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MILANO 1863

Requirement Analysis and Specification Document

An Interactive Application for Air Quality Monitoring

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10930504

Deliverable:	RASD
Title:	Requirement Analysis and Specification Document
Authors:	Milad Ramezani Ziarani
Version:	2.0
Date:	18th of June 2023
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Revision history

Version	Date	Change
version 1.0	17/4/2023	First submitted version
version 2.0	18 th of June, 2023	Second submitted version

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Introduction

Purpose

The importance of understanding the impact of air pollution on health cannot be overstated. In order to enhance the well-being of individuals, it is vital that data on this phenomenon is accessible and comprehensible to a wide range of audiences.

While scientists and academics already have tools to access and analyze air quality data, the average person lacks comprehensive resources to explore and make sense of such information. This application aims to bridge that gap by providing an engaging experience for citizens while educating them about various types of air pollution, using real-world data.

Government agencies typically collect real-time air quality and weather data through ground-based sensor stations, storing it digitally. These datasets consist of extensive time-series observations and associated metadata, including sensor locations and measured variables. However, accessing, harmonizing, and processing data from different providers and sensors often present challenges. This is where interactive applications and dashboards come into play, playing a crucial role in facilitating these tasks and supporting both public authorities and the general public in data processing and visualization.

The objective of this project is to develop an efficient client-server application that empowers users to access, analyze, and visualize air quality data seamlessly. By creating an interactive interface, this application will enable users to explore the collected data, understand its implications, and gain insights into the complex world of air pollution.

Through this endeavor, we strive to empower individuals with knowledge and awareness, fostering a greater understanding of air pollution and its consequences on public health. By democratizing access to air quality data, we can collectively work towards creating a healthier and sustainable environment for everyone.

Scope of the project

The aim of the project is to develop a web-based application that allows users to access, analyze, and visualize air quality and weather data obtained from public digital archives. The application will consist of a database for storing the retrieved data, a web server exposing a REST API for querying the database, and a user-friendly dashboard for requesting, processing, and visualizing the data through maps, graphs, and other means. The focus is on educating users about different air pollutants by retrieving data from a specific website and displaying time series of pollutant concentrations for different cities, along with a ranking of cities based on pollution severity. The goal is to empower users with knowledge about air quality and facilitate informed decision-making and actions to protect health and the environment.

Overview

In this project, the main objective is to enable users to compare pollution levels across different countries and identify which country has a higher degree of pollution. The application will provide tools and functionalities to access and analyze air quality data from various sources. By leveraging this data, users will be able to make informed comparisons and gain insights into the variations in pollution levels among different countries.

The application will offer interactive features that allow users to select specific countries and retrieve relevant pollution data. This data may include information on various pollutants such as particulate matter (PM), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and others. Through visualizations and comparative analysis, users will be able to identify patterns and differences in pollution levels between countries.

The primary goal of this project is to raise awareness about the varying degrees of pollution worldwide and provide users with the necessary information to understand and address environmental challenges. By facilitating easy access to pollution data and enabling comparisons, the application aims to empower individuals, organizations, and policymakers to take appropriate actions towards mitigating pollution and promoting healthier environments.

Acronyms' and other definitions

In the context of the documentation, here is a summary of the defined terms and acronyms:

- "The web app" or "app": Refers to the application being developed.
- "Use case": An example that demonstrates how a user interacts with the system.
- "User": Any individual who uses the website and meets the criteria described under the "user characteristics" section.
- "Bookmark": Saving a snapshot of the presented information at a specific location on the map.
- JSON: Stands for JavaScript Object Notation, a data interchange format.
- JS: Abbreviation for JavaScript, a programming language used for web development.
- df: Short for Dataframe, representing a pandas dataframe object.
- gdf: Short for geodataframe, representing a geopandas dataframe object.
- RASD: Refers to the Requirements Analysis and Specification Document, a document for capturing software requirements and specifications.
- "OpenAQ": An organization that provides open air quality data through their API.
- API: Stands for Application Programming Interface, which allows software applications to communicate with each other.
- "REST": Abbreviation for Representational State Transfer, an architectural style for designing networked applications.
- "Python": A high-level programming language used as the foundation for building the web application's functionality.
- "AQI": Air Quality Index, a measure of air quality and its impact on health.

These terms and acronyms are defined within the documentation to provide clarity and ensure consistent understanding throughout the project.

Assumptions and dependencies

The target user profile for this project is a person or researcher who is interested in studying the relationship between air quality and weather observations. The user(s) want to collect and analyze data related to air pollution and weather patterns in a specific geographic location or series of locations, either at a point in time or over a period of time.

As a non-expert in data analysis, the user(s) lack the technical skills to extract and present the data effectively and may have limited knowledge of the underlying concepts. The user(s) would like to utilize a solution that allows them to easily visualize and interpret the data, and to share their findings with others in the academic community.

