

AI-ENABLED IOT SYSTEM FOR SMART AIR QUALITY MONITRING

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Abstract:

Air pollution has become a major environmental concern, significantly affecting human health, ecosystems, and industrial environments. The hardware system uses sensors such as MQ7 for carbon monoxide (CO), MQ135 for air quality gases, a dust sensor for par ticulate matter, and DHT11 for temperature and humidity. These sensors are connected to an ESP8266 microcontroller, which collects real-time environmental data. On the software side, a dataset is created using collected sensor values and processed using Ma chine Learning techniques. The XG Boost algorithm is employed to predict air quality conditions and classify them as normal or abnormal. The system also integrates with Firebase for real -time data storage and visualization enabling remote monitoring. The system also integrates with Firebase for real - time data storage and visualization, enabling remote monitoring. This combined hardware and intelligent software solution provides a cost-effective, real-time, and automated approach to improving air quality management in homes and industrial environments

Keywords — *Bearing Fault Diagnosis, Predictive Maintenance, Vibration Analysis, Convolutional Neural Network (CNN), Bidirectional Long Short-Term Memory (BiLSTM), Hybrid Deep Learning Model.*

Introduction:

- Air quality monitoring is essential for preventing respiratory diseases and environmental hazards.
 - Traditional monitoring systems are expensive and lack intelligent automation features.
 - IoT technology enables real-time environmental monitoring with remote data access.
 - Artificial Intelligence enhances decision-making by analyzing complex environmental patterns.
 - This project integrates IoT and AI to create an automated smart air purification control system.
- Additionally, ventilation or pollution control depends on manual intervention, where users must observe the readings and take action themselves, such as turning on fans or ventilation systems.
 - Another major limitation is the lack of integration between modern Artificial Intelligence (AI) and embedded control systems, which reduces the system's
 - ability to make smart, real-time decisions.
 - Overall, these traditional methods are less efficient, time-consuming, and do not support automation or intelligent environmental control.

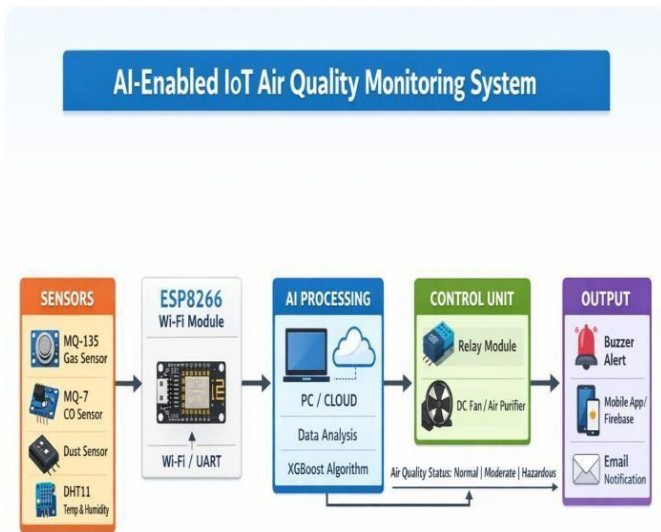
EXISTING METHOD:

- The air quality monitoring mainly relies on conventional systems that use standalone gas detection units to measure pollutants in the environment.
- These systems are typically limited to only monitoring air quality and do not provide any automatic corrective action when pollution levels increase.
- In many cases, especially in industrial setups, air monitoring systems are expensive, complex, and require skilled operation.

