Software Requirements Specification

for

< Simulating Traffic Prediction on Urban Road Network using Machine Learning>

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1. Introduction

1.1 Purpose

This document plays a pivotal role in outlining the requirements for my final year project, which involves the development of a web application dedicated to simulating traffic predictions on an urban road network using machine learning. Its primary purpose is to provide a comprehensive guide for my academic project, offering a clear and structured overview of the project's objectives, scope, and functionalities. Key components, including user scenario creation, integration with the SUMO simulator, and the implementation of machine learning algorithms, are highlighted. The document also addresses administrative functionalities, system configurations, and considerations for logging and monitoring. Non-functional requirements, such as performance, security, usability, and scalability, are outlined to establish evaluation criteria for the success of the web application. In essence, this document serves as a roadmap and contractual agreement for the systematic development of my academic project, which aims to seamlessly integrate user input, traffic simulation, and machine learning to deliver accurate predictions for urban road networks.

1.2 Document Conventions

This document follows standard document conventions.

1.3 Intended Audience and Reading Suggestions

This document is tailored for developers, project managers, and stakeholders actively engaged in the development and implementation of the Traffic Simulation web application for urban road networks utilizing machine learning. It is strongly recommended that all involved parties carefully examine the entire document to gain a comprehensive understanding of the project's specific requirements and functionalities.

1.4 Project Scope

The project scope involves the development of a web application designed to facilitate traffic prediction simulations on an urban road network, utilizing machine learning methodologies. Within this scope, the application aims to provide a user-friendly experience through features such as user registration and login functionalities. New users are required to register by providing their email, while returning users can access the system using their unique username and password. The main functionality of the application lies in two distinct scenario creation approaches: a map-based approach and a form-based approach. Users can define custom traffic scenarios using either method, leading to the initiation of simulations through the SUMO simulator. The results of these simulations, alongside predictive insights generated by machine learning algorithms, are then presented to the user. Additionally, the scope encompasses a feature allowing users to access and review their previous simulation and prediction results, fostering a comprehensive and iterative user experience within the context of traffic prediction simulations.

2. Overall Description

2.1 Product Perspective

The Traffic Simulation web application operates within a broader technological context, integrating seamlessly with external components to provide a comprehensive user experience. At its core, the application serves as a user interface, allowing individuals to interact with the SUMO simulator for accurate traffic simulations and leveraging machine learning algorithms for predictive insights. While the application acts as a standalone system, its perspective is integrative. It interfaces with the SUMO simulator for traffic simulations and relies on machine learning models for predictive analysis. The application is designed to be user-centric, offering a range of functionalities for creating custom traffic scenarios, visualizing simulation results, and accessing historical data. This product perspective underscores the interconnected nature of the Traffic Simulation web application within the broader landscape of traffic simulation tools and machine learning applications, aiming to provide users with a comprehensive and integrated solution for urban road network analysis.

2.2 Product Features

The Traffic Simulation web application boasts a range of features designed to provide users with a robust and intuitive platform for urban road network analysis. These features include:

User Authentication:

Registration and Login: The application provides a straightforward registration process for new users, requiring an email for account creation. Returning users can efficiently log in using a unique username and secure password. This feature ensures personalized user experiences and secure access control.

Scenario Creation:

Map-Based Approach: Users engage in an immersive experience by defining traffic scenarios on a graphical map. Parameters such as traffic density, road types, and special events are dynamically set on the map, offering a spatially intuitive approach to scenario creation.

Form-Based Approach: For users preferring structured input, a comprehensive form-based approach is available. This allows users to input specific parameters like time of day, weather conditions, and vehicle types through a user-friendly form, ensuring a detailed and systematic scenario definition.

Simulation Integration:

SUMO Simulator Interaction: The application seamlessly integrates with the Simulation of Urban MObility (SUMO) simulator. This key integration enables users to translate their defined scenarios into realistic traffic simulations, providing a dynamic representation of traffic behaviors on urban road networks.

Machine Learning Predictions:

Algorithmic Analysis: Leveraging machine learning algorithms, the application analyzes simulation results from SUMO. This feature provides users with predictive insights into potential traffic patterns, congestion scenarios, and other dynamic aspects, enhancing the analytical capabilities of the application.

Result Visualization:

User-Friendly Displays: Simulation outcomes and machine learning predictions are presented through visually intuitive displays, including graphs, charts, and maps. This ensures that users can easily interpret and analyze complex data, facilitating effective decision-making based on simulation results.

