EnviroGuard

Advanced Indoor Air Quality Monitoring And Purification

Guided By:
Prof Kishore Sebastian

Team Members:
1. Alan Joy
2. Savio Shaji
3. Allwina Anna Soy Jose
4. Anitta Siby

SENSING AND PREDICTIVE ANALYSIS OF INDOOR AIR QUALITY BASED ON INTERNET OF THINGS: A COVID-19 PERSPECTIVE (IRJMETS - 2023)

Key Findings: Accurate prediction of pollutant concentration and air quality. Impressive Metrics: Accuracy (99.37%), Precision (99%), Recall (98%), F1-score (99%).

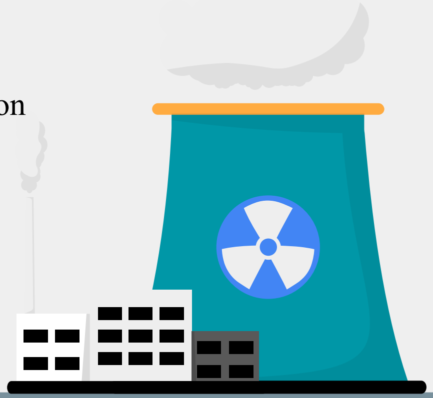
Methodology and Keywords: Utilized MQ135 Sensor, IoT, Arduino Uno, Air Pollution, Air Purifier Model, LCD. Employed machine learning and deep learning for air quality classification. Employed a sophisticated recurrent neural network (RNN) for air quality predictions. The Long-and-Short Term Memory (LSTM) model is utilized to analyze historical air quality data

Health Implications: Defined Particulate Matter (PM) 2.5 and its impact on the respiratory system. Emphasized the relevance of detecting PM 2.5 during the COVID-19 epidemic.

Gas Heaters and CO: Highlighted the dangers of gas heaters, particularly the lethal gas CO.

Humidity and Air Quality: Humidity is a quantitative representation of the atmospheric concentration of water vapour,Humidity makes existing issues with indoor air quality worse.

Temperature Effects: Rising temperatures have a negative impact on air quality because they speed up a number of chemical reactions that contribute to or exacerbate pollution.



Development of an IoT-Enabled Air Pollution Monitoring and Air Purifier System, Journal of Metrology Society of India (September 2023)

Objective: Designing a smart air pollution prototype to purify air in urban areas. Utilizes PM sensor, gas sensors (MQ2 and MQ-135), ADC, Raspberry Pi 3 B and multiple filters.

Components: PM Sensor: PMSA003 for PM detection (0.3-10 microns). Gas Sensors: MQ2 and MQ-135 for LPG, smoke, CO, CO_2, NH_4. Data Conversion: ADC and Raspberry Pi for converting sensor outputs. Connectivity: Transmit data to Thingspeak Cloud via WiFi Module.

Functionality: Monitor and purify air by filtering particles (200 to 0.3 lm). Assess gas concentrations before and after filtration. Visualize results on the Thingspeak Cloud platform. There are three different filters used to filter particles of various sizes. They are <u>pre/primary filter</u>, <u>activated carbon filter</u>, and <u>HEPA filter</u>

ThingSpeak Cloud Platform: The data transfer between Raspberry Pi to Thingspeak is performed by importing the required API keys and necessary libraries to the python program. This software has the provision to display the live value digitally in the widget, which helps to graphically represent the concentration of gases before and after the filtering process every 15 s. With the use of an internet connection, the client can log on to the user account and view the recorded data anywhere and anytime. The recorded data can also be downloaded in the form of a CSV file, and we used MATLAB software for plotting those values.

Efficient Monitoring and Adaptive Control of Indoor Air Quality Based on IoT Technology and Fuzzy Inference(September 2022)

Method & Assessment: Indoor Air Quality Monitoring and Control System (IAQMCS) using IoT technology. Introduce a fuzzy air quality index (FAQI) model based on fuzzy inference.

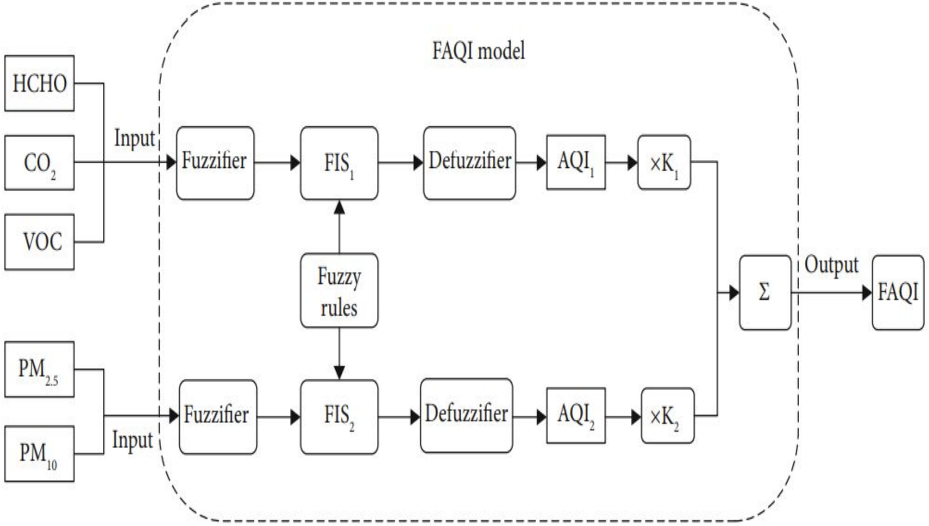


FIGURE 2: FAQI model for evaluating indoor air quality.