PROPOSED SYSTEM:

- Use of MQ-135 to detect harmful gases like NH₃, NO_x, benzene, and smoke.
- MQ-7 sensor to measure Carbon Monoxide (CO) concentration.
- Dust sensor to measure particulate matter levels in air.
- AI model processes sensor data and classifies air quality condition.
- Based on AI output, ESP8266 activates relay driver to control DC fan automatically

Figure:1



READ SENSOR:



MQ-135 GAS SENSOR

1. Sensors → Controller → AI → Control → Output
2. Input → Process → Output
3. Sensors → ESP8266 → AI (PC) → Relay → Fan



MQ -7 CO SENSOR

ESP8266 MICRO CONTROLLER

HARDWARE COMPONENTS:

- ESP8266 Wi-Fi Microcontroller
- MQ-135 Gas Sensor
- MQ-7 Carbon Monoxide Sensor

- Dust Sensor Module
- DHT11 Temperature and Humidity Sensor
- Relay Module and Driver Circuit
- DC Fan
- USB to UART Converter
- Power Supply Unit
- This data is then sent to the ESP8266, which acts as the central controller by processing the sensor inputs and transmitting them to a computer through UART communication.
- On the computer side, an AI-based model receives this multi-parameter data, performs preprocessing, and analyses patterns to understand the air quality condition.
- Based on this analysis, the system classifies the pollution level into categories such as normal, moderate, or hazardous.

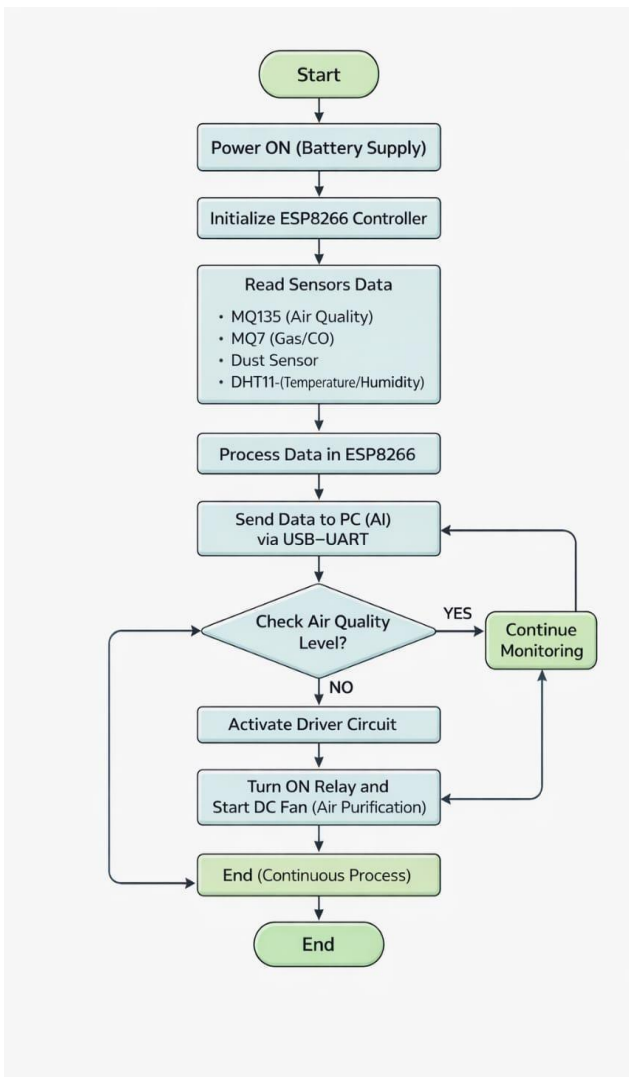
SOFTWARE COMPONENTS:

- Arduino IDE for ESP8266 programming
- Embedded C for firmware development
- Python (3.8 or above)
- VS Code / PyCharm
- NumPy
- Pandas
- Matplotlib
- Scikit-learn
- Py Serial
- SQLite / MySQL
- Flask
- Windows 10 / 11 or Ubuntu Linux
- After classification, a decision signal is generated and sent back to the ESP8266, which then activates a relay module if necessary.
- This relay controls a DC fan that automatically turns on to improve air circulation and reduce pollution levels.
- This entire process operates as a closed-loop system, ensuring continuous monitoring, intelligent decision-making, and automatic corrective action without human intervention.

FLOWCHART:

EXECUTION METHODOLOGY:

- The control process works in a continuous and automated manner. Initially, multiple environmental sensors collect real-time data such as gas concentration, temperature, humidity, and dust levels from the surroundings.