Historical Data Access:

Review and Comparison: Users can access and review their historical simulation and prediction results. This feature supports iterative analysis, enabling users to compare different scenarios and gain insights into the evolution of traffic patterns over time.

User-Friendly Interface:

Intuitive Design: The application boasts a thoughtfully designed user interface for a seamless and user-friendly experience. Navigating between creating scenarios, viewing results, and accessing historical data is intuitive, catering to users with varying levels of expertise.

These features collectively form a comprehensive and powerful Traffic Simulation web application, providing users with diverse tools for creating, simulating, and analyzing traffic scenarios on urban road networks. The combination of interactive approaches, advanced simulation techniques, and machine learning insights contributes to a versatile and adaptable platform for urban mobility analysis.

2.3 User Classes

The Traffic Simulation web application caters to distinct user classes, each with specific roles and responsibilities tailored to their interaction with the system:

Registered Users:

Access Level: Full access upon successful registration and login.
Responsibilities: Registered users have the ability to create, simulate, and analyze custom traffic scenarios using both map-based and form-based approaches. They can access historical data, review previous simulation and prediction results, and enjoy a personalized and interactive experience within the application.

System Administrators:

Access Level: Highest level of access and control.
Responsibilities: Administrators have the authority to configure and manage system settings, ensuring optimal performance and adaptability. They oversee user accounts, security protocols, and system maintenance. Additionally, administrators play a key role in addressing technical issues, ensuring data integrity, and facilitating the overall smooth operation of the Traffic Simulation web application.

This refined user classification ensures that registered users are the primary users of the application, actively engaging in scenario creation and analysis, while system administrators maintain control and oversight to ensure the system's proper functioning.

3. System Features

The Traffic Simulation web application is equipped with a comprehensive set of features to provide users with a powerful and intuitive platform for urban road network analysis. These features include:

3.1 User Authentication

This feature is responsible for user authentication and authorization within the system.

3.1.1 Purpose

- This crucial feature is designed to ensure the security of user data and provide a robust access mechanism. It facilitates a personalized user experience through the creation of user accounts, requiring a unique email during registration, and employing secure login credentials.

3.1.2 Acceptance Criteria

- Users must be able to successfully log in using valid credentials, including a unique username and password.
- Role assignment should occur seamlessly upon registration, ensuring users are categorized appropriately (e.g., researcher, student).
- Access permissions are strictly enforced, allowing users access only to features and resources aligned with their assigned roles.
- Administrators should have access to user management features for assigning roles and facilitating password resets.

3.2 User Registration

This feature allows new users to register for an account within the system.

3.2.1 Purpose

- This feature allows new users to register by providing necessary details such as email, creating a unique username, and setting a secure password.

3.2.2 Acceptance Criteria

- New users must be able to complete the registration form, providing required information.
- The system should verify that the provided username and email address are unique.
- Upon successful registration, users should receive a confirmation email.
- Users should be able to log in immediately after registration.

3.3 Scenario Creation

3.31 Purpose

- This feature empowers users to create diverse traffic scenarios through both a map-based and a form-based approach. The goal is to cater to various user preferences in defining scenarios, offering both spatially intuitive and detailed parameter input options.

3.3.2 Acceptance Criteria

- Users should be able to successfully create scenarios using the map-based approach by dynamically interacting with the graphical map.
- The form-based approach should enable users to input specific parameters accurately, contributing to a detailed and systematic scenario creation process.
- The system must accurately interpret both map-based interactions and form-based inputs, ensuring a seamless scenario creation experience.

3.4 Simulation Integration

3.4.1 Purpose

- This integral feature ensures a seamless integration of the application with the SUMO simulator. By doing so, it enables users to observe realistic representations of urban traffic behaviors based on their defined scenarios.

3.4.2 Acceptance Criteria

- The application must interface effectively with the SUMO simulator, initiating accurate and dynamic traffic simulations.
- Simulation results should align closely with expected traffic behaviors, providing users with a reliable and realistic representation of their defined scenarios.

3.5 Machine Learning Predictions

3.5.1 Purpose

- This advanced feature integrates machine learning algorithms to analyze simulation results. Its primary purpose is to provide users with predictive insights into potential traffic patterns, congestion scenarios, and other dynamic aspects.