FIGURE 11: IoT prototype of IAQMCS system.

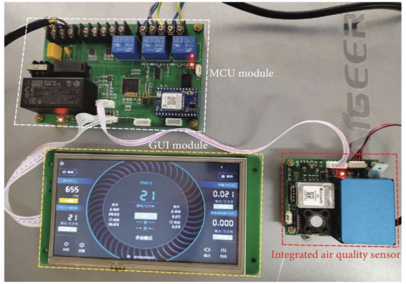


FIGURE 12: Prototype of air quality sensing system.

Internet of Things (IoT) Based Indoor Air Quality Sensing and Predictive Analytic A COVID-19 Perspective(JAN-2021,MDPI)

Sensors Used: Grove-Multichannel Gas Sensor: Detects multiple gases: CO, Ammonia, NO_2, Methane. Fresh air sensing for 30 mins.
MH-Z19: Detects Carbon Dioxide concentration in parts per million (ppm).
HM3301 Laser PM 2.5 Sensor: Uses laser diffraction to measure PM 2.5 concentration. Built-in temperature and humidity compensation, no calibration required.

Key Points:

- LSTM (Long Short-Term Memory) is utilized for indoor air quality prediction, an advanced form of RNN.
- An IoT node placed in the experimental lab records time series readings of various air pollutants.
- LSTM with one hidden layer (10 nodes) is employed for predicting pollutant values.
- Mean squared error' loss function and 'adam' optimizer enhance LSTM performance.
- Predictions focus on the next 50 air quality readings due to the importance of rapid decision-making, particularly during COVID-19.
- Feature scaling with min-max normalization minimizes the impact of exploding gradients, ensuring more accurate predictions.

IoT monitoring system for air quality assessment and collecting data (IJEEC, September 2022)

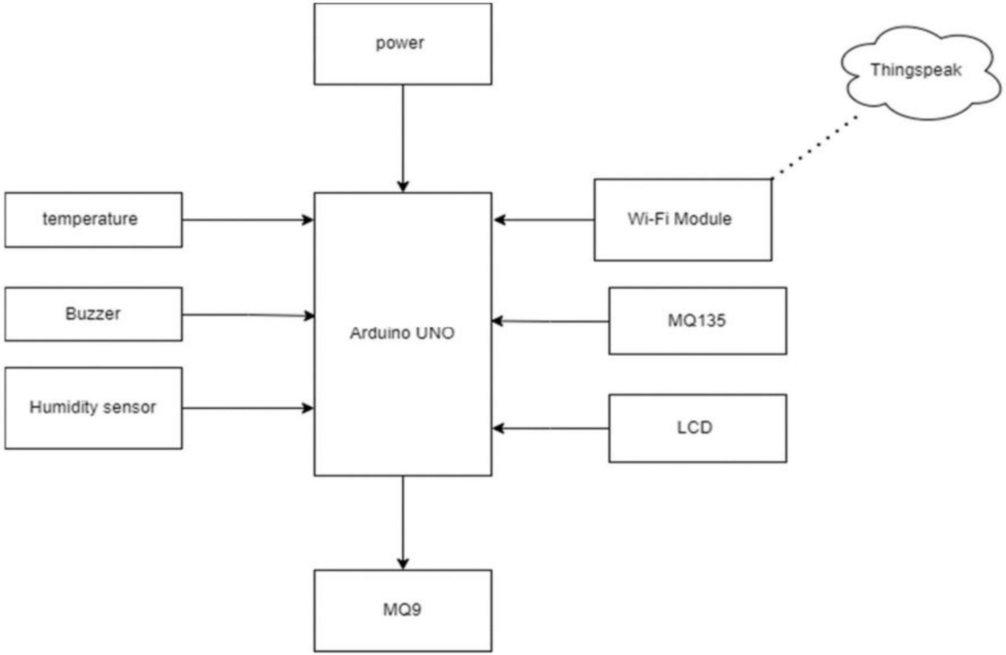
Challenges Addressed: Air pollution's detrimental effects on ecosystems and human health. The global need for real-time air quality monitoring solutions.

Solution: Developed a hardware and software solution for low-cost environmental data acquisition. Measures parameters like CO, CO2, NH3, NO2, temperature, and humidity. Includes user interface development and a reliable circuit layout.

