traffic data, to provide a comprehensive view of air quality.

Real-time Monitoring: AI algorithms can process data in real time, enabling timely updates of AQI values and forecasts.

5.1. Air Quality Modeling

Machine Learning Models: AI and machine learning algorithms can develop sophisticated air quality models that take into account historical data, meteorological conditions, and pollutant emissions to predict future air quality levels. AI can identify complex relationships between various factors influencing air quality, such as the interactions between different pollutants and weather conditions.

5.2. Early Warning Systems

Predictive Analytics: AI-driven early warning systems can provide alerts to the public and authorities about potential air quality deterioration, helping people take precautions in advance.

5.3. Optimizing Emission Reduction Strategies

5.3.1. Source Identification

AI can help identify and locate pollution sources, including industrial emissions, transportation emissions, and natural sources like wildfires.

5.3.2. Optimization

AI algorithms can optimize emission reduction strategies by recommending the most effective actions to reduce pollution from specific sources or regions.

5.3.3. Data Imputation and Quality Control

Missing Data Handling

AI can impute missing air quality data using statistical methods, ensuring complete and accurate AQI calculations.

Quality Assurance

AI can help identify and flag data anomalies or sensor malfunctions, ensuring the integrity of air quality data.

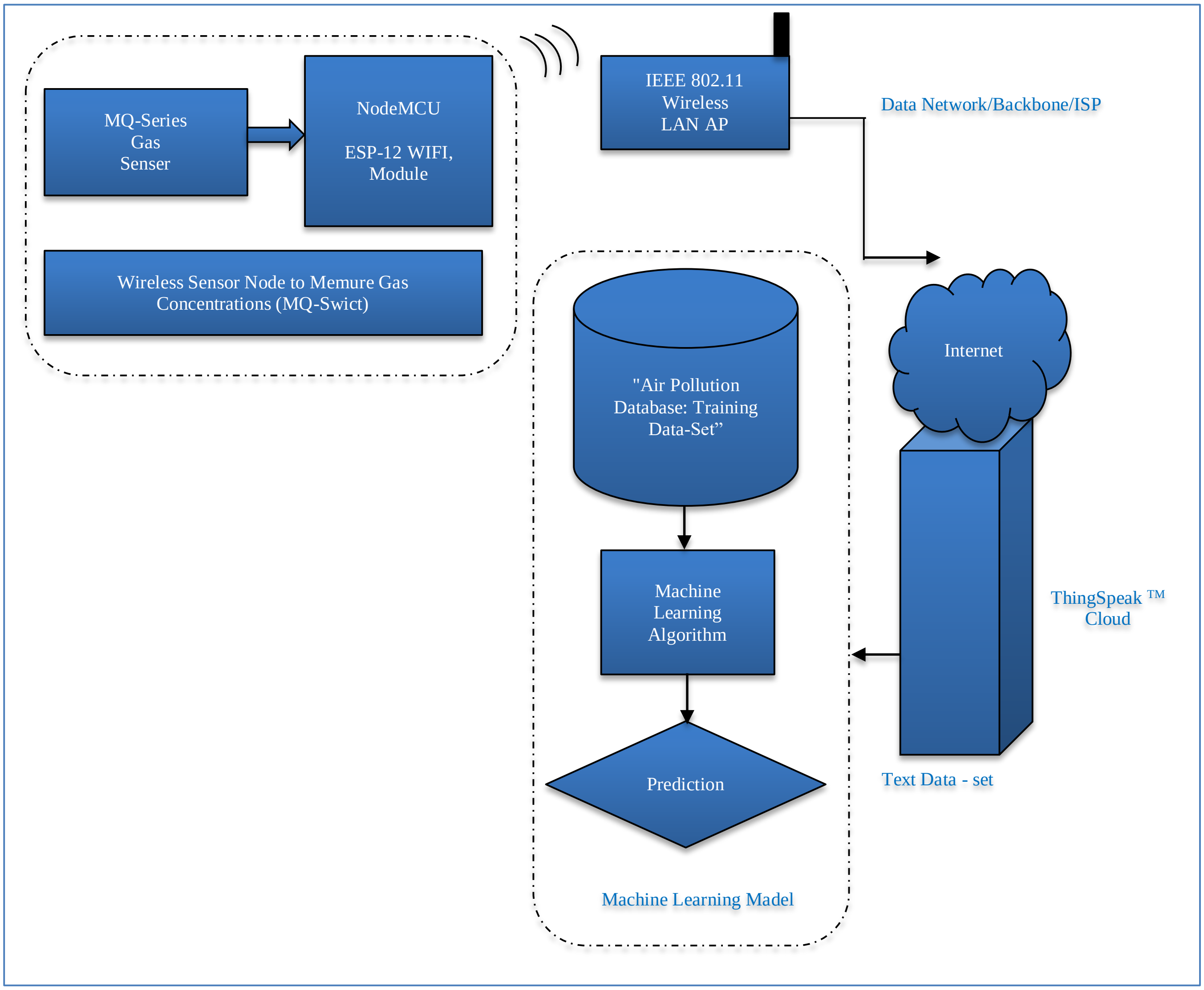

Fig. 3 Sample block diagram of AI -IOT AQI monitoring system

5.3.4. Personalized Air Quality Information

Mobile Apps and Wearables

AI-powered mobile apps and wearable devices can provide individuals with personalized air quality information.