3.5.2 Acceptance Criteria

- Machine learning algorithms must accurately analyze simulation results, offering users meaningful and reliable predictive insights.
- Predictions generated by the system should align with real-world traffic dynamics, enhancing the overall analytical capabilities of the application.

3.6 Result Visualization

3.6.1 Purpose

- Focused on user experience, this feature presents simulation outcomes and machine learning predictions through visually intuitive displays. Its aim is to facilitate easy interpretation and analysis of complex data.

3.6.2 Acceptance Criteria

- Visualizations, including graphs, charts, and maps, must be presented in a user-friendly manner, ensuring users can interpret and analyze results effortlessly.
- The visual representation should contribute to effective decision-making based on simulation outcomes.

3.7 Historical Data Access

3.7.1 Purpose

- This feature allows users to access and review their historical simulation and prediction results, fostering iterative analysis and scenario comparison.

3.7.2 Acceptance Criteria

- Users should be able to successfully access and review their historical data, supporting a comprehensive understanding of the evolution of traffic patterns.
- The system must facilitate the comparison of multiple scenarios over time, enabling iterative analysis and insights.

3.8 User-Friendly Interface

3.8.1 Purpose

- Centered on usability, this feature emphasizes a thoughtfully designed user interface to ensure a seamless and user-friendly experience. It enables users to navigate effortlessly across different functionalities.

3.8.2 Acceptance Criteria

- The interface must be intuitive and user-friendly, promoting ease of navigation between creating scenarios, viewing results, and accessing historical data.
- Users should find the interface accessible and conducive to a positive overall experience.

3.9 System Configuration

3.9.1 Purpose

- Providing administrative control, this feature empowers system administrators to configure and manage system settings, ensuring optimal performance and adaptability to evolving project requirements.

3.9.2 Acceptance Criteria

- System administrators must be able to successfully configure and manage system settings, adapting the system to changing project requirements.
- The system should demonstrate adaptability to changes without compromising performance or security, meeting the evolving needs of the project.

4. Other Nonfunctional Requirements

4.1 Performance Requirements

In ensuring optimal performance, the application must not only be responsive but also efficient in handling simulations. The target response time of 2 seconds for user actions emphasizes a seamless user experience, while simulations concluding within 5 minutes for average scenarios is crucial for preventing user frustration. This ensures that users can interact with the application swiftly and receive timely results, enhancing overall satisfaction.

4.2 Scalability Requirements

Scalability is a key consideration for accommodating the application's growth. The system should gracefully handle a 20% increase in simultaneous users and a doubling of data volume without compromising performance. This scalability ensures that as the user base expands, the application can maintain its responsiveness and provide a consistent experience to all users.

4.3 Security Requirements

Security is paramount in safeguarding user data. Beyond encryption and strict access controls, additional measures such as intrusion detection systems and regular security assessments should be implemented. This comprehensive approach ensures continuous protection against evolving security threats, maintaining user trust and confidence in the application.

4.4 Reliability Requirements

Reliability is fundamental for user trust. Achieving a 99.9% uptime requires not only robust server infrastructure but also effective monitoring systems for detecting and addressing issues promptly. Communicating scheduled maintenance well in advance ensures users are informed, minimizing disruptions and reinforcing the application's reliability.

4.5 Usability Requirements

Usability extends beyond interface design to user onboarding and guidance. Providing interactive tutorials or tooltips can enhance the learning curve, ensuring that users can proficiently navigate the application within the targeted 10-minute usability benchmark. User feedback mechanisms should also be in place to continuously improve usability based on user experiences.

4.6 Compatibility Requirements

Ensuring compatibility involves thorough testing on various platforms and devices. Beyond common web browsers, the application should be optimized for accessibility, considering users with

disabilities. Compatibility checks should extend to different screen sizes, ensuring a consistent and user-friendly experience across diverse environments.

4.7 Maintainability Requirements

Maintainability is critical for the long-term viability of the application. Going beyond code documentation, a version control system, and modular coding practices facilitate easier updates and troubleshooting. Automated testing procedures should be in place to ensure that new updates do not introduce unintended issues, and regular code reviews can maintain code quality.

4.8 Compliance Requirements

Compliance goes beyond meeting basic regulations; it involves an ongoing commitment to ethical data use. Regular internal audits should be complemented by third-party assessments to ensure adherence to GDPR guidelines and other relevant data protection regulations. Transparent communication with users about data handling practices further reinforces the application's commitment to compliance and ethical standards.