Hardware Layout: Initially, the ESP8266 was used for data collection and redistribution. However, it proved unreliable during prolonged deployment of the AQS device. Deploying the AQS device over several days uncovered reliability issues and real-time response delays. The need for real-time response led to the adoption of the ESP32 for improved performance

Software Framework: The Arduino Framework was utilized to support various sensor libraries and facilitate functional mutual exclusion. FreeRTOS (a real-time operating system) was integrated to manage parallel programming with the ESP32. This ensured data integrity when writing into the RAM, as atomic instructions were not supported by the hardware.

Air Quality Monitoring Using Arduino and Cloud Based System in IoT



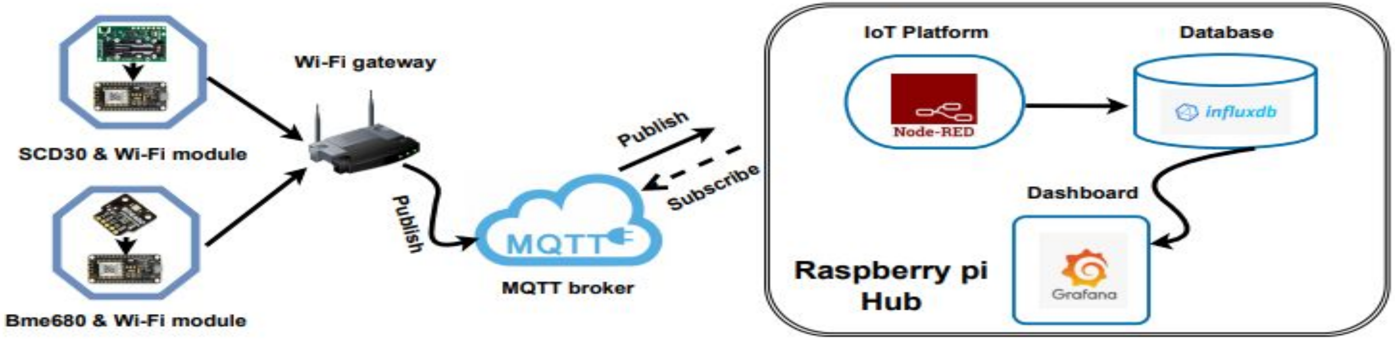
Hardware used:
1) Arduino uno board
2) Connecting Wires
3) LCD screen
4) Buzzer
5) Wi-Fi Module(ESP8266)
6)Sensors used:
   MQ9 Gas Sensor: measure and monitor CO
   MQ135 :detect smoke ,NH3,NO and volatile organic compounds
   DHT11 : measures temperature and humidity

Software Requirements
1) Arduino Ide 1.08.19
2) ThingSpeak Cloud Based Platform

LSTM-Based IoT-Enabled CO2 Steady-State Forecasting for Indoor Air Quality Monitoring(December 2022)

Objective

- Detect harmful gases, trigger alarms, and enable automatic ventilation.
- Provide a cost - effective, connected, and energy-efficient solution.



Hardware:

- Raspberry Pi 3B: Manages the dashboard and data processing.
- ESP8266 Wi-Fi Module: Provides wireless connectivity.
- SCD30 CO2 Sensor: Measures CO2 levels accurately.
- BME680 IAQ Sensor: Monitors temperature, humidity, pressure, and air quality.

Software:

1. MQTT (Message Queuing Telemetry Transport):
   - Efficient IoT protocol for reliable message delivery.
2. Node-Red:
   - Open-source tool for connecting devices and services.
3. InfluxDB:
   - Time-series database integrated with Node-Red for data storage.
4. Grafana:
   - Data visualization and analysis tool with rich dashboards.

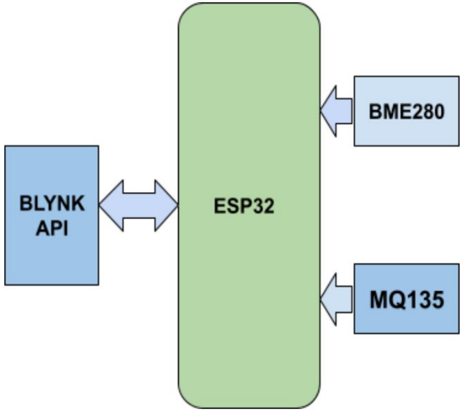
IoT based Indoor Air Pollution Monitoring System