While there may be existing tools and resources available, they may not be sufficiently precise or customizable to meet the user's specific needs. As such, the user(s) require access to a new solution that is relevant to their project and enables them to effectively collect, analyze, and communicate their findings related to air quality and weather observations.

Use Cases

Actors involved - Individual user, Interactive web application, OpenAQ API. Entry requirement - The interactive web application must be able to retrieve air pollution data for a specific geographic location from the OpenAQ API at all times.

User characteristics

The application is designed for users who are trying to learn something about how air quality monitoring works, as well as the possible health hazards that different substances present in the air imply. Therefore, the user wants to be presented with data and explore it in a way that is guided by the application and not overly technical. The user is interested in comparing the data available for the different cities and seeing the results of his exploration represented on an interactive map supplemented by graphs. The user wishes to see which concentration of pollutants are considered hazardous to his health.

User stories

1. As a user, I want to view the concentration of a specific pollutant across all European countries, so that I can assess the pollution levels comprehensively.
2. As a user, I want to identify European countries that have exceeded the concentration of a hazardous pollutant as defined by public health authorities in the past few days, to stay informed about potential health risks.
3. As a user, I would like to know which European countries had the best and worst air quality in the last couple of days, enabling me to understand the variations and make informed decisions regarding my activities or travel plans.

These user stories reflect the goals and intentions of the users interacting with the web application. They highlight the key functionalities required to meet the users' needs and provide a clear direction for the development process.

Use cases

Use Case 1: Choose Pollutant

Participating actors: All users

Entry condition: None

Flow of events:

1. The user navigates to the main menu of the web application.
2. The user locates and clicks on the "Choose pollutant" button.
3. A list of available pollutants is displayed.
4. The user selects the specific pollutant they want to explore by clicking on it.
5. The system redirects the user to the corresponding interface or page related to the selected pollutant.

Exceptions: None

This use case describes the process of a user selecting a specific pollutant from the available options within the web application. By clicking on the "Choose pollutant" button in the main menu, the user is presented with a list of pollutants. After selecting a pollutant of interest, the system then directs the user to the corresponding interface or page that provides information or tools related to the chosen pollutant.

Use Case 2: Pollutant Information

Participating actors: All users

Entry condition: The user has selected a specific pollutant.

Flow of events:

1. After selecting a pollutant, the user is presented with detailed information about the chosen pollutant, including its origin and potential health hazards associated with exposure.
2. The user can read and review the provided information to gain a better understanding of the selected pollutant.
3. Once the user has reviewed the information, they can click on the "Continue" button to proceed with their interaction or exploration of the web application.

Exceptions: None

This use case focuses on providing users with relevant information about the pollutant they have selected. The web application displays details such as the pollutant's origin and potential health hazards, allowing users to familiarize themselves with the characteristics and risks associated with the chosen pollutant. Users can then choose to continue their engagement with the application by clicking the "Continue" button.

Use Case 3: Explore Map

Participating actors: All users

Entry condition: The user has completed the game.

Flow of events:

1. The system displays a map of Europe.
2. The map shows pins positioned on the locations of cities or countries present in the database.
3. Each pin represents a city or country and displays the corresponding pollutant concentration recorded in the previous 24 hours.
4. The user can click on a specific city or country on the map to view more detailed information.
5. Upon clicking a city or country, the system presents the user with the time series of pollutant concentrations recorded in that location for the previous 2 days.
6. The user can interact with the time series to explore different time intervals or view additional details if available.

Exceptions: None

This use case allows users to explore the map of Europe after completing the game. The map displays pins representing cities or countries, indicating the pollutant concentration recorded in the previous 24 hours. By clicking on a specific city or country, users can access the time series of pollutant concentrations recorded in that location for the previous 2 days. This functionality enables users to gain insights into the pollution trends of specific locations and explore different time intervals for further analysis.

Use Case 4: Show Best/Worst Cities

Participating actors: All users

Entry condition: The user has finished the game.

Flow of events:

1. The user clicks on the "Show Rankings" button.
2. The system generates a table displaying the cities ordered based on pollutant concentration, from best to worst or worst to best.
3. The table includes additional basic statistics related to the pollutant concentration, such as average, maximum, or minimum values.
4. The user can view the rankings and analyze the data presented in the table to identify the cities with the best and worst air quality based on the selected pollutant.

Exceptions: None

This use case allows users to access the rankings of cities based on pollutant concentration. By clicking on the "Show Rankings" button, the system generates a table that lists the cities, ordered either from best to worst or worst to best, based on the pollutant concentration. The table may also provide additional basic statistics to enhance the understanding of the pollutant levels in each city. Users can review the rankings and gain insights into the cities with the best and worst air quality for the selected pollutant.