- When pollution exceeds safe levels, the system automatically activates a fan/purifier and triggers a buzzer alert.
- Firebase cloud platform stores data and enables real-time remote monitoring along with email notifications for user awareness.

1. Input side:

- Battery supplies power.
- Sensors (MQ135, MQ7, dust sensor, DHT11) feed data to the ESP8266 microcontroller.

2. Processing:

- ESP8266 processes sensor data and makes decisions.

3. Output side:

- Data is sent to a PC (with AI) via USB-to-UART.
- ESP8266 drives a relay through a driver to control a DC fan for ventilation.

INFERENCE:

- AI-based automation transforms traditional air monitoring into an active, intelligent system by integrating data from multiple sensors for high-accuracy detection.
- This setup enables real-time, autonomous decision-making that significantly reduces the need for human intervention while maintaining safety.

RESULT AND DISCUSSION:

- Real-time air quality data is collected using sensors like MQ7, MQ135, dust sensor, and DHT11 for accurate environmental monitoring.
- The collected sensor data is processed and used to create a dataset for training the machine learning model.
- XG Boost algorithm analyzes the data and predicts air quality as normal or abnormal with good accuracy.

- Because the architecture is cost-effective and scalable, it can be easily adapted to various environments.
- Ultimately, smart ventilation control optimizes energy use and ensures a safer, more stable environment for all occupants.
- The system was tested with different air conditions and produced reliable and consistent results.
- The XG Boost model showed good accuracy in predicting and classifying air quality levels.

Output and system performance:

- The AI-enabled IoT system for smart air quality monitoring uses sensors to measure environmental parameters such as temperature (30–40°C), smoke (70– 90), humidity (40–55%), alcohol gas (0 – 120), and dust levels (200 –400), and sends this data to the ESP8266, where it is transmitted to an AI model for analysis; based on the combined sensor values, the system classifies air quality and automatically activates a fan through a relay if pollution levels exceed safe limits, ensuring real-time monitoring and control.
- Automatic control of fan/purifier worked effectively when pollution exceeded safe limits.
- Alert system (buzzer and email) successfully notified users without delay.
- Overall, the system is cost-effective, efficient, and suitable for real-time air quality monitoring and control.

ADVANTAGE:

- Real-time monitoring – Sensors (MQ135, MQ7, dust, DHT11) continuously measure air quality, temperature & humidity, giving instant feedback to the ESP8266.
- Automated ventilation – When pollution levels exceed a threshold, the ESP8266 triggers the relay & DC fan to improve air quality automatically.
- Alert system – The buzzer warns users of unsafe air conditions, enabling quick action
- Data logging – Sensor data is sent to a PC (AI) via USB-to-UART for advanced analysis, trend tracking & predictive maintenance
- Energy efficient – Battery supply makes the system portable and suitable for off-grid or mobile applications.

FUTURE ENHANCEMENT:

- More advanced and high-precision sensors can be used to improve accuracy of air quality measurement.
- Integration of mobile application for real-time monitoring and instant user alerts.
- Implementation of deep learning models for more accurate and intelligent prediction.
- Solar power system can be used to make the device energy-efficient and eco- friendly.
- Integration with smart home systems for fully automated environmental control.

VALIDATION AND CONCLUSION:

DISADVANTAGE:

- Power dependency – The whole setup relies on a battery supply; if the battery drains or fails, the monitoring and ventilation stop working.
- Sensor limitations – MQ135 & MQ7 need pre-heating & calibration; they can drift or give false readings in varying humidity (DHT11 measures humidity but can't fully compensate for sensor cross-sensitivity)
- Single-point control – Only one relay-driven DC fan is used for ventilation; it may be insufficient for large spaces or severe pollution levels.
- Data transmission bottleneck – USB-to-UART link can introduce latency or loss when sending data to the PC (AI) for analysis, affecting real-time response.
- No redundancy – No backup alert mechanism (e.g., LED or secondary buzzer) if the primary buzzer fails.

APPLICATION :

- Smart cities
- Industrial areas
- Schools and hospitals
- Traffic monitoring zones

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