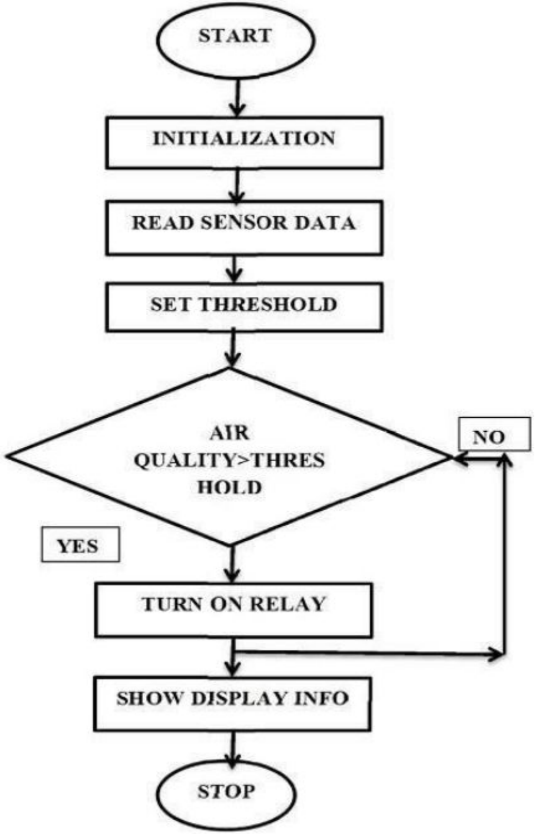
Hardware Requirements:

BME280: A compact, low-power humidity sensor with high accuracy and EMC robustness.
MQ-135: Gas sensor for detecting NH3, NOx, Alcohol, Benzene, Smoke, and CO2 with a standalone mode.
Raspberry Pi 3B+: collects the data from the given sensors and displays the data on the BLYNK platform.
Raspberry Pi camera :used to count the no. of people present in the room

Software Requirements:

Blynk: An IoT platform for iOS and Android to control Arduino, Raspberry Pi, and NodeMCU over the Internet, creating graphical user interfaces for devices.





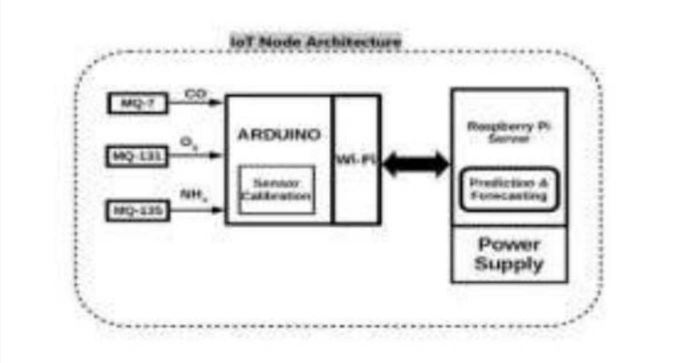
AI powered IoT based Real-Time Air Pollution Monitoring and Forecasting

Objective:

1. Continuous environmental monitoring.
2. Data collection using IoT sensors.
3. Forecasting air pollutant levels with Time Series models.
4. Model validation through performance indices.
5. Deploying the model on a Raspberry Pi for edge computing.
6. Providing real-time data access through an online dashboard.

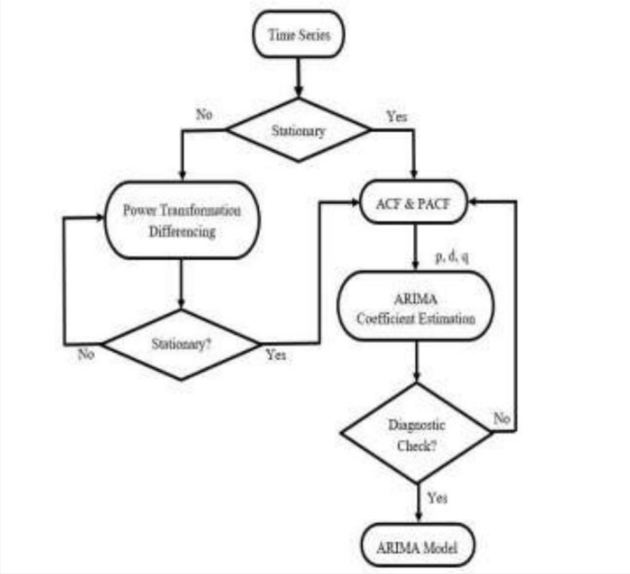
Hardware:

Raspberry Pi 3-Model B, an Arduino Uno board, and three gas sensors: MQ-7 for Carbon Monoxide, MQ-131 for Ozone, and MQ-135 for Air Quality.