Use Case 5: Show Hazard

Participating actors: All users

Flow of events:

1. The user clicks on the "Show Hazard" button.
2. The system updates the colors of the countries on the map based on their pollutant concentration relative to a reference value considered dangerous for human health.
3. Countries with pollutant concentrations below the reference value may be displayed in green or other safe colors.
4. Countries with pollutant concentrations exceeding the reference value may be displayed in red or other warning colors.
5. The user can visually identify the countries that pose a potential hazard to human health based on the updated color scheme.

Exceptions: None

This use case enables users to visualize the hazard level of countries based on their pollutant concentration relative to a reference value. By clicking on the "Show Hazard" button, the system updates the colors of the countries on the map. Countries with pollutant concentrations below the reference value are displayed in safe colors, while countries with pollutant concentrations above the reference value are highlighted in warning colors. This visual representation allows users to identify the countries that may pose a potential risk to human health due to high pollutant levels.

Use Case 6: Compare Countries

Participating actors: All users

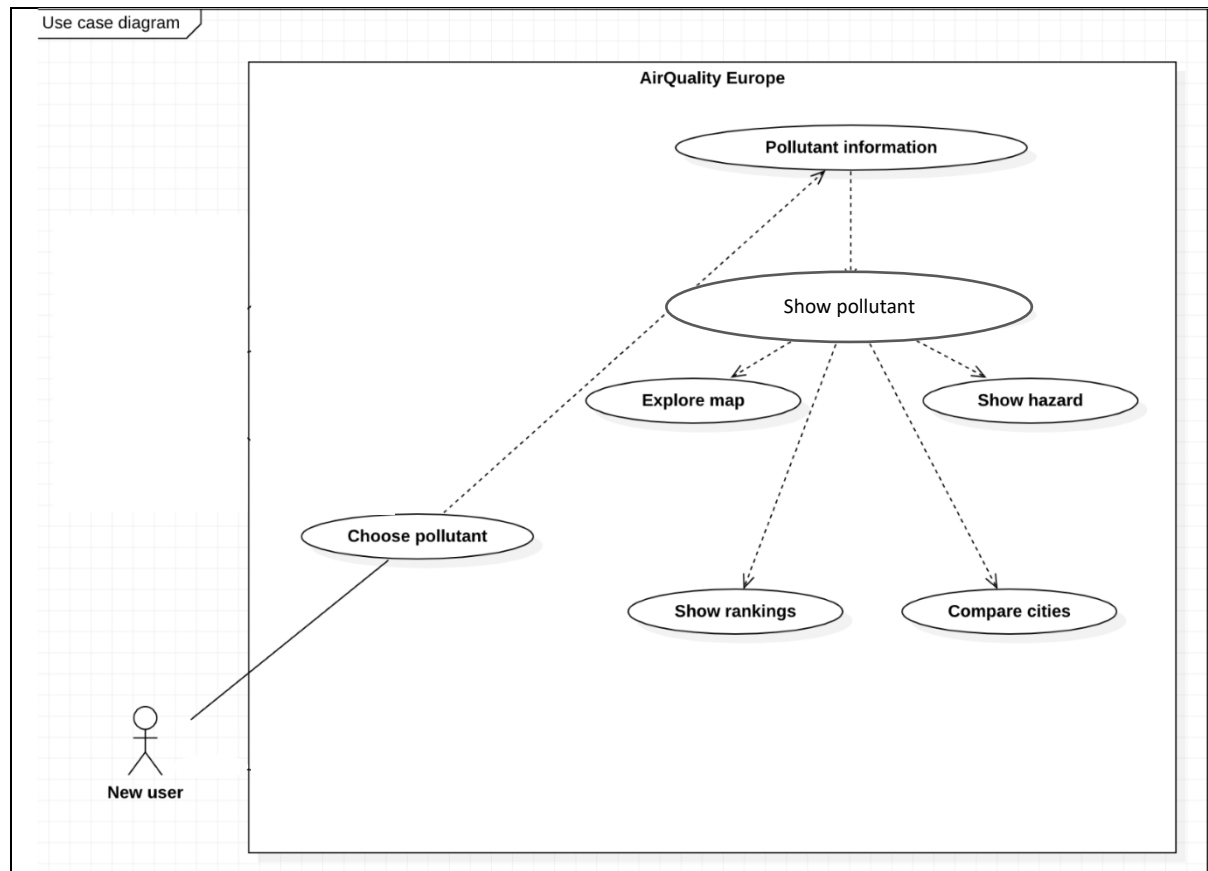
Flow of events:

1. The user clicks on the "Compare Countries" button.
2. The user is presented with a list of countries to choose from for comparison.
3. The user selects the countries they want to compare from the list.
4. The system generates a graph displaying the time series of pollutant data for the selected countries over the last 2 days.
5. Each country's data is represented by a different color on the graph for easy comparison.
6. The user can analyze the graph and observe the pollutant trends in the selected countries over the specified time period.

