Software Requirements Specification(SRS)

Integrating IoT and Machine Learning for Comprehensive Air Pollution Monitoring: A Sustainable Approach Towards Greener Skies

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Revision History

Name	Date	Reason for Changes	Version
Dr.			1.0.0

1. Introduction

1.1 Purpose

The purpose of this document is to outline the software requirements for the development of an innovative IoT based air pollution monitoring system that integrates machine learning algorithms. This system aims to provide comprehensive and real time data on air quality parameters, including pollutant levels, temperature, humidity, and rain acidity. By leveraging IoT technology and advanced machine learning techniques, the system seeks to contribute to environmental sustainability and promote healthier living conditions by integrating solar panels as the system's power source as renewable energy.

1.2 Scope

This document defines the functional and nonfunctional requirements of the air pollution monitoring system. It covers the design and implementation aspects necessary for building a robust and scalable solution. The system's scope includes air pollution detection, result analysis, live updates, solar power utilization, and various environmental sensors' integration. It also addresses user interactions, data processing, and system performance criteria. All of these are well explained in this document.

1.3 Definitions

I. IoT (Internet of Things): Refers to a network of interconnected devices that can collect and exchange data.
II. Machine Learning (ML): A subset of artificial intelligence that enables systems to learn and improve from experience without being explicitly programmed.
III. Air Pollution: Contamination of the air by harmful or undesirable substances, adversely affecting human health and the environment.

1.4 Acronyms, and Abbreviations

2. Overall Description

2.1 Product Perspective

The air pollution monitoring system is part of a larger environmental monitoring framework aimed at improving air quality and public health. It interfaces with various hardware components such as sensors, IoT devices, and a solar power system. The system's data and insights can also integrate with existing environmental databases or platforms for broader analysis and decision making.

2.2 Product Functions

- **Air pollution detection:** Identifying and measuring pollutant levels in the air, including particulate matter, gasses, and volatile organic compounds.
- **Result analysis and prediction using machine learning:** Processing collected data to generate insights, trends, and predictive models for air quality forecasting.
- **Temperature monitoring:** Tracking ambient temperature to understand its impact on air quality variations.
- **Live updates to the connected computer:** Providing real time data updates and alerts to users via a connected computer or mobile device.
- **Rain detection using pH scale sensor:** Monitoring rain acidity levels to assess its effect on environmental acidity and pollution levels.
- **Humidity monitoring:** Measuring atmospheric humidity to gauge its influence on air pollutant dispersion and concentration.
- **Utilizing solar renewable energy for system stability:** Integrating a sustainable power source to ensure continuous operation and reduce environmental impact.
- **Monitoring gasses levels for air pollution monitoring:** Tracking levels of specific gasses like carbon dioxide, carbon monoxide, and sulfur dioxide to assess their contribution to air pollution.

2.3 User Characteristics

- **Environmental scientists and researchers:** Analyzing and interpreting air quality data for research purposes and policy recommendations.
- **Government agencies and policymakers:** Using the system's insights for regulatory compliance monitoring and decision making.
- **General public and communities:** Accessing air quality information for awareness, health protection, and lifestyle adjustments.

2.4 Constraints

- **Network connectivity:** Reliability of network connections for data transmission and communication with external systems.
- **Environmental conditions:** System performance may vary under extreme weather conditions or in remote areas with limited infrastructure.

2.5 Assumptions and Dependencies

- **Assumption of sensor accuracy:** Assuming sensors provide accurate and reliable data for air quality monitoring.
- **Dependence on IoT infrastructure:** Relying on IoT devices and networks for data collection, communication, and control.
- **Availability of machine learning resources:** Access to computational resources and machine learning algorithms for data analysis and prediction.

3. Specific Requirements

3.1 Functional Requirements

1. Air Pollution Detection

- The system shall detect and measure pollutant levels in the air, including particulate matter (PM2.5 and PM10), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and volatile organic compounds (VOCs).
- Sensors for air pollution detection shall have a minimum accuracy of ±5% for all measured pollutants.
- The system shall continuously monitor air quality parameters at a frequency of at least once every 15 minutes.

2. Result Analysis and Prediction using Machine Learning

- The system shall analyze collected data using machine learning algorithms, such as linear regression, decision trees, and neural networks, to identify trends, patterns, and correlations related to air pollution.
- Machine learning models shall be trained and validated using historical air quality data from reliable sources.
- The system shall predict air quality levels (e.g., Good, Moderate, Unhealthy) based on historical data and environmental factors such as weather conditions and geographical location.