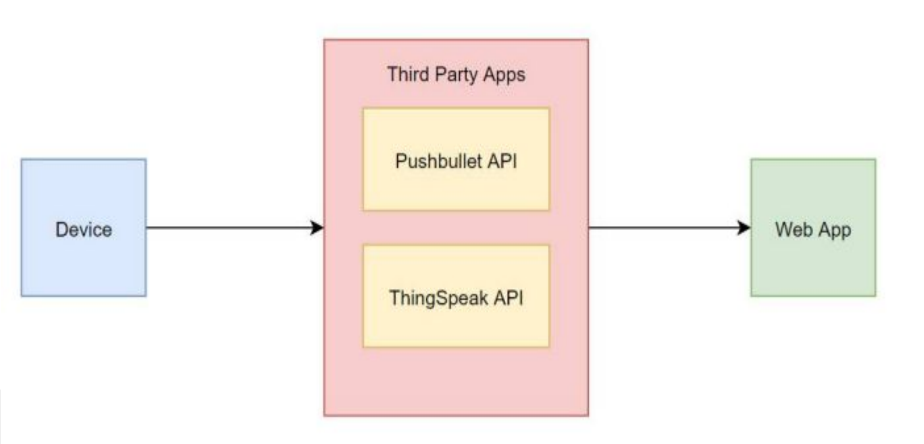
Air Quality Forecasting using Machine Learning (ML) Techniques

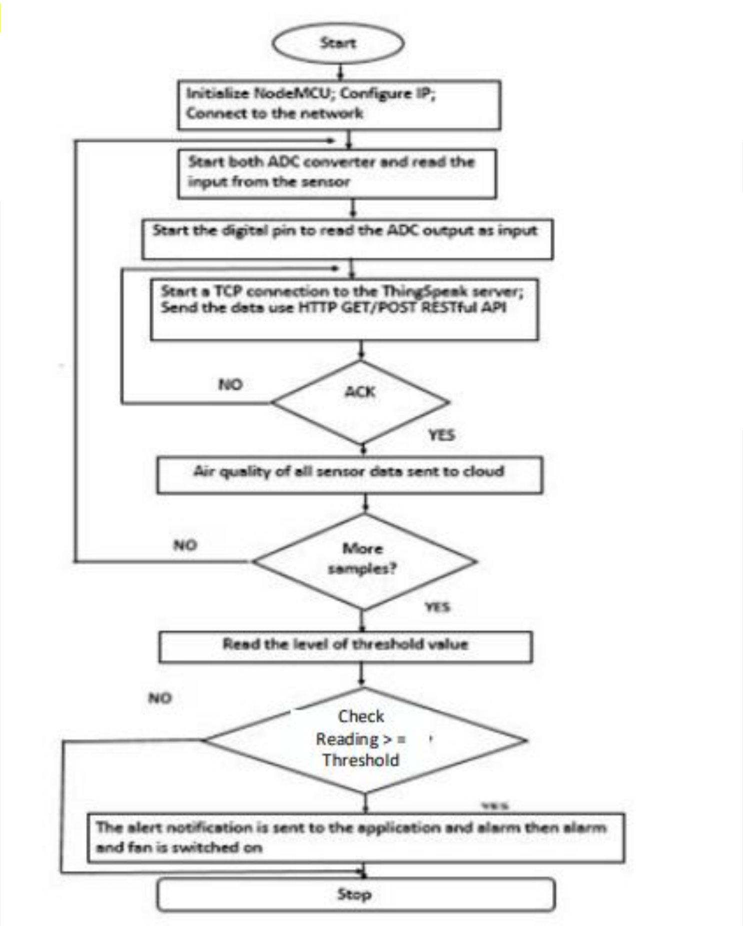
- Time series analysis
- Naïve Bayes
- Autoregression model
- Auto Regression Moving Average Model
- Auto Regression Integrating Moving Average Model



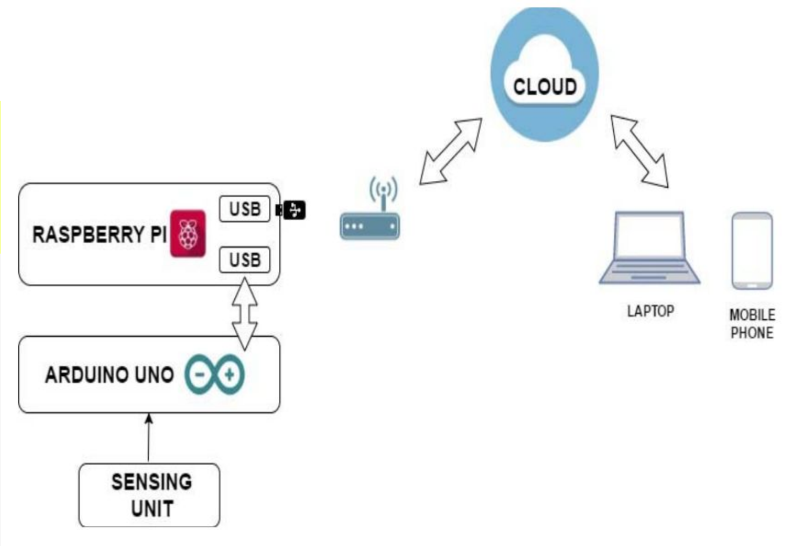
Air-MIT: Air Quality Monitoring Using Internet of Things (March 2022)

Hardware:
NodeMCU ESP8266.12E: Microcontroller
MQ7:CO,MQ4: CH_4,MQ2: Smoke & LPG,MQ137 : NH_3,
MQ135: Overall products,MG811:CO_2
ADS115: convert analog input into digital
ThingSpeak: medium to read results from
NodeMCU;graphical results.