5.3.5. Quality Forecasting

Short-Term and Long-Term Forecasts

AI models can generate short-term and long-term air quality forecasts, helping communities and policymakers plan for pollution events and make informed decisions.

5.3.6. Traffic Management and Urban Planning

Traffic Optimization

AI can optimize traffic flow to reduce congestion and emissions, improving air quality in urban areas.

Urban Design

AI can assist in urban planning by recommending green spaces, reducing industrial emissions in residential areas, and optimizing public transportation routes.

5.3.7. Response to Pollution Events

Emergency Response

AI can assist in emergency response during pollution events, helping authorities allocate resources, evacuate affected areas, and provide healthcare services.

5.3.8. Policy Development and Compliance

Policy Analysis

AI can analyze the impact of air quality policies and recommend data-driven policy adjustments.

Compliance Monitoring

AI can assist in monitoring compliance with air quality regulations and standards.

6. Improving Air Quality Using ML

Improving air quality using machine learning involves leveraging data-driven algorithms and techniques to understand better, predict, and mitigate air pollution.

Data-driven Models: Machine learning models can analyze the backup and interpret the historical data, meteorological data, and pollutant emission data to make accurate short-term and long-term air quality predictions. These predictions can be used to issue timely warnings and plan interventions. The most commonly used approaches to predict air quality were deterministic and statistical methods [8, 9].

6.1. Source Identification and Control

6.1.1. Source Apportionment

Machine learning can help identify pollution sources by analyzing data from air quality sensors and emissions data. This information can inform targeted control measures.

6.1.2. Optimization

ML can optimize emission reduction strategies by recommending the most effective actions for specific pollution sources, industries, or regions.

6.2. Data Fusion and Integration

6.2.1. Multi-Source Data Integration

Machine learning techniques can integrate data from various sources, such as air quality sensors, satellite imagery, and weather stations, to provide a more comprehensive view of air quality.

6.2.2. Continuous Monitoring

Machine learning algorithms can process real-time data from sensors and issue immediate alerts when pollution levels exceed thresholds, enabling rapid responses. ML can predict air quality deterioration events in advance, allowing communities and authorities to take preventive actions. The ANN has become one of the most widely used methods for predicting air quality [7].

6.3. Data Imputation and Quality Assurance

6.3.1. Missing Data Handling

ML algorithms can impute missing air quality data using statistical methods, ensuring complete and accurate AQI calculations.

6.3.2. Anomaly Detection

Machine learning can identify outliers and anomalies in air quality data, which may indicate sensor malfunctions or data quality issues.

6.4. Personalized Air Quality Information

6.4.1. Mobile Apps and Wearables

ML-powered mobile apps and wearable devices can provide individuals with real-time, personalized air quality information and recommendations for reducing exposure.

6.5. Traffic Management and Urban Planning

6.5.1. Traffic Optimization

Machine learning can optimize traffic flow, reduce congestion, and minimize emissions in urban areas by providing real-time traffic data and recommendations.

6.5.2. Urban Design

ML can assist in urban planning by recommending green spaces, reducing industrial emissions in residential areas, and optimizing public transportation routes.

6.6. Air Quality Forecasting

6.6.1. Advanced Models

Machine learning can improve the accuracy of air quality forecasts by developing more complex models that consider multiple variables and historical trends.

6.7. Response to Pollution Events

6.7.1. Emergency Response

ML can assist in emergency response by analyzing real-time data and helping authorities allocate resources, implement evacuation plans, and provide healthcare services during pollution events.

6.8. Policy Development and Compliance

6.8.1. Policy Analysis

Machine learning can analyze the impact of air quality policies and recommend data-driven policy adjustments.

6.8.2. Compliance Monitoring

ML can assist in monitoring compliance with air quality regulations and standards by analyzing large datasets. By harnessing the power of machine learning, air quality monitoring and management can become more precise, proactive, and effective. These AI-driven approaches can help reduce air pollution and its associated health and environmental impacts, ultimately leading to improved air quality and quality of life for communities.

