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**CEF 440: Internet programming and mobile programming**

**Design and Implementation of a Road Sign and Road State Mobile Notification Application**

Group 15

**TASK 3: REQUIREMENT ANALYSIS**

[GitHub - Asumu22/group-15](https://github.com/Asumu22/group-15)

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Abstract

This document presents a requirements analysis for a mobile application designed to assist drivers with real-time road sign recognition and road state information. The analysis emphasizes a structured approach to ensure user safety and a user-friendly experience. Key steps include scrutinizing the completeness, clarity, and technical feasibility of initial requirements, identifying any inconsistencies or missing details, and prioritizing features based on importance and development effort. Stakeholder feedback through user interviews and consultations with domain experts further refines the requirements. Finally, a clear and concise requirements document is created, encompassing both functional and non-functional requirements along with acceptance criteria. This analysis provides a roadmap for developing a well-defined application that prioritizes user needs and driver safety.

Contents

[Introduction 3](#_Toc166530863)

[1. Review and Analyze Gathered Requirements 3](#_Toc166530864)

[2. Identify Inconsistencies, Ambiguities, and Missing Information 4](#_Toc166530865)

[3. Prioritize Requirements based on Importance and Feasibility 5](#_Toc166530866)

[4. Validate Requirements with Stakeholders 7](#_Toc166530867)

[5. Document Final, Refined Requirements 7](#_Toc166530868)

[5.1 Functional Requirements: 7](#_Toc166530869)

[5.2 Non-Functional Requirements: 10](#_Toc166530870)

[5.3 Acceptance Criteria: 11](#_Toc166530871)

[Conclusion: 12](#_Toc166530872)

**Requirements Analysis for Road Sign and Road State Mobile Notification Application.**

# **Introduction**

Requirements Analysis is the heart of a successful software development project. It's where you take the raw desires and needs (gathered requirements) and transform them into a clear, actionable roadmap for development.

This document outlines the requirements analysis for a mobile application designed to provide drivers with real-time information on road signs and road state. The analysis is based on the information provided in the requirements gathering document and focuses on ensuring the application delivers a safe and user-friendly experience. Here's a breakdown of the key activities involved:

# **1. Review and Analyze Gathered Requirements**

This initial step involves a thorough examination of the information collected during the requirements gathering phase. The goal is to ensure:

* **Completeness:** Are there any essential functionalities missing for the application to function effectively?
* **Clarity:** Are the requirements clearly defined, with specific details about functionalities and data types? (e.g., Does the document specify supported sign types or notification customization options could be voice ot text?)
* **Technical Feasibility:** Can the desired features be realistically implemented with current technology considering device limitations? (e.g. network connectivity for real-time updates?)
* **Understand the "why" behind the "what":** Don't just accept requirements at face value. Ask questions to understand the underlying needs and motivations.
* **Identify dependencies and relationships:** Are there requirements that rely on others being implemented first? How do different features interact?

### Application to Road Sign App:

We will scrutinize the gathered requirements for the Road Sign and Road State Mobile Notification Application, ensuring all crucial functionalities are accounted for (e.g., real-time sign recognition, user interface for notifications). We will also verify if the requirements are clearly described with specific details (e.g., supported sign types) and assess their technical feasibility considering limitations of mobile devices and network connectivity.

# **2. Identify Inconsistencies, Ambiguities, and Missing Information**

This step focuses on identifying any gaps or unclear details within the requirements that could hinder development. We look for:

1. **Inconsistencies (**overlapping functionalities**):** Are there any contradictions or conflicts within the requirements that need to be resolved?

* the requirements gathring document mention both AR navigation and route planning functionality without clarifying if they are separate features?

1. **Ambiguities (**Uncover unclear language) **:** Are there any unclear or unspecified aspects of a requirement that need further definition?

* Does the document specify the level of detail needed for lane detection in AR navigation? .
* **User Profiles:** The document mentions user profiles but doesn't specify what data will be stored or how it will be used. This needs clarification to ensure user privacy is protected.

1. **Missing Information (**Find the gaps**):** Are there any essential details missing from a requirement that need to be identified and addressed?

* the requirements gathring document does not specify how the application will handle situations where AR navigation might be unreliable?)