Air Quality Monitoring System Based on IoT using Raspberry Pi (ICCCA - 2017)



Significance of Air Quality Monitoring: Acknowledges air pollution as a major global challenge affecting human health, climate, and ecosystems.

Parameters Monitored: PM 2.5, carbon monoxide, carbon dioxide, temperature, humidity, and air pressure.

Sensors Used:

- DSM501A dust sensor
- MQ 9 for measuring CO
- MQ 135 for measuring CO2, NH3, smoke
- DHT 22 for measuring temperature and humidity
- BMP180 for measuring pressure

Softwares:

* Raspberry Pi, * Node-Red, * Integrated Development Environment, * MQTT Protocol

Cloud Integration:

IBM Bluemix (IBM Cloud)

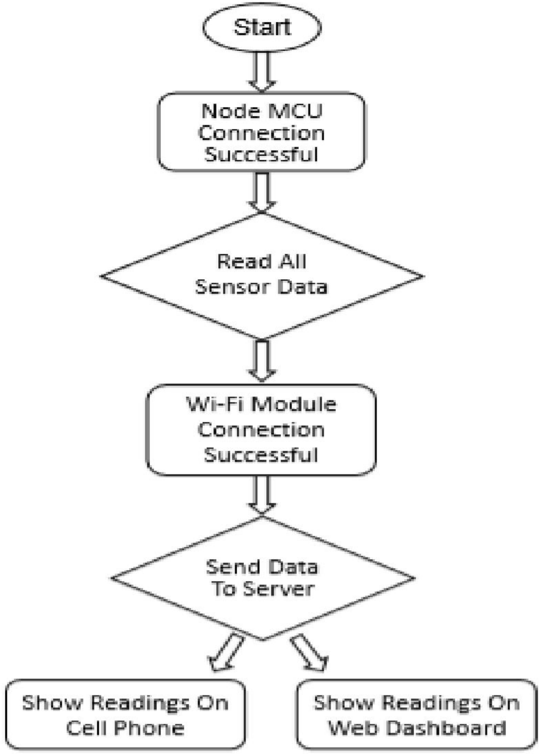
Iot Based Air Pollution Monitoring System (IJSRET - 2023)

Objective:
Monitoring industrial pollution and air quality levels in areas with high traffic

Technologies Used:
a. Sensor Array
- MQ135 for measuring CO_2, SO_2, CH_4, NH_3.
- MQ 9 for measuring CO and Propane (C_3H_8).
- MQ2 for detecting gas leakage.

b. ESP32 Microcontroller
c. Blynk 2.0

Methodology:
The system uses a sensor array and an ESP32 microcontroller which reads sensor data, and through Wi-Fi connectivity, transmits it to the Blynk 2.0 Cloud. The Blynk platform enables real-time data visualization on mobile devices and a web dashboard. In case of gas leakage detected by the MQ2 sensor, the system sends notifications to mobile phones.



A Design of Indoor Air-Quality Monitoring System (J. Phys. - Conf. Ser. - 2022)

Objective:
To realize the monitoring and evaluation of indoor air quality.

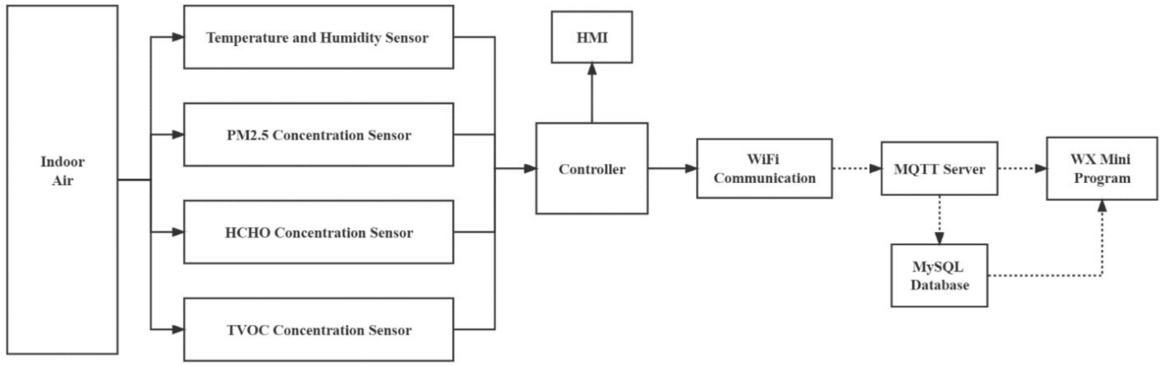
System design:

It uses sensors, MCU, WiFi, Elastic Compute Service (ECS), MQTT (Message Queuing Telemetry Transport), MySQL Database, WeChat Mini Program.