7. Design and Development of Web Based Analyzers

Designing and developing a web-based analyzer for the Air Quality Index (AQI) involves several steps and considerations. Figure 4 shows a Process flow for the Development of a web application for AQI. Determine the specific features and functionalities of the AQI analyzer. Collect air quality data from various sources, including government monitoring stations, sensors, weather data, and satellite imagery. Ensure data quality and reliability by performing data validation and cleaning selection of appropriate technologies for the web-based application, including programming languages, frameworks, and databases. Common choices include Python, JavaScript, Django, Flask, React, and PostgreSQL. Creating a user-friendly and responsive web interface that displays AQI data in a visually appealing manner. Consider the use of maps, charts, graphs, and tables to present data effectively. Designing an intuitive navigation system for users to access different AQI parameters, locations, and time periods. Implementation of algorithms and machine learning models to disseminate air quality data. Calculate the AQI based on pollutant concentrations and other relevant factors. Provide historical trend analysis and predictive capabilities, such as short-term and long-term forecasting. Integrate real-time data from monitoring stations and sensors to provide users with up-to-date AQI information. Implement data streaming or WebSocket communication for live updates. Set up a database system to store historical AQI data, sensor information, and user preferences.

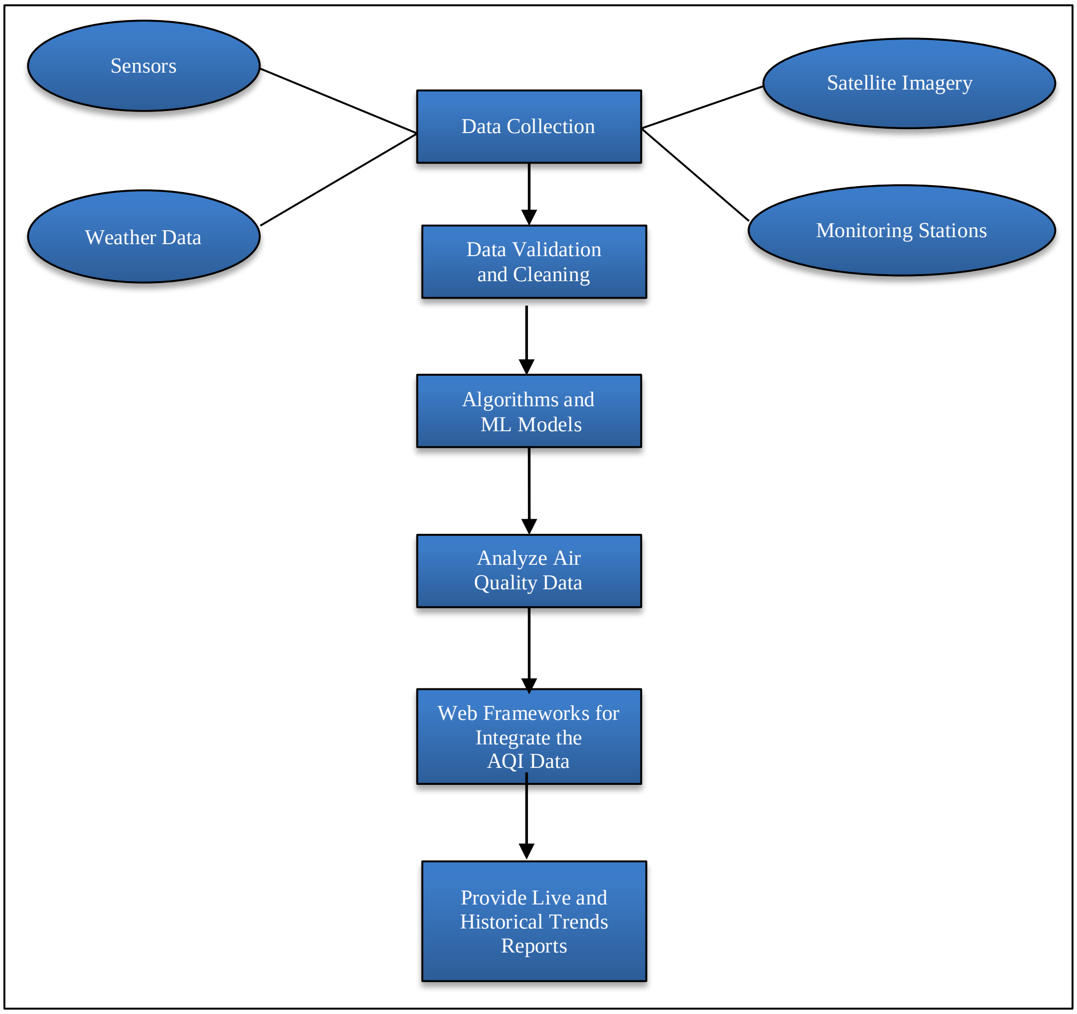

Fig. 4 Process flow for development of web application for AQI

7.1. User Authentication and Security

Implement user authentication and authorization to protect sensitive data. Ensure data security through encryption and secure API endpoints.