### **Application to Road Sign App:**

We will analyze the requirements for the Road Sign App, identifying any inconsistencies (e.g., overlapping functionalities) or ambiguities (e.g., unclear level of detail for AR navigation). Additionally, we will highlight any missing information (e.g., handling unreliable AR navigation situations) that needs to be addressed before development begins. **User Profiles:** The document mentions user profiles but doesn't specify what data will be stored or how it will be used. This needs clarification to ensure user privacy is protected.

# **3. Prioritize Requirements based on Importance and Feasibility**

Not all requirements carry the same weight. Here, we categorize them based on two key factors:

* **Importance:** Not all requirements are created equal. How critical is a feature to the core functionality of the application and user safety? (e.g., Traffic light detection is highly important for safety)
* **Feasibility:** Consider the effort involved. How complex and resource-intensive is it to implement a feature with current technology and resources? (e.g., AR navigation might be less feasible than basic route planning)

### **Buea Specifics influencing technical feasibility and user needs:**

**a. Network Connectivity:**

* **Availability:** Internet connectivity in Buea can vary depending on location. Investigate the prevalence of reliable 3G/4G networks in areas where the application will be used.
* **Data Costs:** Data usage associated with features like real-time traffic updates and map downloads, options for offline functionalities (e.g., pre-downloaded maps) or data-saving measures for users on limited data plans.

**b. Road Infrastructure and Signage:**

* **Road Sign Standards:** The application's computer vision algorithms for sign recognition will need to be trained on these specific signs.
* **Road Conditions:** Potholes, narrow lanes the impact on features like lane detection and navigation accuracy.

**c. User Demographics and Preferences:**

* **Device Availability:** The most common smartphones and operating systems used in Buea.
* **Language Support:** English and French, catering to the multilingual population of Buea.
* **User Preferences:** understand their preferred notification types (e.g., audio/visual), data privacy concerns.

**d. Regulatory Environment:**

* **Data Privacy Laws**

### **Prioritization Matrix:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Importance** | **High** | **Medium** | **Low** |
| **High Feasibility** | Must-Have | Should-Have | Consider Later |
| **Medium Feasibility** | Should-Have | Consider Later | May Not Include |
| **Low Feasibility** | Consider Later | May Not Include | Not Included |

### **Application to Road Sign App:**

We will utilize a prioritization matrix to categorize the requirements for the Road Sign App. This ensures critical features for user safety are designated as "Must-Have," while less essential but valuable features might be "Consider Later" depending on technical limitations.

|  |  |  |  |
| --- | --- | --- | --- |
| **Must-Have** | **Should-Have** | **Consider Later** | **MayNot Included** |
| Real-time Road Sign Recognition | Route Planning | Scalable Infrastructure | A R Navigation |
| Traffic Light and Sign Detection | User Profiles | Pedestrian Detection |  |
| Real-time Processing | Accurate Navigation Information |  |  |
| Navigation Integration | Modular Design |  |  |
| High Detection Accuracy | Minimized Interruptions |  |  |
| Broad User Accessibility | Touch Screen Responsiveness |  |  |
| Data Protection and Data Encryption | Simple and Responsive Interface |  |  |
|  |  |  |  |

# **4. Validate Requirements with Stakeholders**

This step involves getting feedback and refining the requirements through discussions with key stakeholders. Aims here are;

* **Ensure everyone is on the same page**
* **Address concerns and clarifications**

# **5. Document Final, Refined Requirements**

This final step involves creating a clear and concise requirements document incorporating the insights from stakeholder validation. Using **standardized format:** This that ensures everyone **understands the structure and terminology** used and **maintaining the document throughout the project a**s requirements evolve, the document is updated to reflect the latest agreed-upon state.. The document will include:

## 5.1 Functional Requirements:

Based on the analysis of user needs and project goals, we have identified the following functional requirements to enhance the application's capabilities:

1. **Real-time Road Sign Recognition:**

The application will leverage computer vision techniques to identify and display relevant road sign information overlaid directly onto the user's view of the road using the device's camera

1. **Location-Aware Information and Navigation:**
2. **Location-based Information:**

The application will use GPS to determine the user's location and display relevant road sign information overlaid on a map. This map integration will allow users to visualize their surroundings and road sign placements.

1. **Real-time Road State Updates:**

The application should provide real-time information about road conditions, including traffic congestion, accidents, construction work, and road closures.