3. Temperature Monitoring

- The system shall monitor ambient temperature with a precision of ±1°C.
- Temperature data shall be synchronized with air quality data for comprehensive analysis and correlation studies.

4. Live Updates to the Connected Computer

- The system shall provide real time updates and alerts to a connected computer or mobile device via a user friendly interface.
- Updates shall include current air quality indices (AQI), pollutant concentrations, temperature, humidity, and rain status.

5. Rain Detection using pH Scale Sensor

- The system shall detect rain and measure rainwater acidity using a pH scale sensor with a range of 014 pH units.
- Rain acidity data shall be correlated with air quality data to assess the impact of acid rain on environmental conditions.

6. Humidity Monitoring

- The system shall monitor atmospheric humidity levels with a precision of ±5% relative humidity.
- Humidity data shall be integrated into air quality analysis to evaluate its influence on pollutant dispersion and health risks.

7. Solar Renewable Energy System Integration

- The system shall integrate a solar renewable energy system, including photovoltaic panels and energy storage solutions, to power sensor nodes and data processing units.
- Solar panels shall have a minimum efficiency of 20% and shall be oriented for maximum sunlight exposure.

8. Gases Level Monitoring

- The system shall monitor levels of specific gases such as carbon dioxide (CO2), methane (CH4), and hydrogen sulfide (H2S) using gas sensors with a detection range suitable for outdoor air quality monitoring.
- Gas sensors shall be calibrated regularly (every 6 months) and replaced if their accuracy falls below ±10% of the calibrated value.

3.2 Nonfunctional Requirements

1. Performance Requirements

- The system shall provide real time data updates with a maximum latency of 1 second.
- Machine learning algorithms shall process data and deliver analysis results within 5 minutes of data collection.
- The system shall support concurrent access by at least 100 users without significant performance degradation.

2. Security Requirements

- Data transmission between sensors, IoT devices, and the central server shall be encrypted using industry standard protocols (e.g., TLS/SSL).
- User authentication shall be implemented using strong password policies and multifactor authentication mechanisms.

3. Reliability Requirements

- The system shall have a mean time between failures (MTBF) of at least 10,000 hours.
- Redundant power supply units and backup data storage shall be available to minimize downtime in case of hardware failures.

4. Usability Requirements

- The user interface shall be intuitive and accessible on multiple devices, including desktop computers, tablets, and smartphones.
- Users shall be able to customize dashboard views, set alert thresholds, and export data for further analysis.

5. Maintainability Requirements

- The system shall have modular components that can be easily replaced or upgraded without affecting overall functionality.
- Maintenance tasks, such as sensor calibration and software updates, shall be documented in a maintenance manual for system administrators.

6. Scalability Requirements

- The system architecture shall be scalable to accommodate up to 1000 sensor nodes and handle data from multiple geographical locations.
- Scalability tests shall be conducted annually to assess system performance under increased load conditions.

4. External Interface Requirements

4.1 User interfaces

4.2 Hardware interfaces

4.3 Software interfaces

4.4 Communication interfaces

5. System Features

Feature 1. Air Pollution Detection

- This feature encompasses the use of highly sensitive sensors to detect and measure a wide range of air pollutants, including particulate matter (PM2.5 and PM10), carbon monoxide

(CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and volatile organic compounds (VOCs).

- The sensors are calibrated to provide accurate readings, and data collection occurs continuously to capture realtime changes in air quality.
- Air pollution data is essential for assessing environmental health risks, identifying pollution sources, and supporting regulatory compliance efforts.

Feature 2. Result Analysis and Prediction

- After collecting air quality data, the system employs sophisticated machine learning algorithms to analyze the data and generate actionable insights.
- Analysis includes identifying trends, patterns, and correlations between pollutant levels, weather conditions, and geographical factors.
- Machine learning models are trained on historical data to predict future air quality levels, enabling proactive measures to mitigate pollution and protect public health.

Feature 3. Temperature Monitoring

- Temperature sensors are integrated into the system to monitor ambient temperature variations.
- Temperature data is correlated with air quality data to assess how temperature changes impact pollutant dispersion, chemical reactions, and atmospheric stability.
- Understanding temperature patterns helps in interpreting air quality trends and predicting potential environmental impacts.

Feature 4. Live Updates

- The system provides real time updates and notifications to users through a user friendly interface.
- Users receive instant alerts about air quality index (AQI) changes, pollutant concentrations, temperature fluctuations, humidity levels, and rainfall status.
- Live updates empower users to make informed decisions, take preventive actions during pollution spikes, and stay informed about environmental conditions.