7.2. API Development

Create RESTful or GraphQL APIs to facilitate data retrieval and interaction with the application. Implement API endpoints for accessing AQI data, historical records, and forecasting results.

7.3. Visualization and Mapping

Utilize libraries like D3.js, Leaflet, or Mapbox to create interactive maps and data visualizations. Customize visualization components to display AQI values, trends, and geographic distributions. Ensure that the web application is accessible to users with disabilities (compliance with WCAG guidelines). Optimize the design for mobile devices and various screen sizes.

Identify and fix bugs and issues to ensure a robust and reliable application. Deploy the web application on a web server or cloud platform (e.g., AWS, Azure, Heroku). Configure domain names and SSL certificates for secure access. Provide user documentation, help guides, and tooltips to assist users in navigating and using the application effectively. Set up a support system to address user inquiries and issues. Monitor application performance, user feedback, and data quality regularly. Continuously improve the application by adding new features, optimizing algorithms, and ensuring data accuracy.

Ensure that your AQI analyzer complies with relevant air quality regulations and standards set by environmental agencies. Educate users about interpreting AQI values and taking appropriate actions based on air quality levels. Promote the web-based analyzer through outreach and marketing efforts.

8. Conclusion

Air pollution is a major concern these days. The presence of an unwanted thing, contaminant, or agent in the air leads to air pollution. AQI is used to represent the quality of air present around us. Throughout the development process, it is important to involve stakeholders, including environmental experts and potential users, to gather feedback and ensure that the AQI analyzer meets their needs.

Regular updates and maintenance are essential to keep the application accurate and relevant to changing air quality conditions., AI enhances the AQI by improving data collection, analysis, and prediction, enabling better decision-making at individual, community, and governmental levels. It contributes to more effective air quality management, pollution reduction strategies, and public awareness, ultimately leading to better air quality and public health.

References

[1] Jose Antonio Moscoso-López et al., “Hourly Air Quality Index (AQI) Forecasting Using Machine Learning Methods,” *15th International Conference on Soft Computing Models in Industrial and Environmental Applications, Advances in Intelligent Systems and Computing*, vol. 1268, pp. 123-132, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[2] Ma Limei, “Neural Network Stock Forecasting System Based on, Beijing University of Posts and Telecommunications,” 2005.

[3] Ai Hongfu et al., “Forecast of Fog and Haze Based on Bp Artificial Neural Network,” *Computer Simulation*, vol. 1, pp. 402-406, 2015.

[4] Li Fenfen, “The Model of Environmental Air Quality Forecasting and Early Warning System and the Causes of Uncertainty and Improvement,” *Energy and Energy Conservation*, vol. 12, pp. 103-105, 2018.

[5] Zuo Jinxin, “Design and Implementation of Atmospheric Quality Monitoring and Prediction and Early Warning Software,” vol. 8, 2018.

[6] Mauro Castelli et al., “A Machine Learning Approach to Predict Air Quality in California,” *Complexity*, vol. 2020, pp. 1-23, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[7] Chavi Srivastava, Shyamli Singh, and Amit Prakash Singh, “Estimation of Air Pollution in Delhi Using Machine Learning Techniques,” *2018 International Conference on Computing, Power and Communication Technologies*, Greater Noida, India, pp. 304-309, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[8] Xiang Li et al., “Deep Learning Architecture for Air Quality Predictions,” *Environmental Science and Pollution Research*, vol. 23, pp. 22408-22417, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[9] Congcong Wen et al., “A Novel Spatiotemporal Convolutional Long Short-Term Neural Network for Air Pollution Prediction,” *Science of the Total Environment*, vol. 654, pp. 1091-1099, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[10] Sumanth Reddy Enigella, and Hamid Shahnasser, “Real Time Air Quality Monitoring,” *2018 10th International Conference on Knowledge and Smart Technology*, Chiang Mai, Thailand, pp. 182-185, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[11] Hammad Aamer et al., “A Very Low Cost, Open, Wireless, Internet of Things (IoT) Air Quality Monitoring Platform,” *2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT*, Islamabad, Pakistan, pp. 102-106, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[12] You are What You Breathe, Air Quality World. [Online]. Available: https://www.airquality.world/?utm_campaign=oxfordshireairquality&utm_medium=referral&utm_source=old-website

[13] Somansh Kumar, and Ashish Jasuja, “Air Quality Monitoring System Based on IoT Using Raspberry Pi,” *2017 International Conference on Computing, Communication and Automation*, Greater Noida, India, pp. 1341-1346, 2017. [CrossRef] [Google Scholar] [Publisher Link]