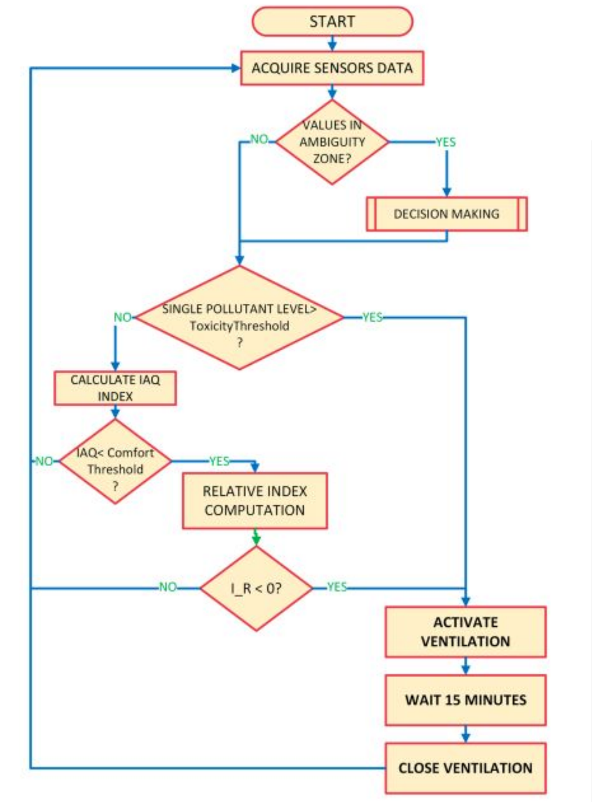
The figure represents the overall architecture. Data flows from sensors through the MCU, WiFi, ECS, MQTT, and into the MySQL database, with remote access facilitated by the **WeChat** Mini Program.

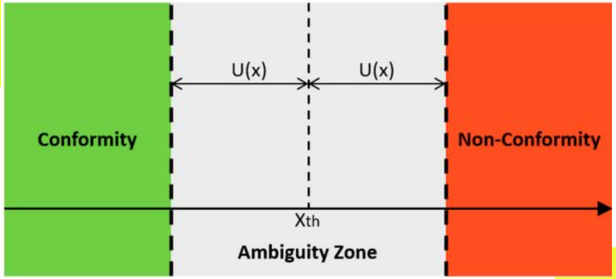
Sensors:

- DHT11 Temperature and Humidity Sensor
- FS00202 Laser Dust Sensor (PM2.5)
- FS00511 Formaldehyde Sensor
- FS00602 TVOC Sensor



An Improvement Strategy for Indoor Air Quality Monitoring Systems (MDPI - 2023)

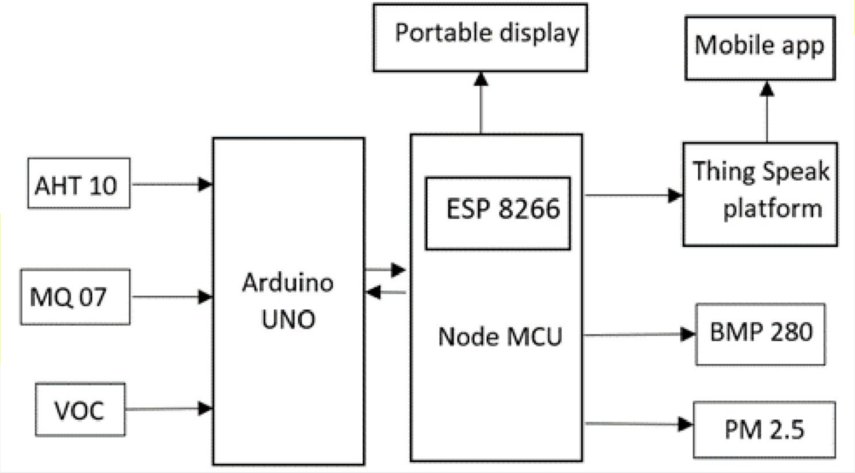


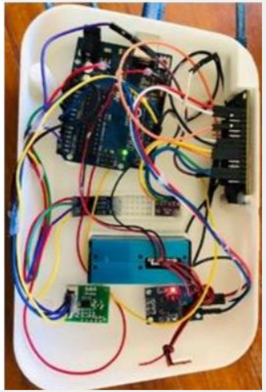


Key points:

- Significant influence of indoor environmental factors (temperature, humidity, ventilation, pollutants, etc.) on health
- To use advanced IoT systems to monitor and improve indoor environment quality (IEQ) by analyzing pollutant concentrations and evaluating thermal, acoustic, and visual comfort.
- Role of Temperature and Humidity
- Relation Between Air Quality and Health
- Algorithm for monitoring and control.
- Key parameters monitored include CO2, VOCs, CO, and PM2.5

An IoT-based handheld environmental and air quality monitoring station (IMEKO - 2023)





Objective:
To create a portable weather monitoring device that measures critical weather and air parameters used in daily life.