Exceptions: None

This use case allows users to compare the pollutant data of different countries. By clicking on the "Compare Countries" button, the user can select the countries they want to compare. The system generates a graph displaying the time series of pollutant data for the selected countries over the last 2 days, with each country represented by a different color. This functionality enables users to visually compare the pollutant trends and observe any variations or similarities in air quality between the selected countries.

Use case diagram



Requirements and Domain Assumptions

The following requirements outline the key functionalities, non-functional aspects, and technological specifications for developing an air quality monitoring web application:

Functional Requirements:

1. Map Feature: Implement a map-based visualization of air quality and weather data for enhanced observation.
2. Dashboard Feature: Develop a user-friendly dashboard to visualize and analyze sensor data in various formats.
4. Data Ingestion: Retrieve air quality and weather sensor data from public digital archives and store it in a secure database.
5. Data Retrieval: Provide a REST API for efficient querying and retrieval of air quality and weather sensor data from the database.
6. Data Visualization: Create an interactive dashboard that allows users to customize views and interact with air quality and weather data.

7. Data Processing: Support essential data processing functions, including trend analysis and data sorting.

Non-Functional Requirements:

1. Usability: Ensure a user-friendly interface, easy navigation, and clear instructions with proper feedback.
2. Performance: Optimize the application to handle user requests and data processing efficiently.

Technological Requirements:

1. Database: Utilize PostgreSQL for reliable storage and management of data.
2. Web server: Implement Flask as the web server framework for streamlined development.
3. Dashboard: Leverage Jupyter Notebooks and Jupyter widgets to create an engaging and interactive dashboard.
4. Programming language: Develop the application using Python 3.x for its versatility and extensive libraries.
5. Data processing and utilities: Utilize Pandas and GeoPandas for efficient data processing.

Additionally, certain assumptions were made, including the availability of the project repository on GitHub, reliable and secure server hosting, users' basic knowledge of air quality and weather measurements, stable APIs for data access, availability of free data from digital archives, and the dedicated use of the application for air quality and weather monitoring.

By adhering to these requirements and assumptions, the aim is to build a comprehensive air quality monitoring web application that enables users to visualize, analyze, and retrieve air quality and weather data effectively.

Conclusion

In conclusion, this document outlines the requirements for developing an air quality monitoring web application. The functional requirements emphasize the importance of providing a map-based view and a dashboard for visualizing and analyzing air quality and weather sensor data. Data ingestion, retrieval, visualization, and processing functionalities are crucial for obtaining meaningful insights from the collected data.

The non-functional requirements highlight the significance of usability, ensuring that the application is user-friendly, easy to navigate, and provides clear instructions and feedback. Performance optimization is crucial to handle user requests and data processing efficiently, ensuring a seamless user experience.

The technological requirements specify the tools and technologies to be employed in the development process. PostgreSQL is chosen as the database management system, Flask as the web server framework, and Jupyter Notebooks along with Jupyter widgets for creating an interactive dashboard. Python 3.x, Pandas, and GeoPandas are selected for programming, data processing, and utilities.

Several domain assumptions are made regarding the availability of the project repository, reliable server hosting, user knowledge, stable APIs, free data access, and the dedicated use of the application for air quality and weather monitoring.

By fulfilling these requirements and considering the assumptions, the aim is to develop a comprehensive air quality monitoring web application that provides users with intuitive visualizations, efficient data retrieval, analysis capabilities, and a seamless user experience. Such an application would contribute to

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enhancing awareness of air quality and weather conditions, enabling users to make informed decisions and take necessary actions to mitigate environmental impacts.

References

1. "MYWAY D2.1 Requirement Specification and Analysis" by European Commission - This document provides a requirement specification and analysis for a traffic-related air quality monitoring system. It can be accessed at:

<https://cordis.europa.eu/docs/projects/cnect/3/609023/080/deliverables/001-MYWAYD21RequirementSpecificationAndAnalysiscnectddg1h520142537023.pdf>

2. "RASD-1: Requirements Analysis and Specification Document" by Politecnico di Milano - This document presents a requirements analysis and specification for a software system. It can be found at:

https://webeep.polimi.it/pluginfile.php/968190/mod_folder/content/0/RASD-1.pdf?forcedownload=1

3. "RASD-2: Requirements Analysis and Specification Document" by Politecnico di Milano - This document continues the requirements analysis and specification for the same software system mentioned above. It is available at:

https://webeep.polimi.it/pluginfile.php/968190/mod_folder/content/0/RASD-2.pdf?forcedownload=1

4. "Air Quality Index" by Robert L. Lux and C. Arden Pope - This publication by the U.S. Environmental Protection Agency discusses the air quality index, providing information on how air quality is assessed and categorized. It was published in 2009.