Feature 5. Rain Detection

- Rain detection involves using specialized sensors, such as pH scale sensors, to detect rainfall and measure rainwater acidity.
- Data from rain sensors is integrated with air quality data to analyze the impact of acid rain on soil, water bodies, vegetation, and overall environmental health.
- Monitoring rain acidity helps in assessing pollution sources and understanding regional pollution patterns.

Feature 6. Humidity Monitoring

- Humidity sensors are deployed to monitor atmospheric humidity levels in realtime.
- Humidity data is analyzed alongside air quality data to evaluate how humidity influences pollutant dispersion, chemical reactions, and human comfort levels.
- Understanding humidity dynamics aids in predicting fog formation, assessing indoor air quality, and managing moisture related pollution issues.

Feature 7. Solar Power System Integration

- The system incorporates solar renewable energy sources, such as photovoltaic panels and energy storage systems, to power sensor nodes and data processing units.
- Solar power ensures continuous system operation, reduces reliance on grid electricity, and promotes sustainability.
- Energy Efficient design and solar power integration minimize the system's carbon footprint and support environmental conservation efforts.

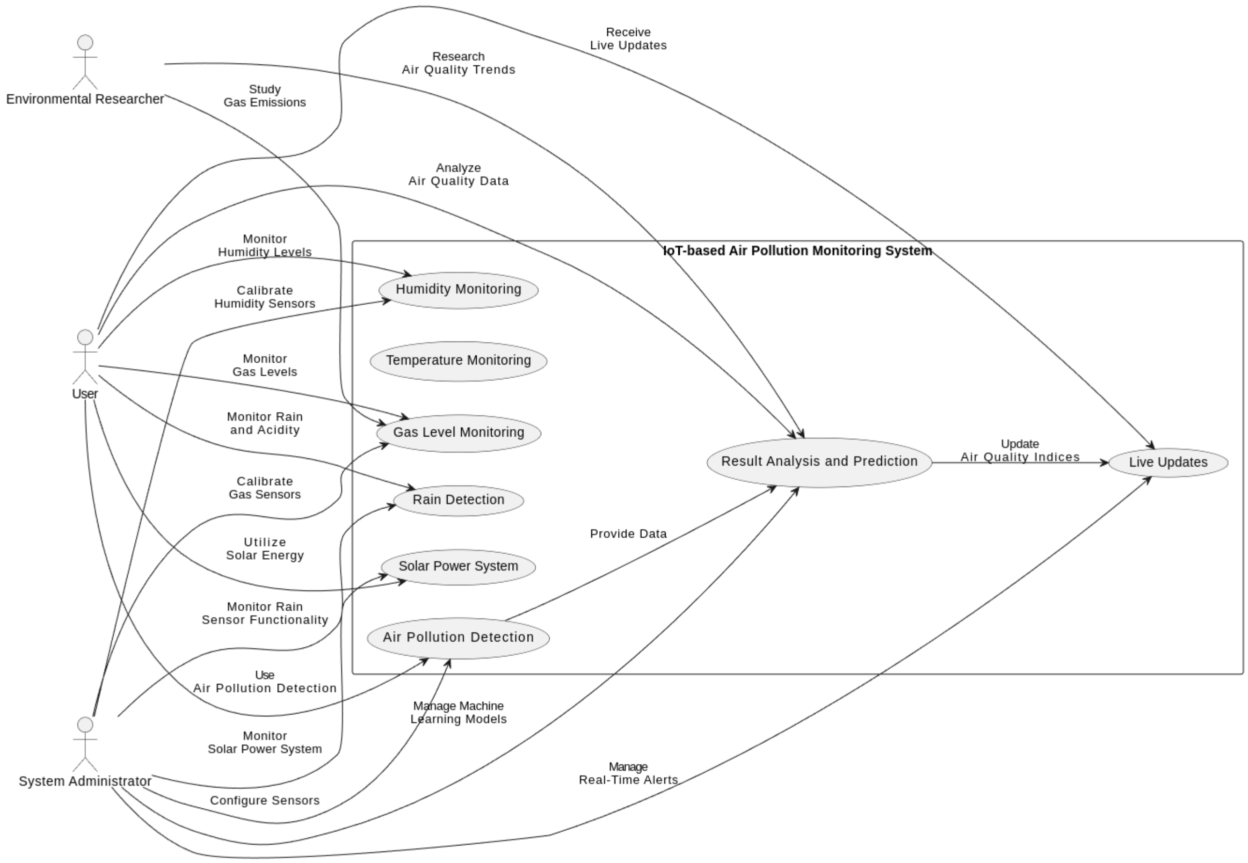
Feature 8. Gas Level Monitoring

- Gas sensors are utilized to monitor levels of specific gases, such as carbon dioxide (CO_2), methane (CH_4), and hydrogen sulfide (H_2S).
- Gas level data provides insights into industrial emissions, vehicular pollution, agricultural practices, and natural gas leaks.
- Monitoring gas levels aids in identifying pollution sources, assessing air quality trends, and implementing targeted pollution control measures.