Key Parameters Measured:
Temperature, pressure, humidity, altitude, PM2.5, PM10 levels, VOC (volatile organic compounds), and CO (carbon monoxide) levels.

Components of the System:
Arduino UNO - microcontroller, nodeMCU (with ESP8266 Wi-Fi module), Portable display and a mobile app integrated with a **ThingSpeak** cloud platform. Wi-Fi and GSM connectivity for data communication.

Advantages Over Existing Models:
The prototype is highly portable, easy to install without the need for trained technicians, and easy to maintain.
It provides worldwide data access via Wi-Fi connectivity and supports data visualization and analysis.

Air pollution prediction with machine learning: a case study of Indian cities

Machine Learning for Air Quality Prediction:

- Machine learning techniques are effective for studying and predicting air quality.
- Six years of air pollution data from 23 Indian cities were analyzed.

Data Preprocessing and Feature Selection:

- The dataset was preprocessed, and key features were selected through correlation analysis.
- An exploratory data analysis revealed hidden patterns and identified pollutants affecting air quality.

- Machine Learning Models:
  - Five machine learning models were employed to predict air quality.
  - Gaussian Naive Bayes achieved the highest accuracy.
  - Support Vector Machine had the lowest accuracy.
- XGBoost Model Performance:
  - The XGBoost model outperformed other models.
  - It showed the highest linearity between predicted and actual data.

Using Machine Learning Methods to Forecast Air Quality: A CaseStudy in Macao

Air Quality Concerns in Macao:

- Despite improvements, high-pollution episodes in Macao still pose health concerns.

Machine Learning Methods Used:

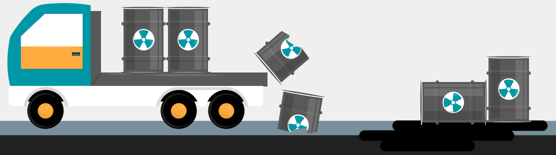
- Random Forest (RF), Gradient Boosting (GB), Support Vector Regression (SVR), and Multiple Linear Regression (MLR) applied for air quality prediction.

Data Sources:

- Meteorological and air quality data from 2013 to 2018 used for model training.
- Air quality data from 2019 to 2021 used for validation.

Recommendation:

- RF is suggested as the most reliable prediction method, particularly for cases of drastic air quality changes due to unexpected circumstances, such as pandemic-related lockdowns.



AIRO: Development of an Intelligent IoT-based Air Quality Monitoring Solution for Urban Areas

Air Pollution and Health in Bengaluru:

- Bengaluru, India, faces air pollution exceeding WHO standards.
- Elevated levels of PM10, PM2.5, SO2, NO2, and CO2 pose health risks.

AIRO: IoT-Based Air Quality Monitoring:

- AIRO is a decentralized IoT-based solution for real-time Air Quality Index (AQI) calculation.
- Designed to notify users about hazardous AQI levels.

Prototyping with Intel Edison:

- A physical prototype is created using the Intel Edison development platform.
- Equipped with GPS, Wi-Fi, PMS5003, and various sensors for data collection.

- Hybrid Deep Learning Model:
  - A hybrid CNN-Bi-LSTM model is proposed for AQI prediction.
  - Requires city-scale evaluation for reliable results.
- User-Friendly Smartphone App:
  - A smartphone app developed to monitor air quality in real-time.
  - Users can select locations and receive real-time and predicted AQI information.

Application of the low-cost sensing technology for indoor air quality monitoring: A review

Scope of the Review:

- 42 studies were analyzed, divided into laboratory (11) and field (31) studies.
- Parameters considered include aim, location, study duration, sampling area, pollutants assessed, sensors/devices, instruments used for comparison, performance metrics, and outcomes.

Indoor Environments Studied:

- Laboratory studies were conducted in controlled chambers.
- Field studies took place in various indoor settings, such as homes, offices, and educational buildings.

- Key Pollutant: Particulate Matter:
  - Particulate matter was the most frequently assessed pollutant in both laboratory and field studies.
  - Assessment used both commercial devices (e.g., Speck, Dylos, Foobot) and sensors (e.g., Sharp GP2Y1010AU0F).
- Performance of Low-Cost Sensors:
  - Based on statistical parameters, low-cost sensors showed moderate correlations with the instruments used for comparison.
  - Sufficient precision was observed, especially for qualitative analysis of air quality in indoor microenvironments.

The application of machine learning to air pollution research: A bibliometric analysis

- ML simulates human learning to solve air pollution problems.
- Sharp increase in publications post-2017, constituting 75% of the total.
- China and the United States are major contributors to research.
- Individual research groups dominate over global collaborations.
- Four main research topics: chemical characterization, short-term forecasting, detection improvement, and emission control optimization.
- ML advancements improve pollutant analysis, chemical reactions, and scenario simulations.
- Combining ML with multi-field data enhances analysis of atmospheric chemical processes and air quality management.

Thank You