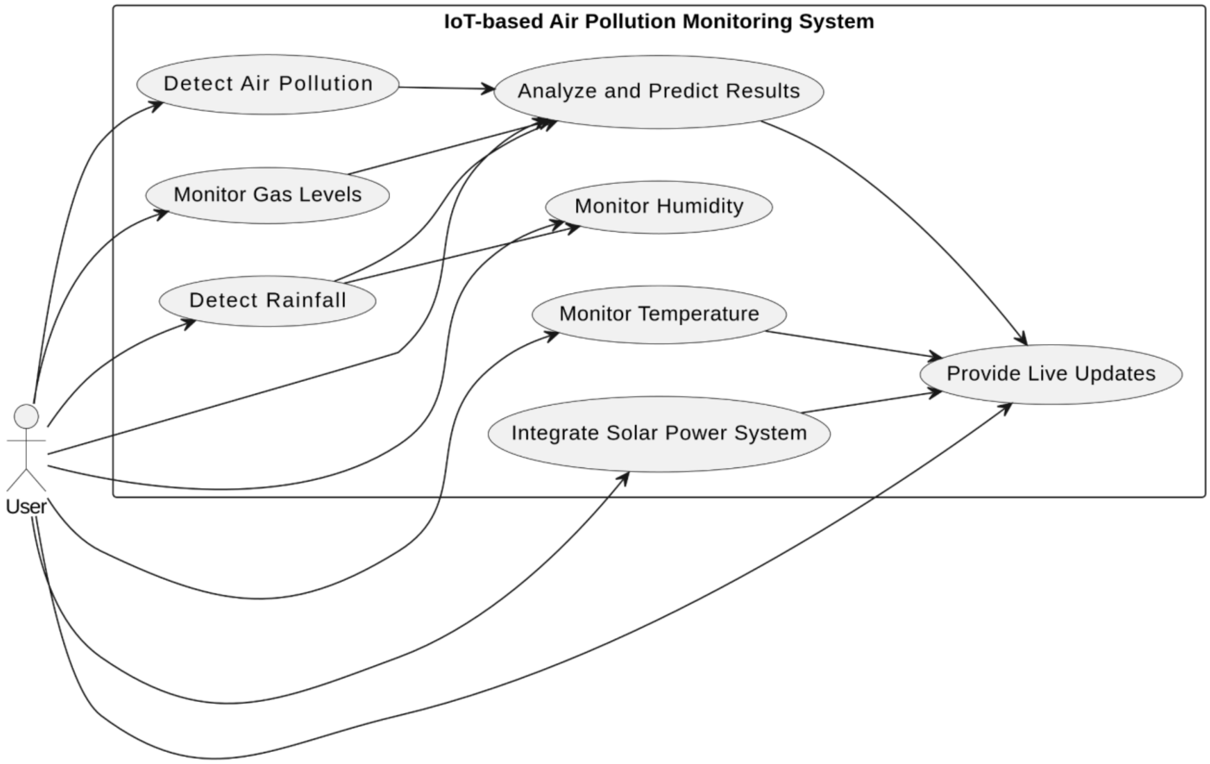
6. System Models

6.1 Use case diagram

6.2 State diagram



Environmental Researcher
User
System Administrator
IoT-based Air Pollution Monitoring System
Receive Live Updates
Research Air Quality Trends
Study Gas Emissions
Analyze Air Quality Data
Monitor Humidity Levels
Calibrate Humidity Sensors
Monitor Gas Levels
Monitor Rain and Acidity
Calibrate Gas Sensors
Utilize Solar Energy
Monitor Rain Sensor Functionality
Use Air Pollution Detection
Monitor Solar Power System
Configure Sensors
Manage Machine Learning Models
Manage Real-Time Alerts
Provide Data
Update Air Quality Indices
Humidity Monitoring
Temperature Monitoring
Gas Level Monitoring
Rain Detection
Solar Power System
Air Pollution Detection
Result Analysis and Prediction
Live Updates



8. References and supporting documents