1. **Interactive Maps:**

Users should be able to view road conditions on interactive maps, with options to zoom in, switch between different map views (e.g., satellite, terrain), and search for specific locations.

1. **Navigation Integration (Optional):**

The application will explore integration with popular navigation apps (e.g., Google Maps, Waze) to allow users to view road sign information and real-time updates within their preferred navigation interface. APIs or libraries will be investigated to facilitate this integration.

1. **Augmented Reality Navigation (Optional):**

The application will leverage Augmented Reality (AR) to provide turn-by-turn navigation instructions directly overlaid on the user's view of the road using the device's camera. Arrows superimposed on the road scene will guide the driver and clearly indicate upcoming turns. Integration with image processing and computer vision techniques will enable real-time road boundary and lane detection, enhancing navigation accuracy.

* + **Identify limitations:** AR depends on factors like lighting conditions, complex road environments, or limitations of the device's camera and sensors.

### Outline how the application handles unreliable(failure) AR scenarios:

* + **Fallback mechanism:** plan when AR navigation becomes unreliable. This could involve:
* Switching to a standard 2D map view with clear directions.
* Providing visual or audio cues to alert the driver of the AR unreliability and advise them to rely on alternative navigation methods (e.g., following road signs).
  + **User feedback:** Consider incorporating a mechanism for users to report areas where AR navigation is unreliable. This feedback can be used to improve the system's performance in future updates.

1. **Traffic Light and Sign Detection:**

The application will continuously analyze live camera footage using computer vision algorithms to detect traffic lights and signs in real-time. Upon detecting a traffic light, the application will display the current light color on the user's screen and provide a pop-up notification for red lights, promoting safe driving practices. Traffic sign detection will trigger the display of the identified sign's meaning and significance on the user's screen. Signs requiring immediate attention, such as stop signs, can have additional pop-up alerts for enhanced awareness.

1. **Pedestrian Detection (Optional):**

The application will employ computer vision to analyze live camera footage and detect pedestrians on the road. Upon detecting a pedestrian, the application will highlight their location on the user's screen and display a warning message to alert the driver.

1. **User Reporting:**

Users will be empowered to contribute to the overall road state awareness by reporting incidents or hazards they encounter on their journeys. This functionality will allow for crowdsourced data collection, improving the accuracy and real-time nature of road condition information within the application.

1. **Route Planning:**

The application should offer route planning functionality, considering road conditions, traffic congestion, and estimated travel times.

1. **User Profiles:**

Users should be able to create profiles, customize their preferences, and save frequently used routes for quick access.

**Specify the data to be stored:**

* + Includes, user names , age, Drivers License ID, preferred notification types (visual/audio), preferred map views(satelite / terrain), saved frequent routes, language preferences.

**Explain data usage:** how the collected data be used to enhance the user experience

* Personalizing notification settings based on user preferences (e.g., audio alerts for critical signs only).
* Offering quick access to frequently used routes.
* Tailoring the user interface language based on user preferences.

## 5.2 Non-Functional Requirements:

Building upon the provided information, here's a revised and enhanced list of non-functional requirements for the mobile application:

**1. Reliability:**

* **Accurate Navigation Information:** The application must consistently provide accurate route planning, direction arrows, traffic light and sign recognition, and SOS message delivery with user location.
* **Minimized Interruptions:** The application should operate smoothly with minimal interruptions throughout a car trip, ensuring uninterrupted navigation and service delivery from initiating navigation to reaching the destination (assuming sufficient battery and network connectivity).

**2. Performance:**

* **Real-time Processing:** The application should achieve a high frame rate during live camera feed processing to minimize delays in information display and user interaction. The application shall maintain a processing delay of less than 2 seconds for real-time sign recognition to ensure minimal visual distraction for drivers.
* **High Detection Accuracy:** The implemented detection models for traffic lights, signs, and pedestrians must demonstrate high accuracy to ensure reliable information delivery.
* **Touch Screen Responsiveness:** The application needs to deliver a seamless user experience with a fast response time for touch screen interactions.
* **Efficient Mobile Performance:** The application should be optimized to function effectively within the limitations of mobile hardware, ensuring smooth operation without being overly resource-intensive.

**3. Usability:**

* **Broad User Accessibility:** The application should be designed with a wide range of user demographics in mind, catering to drivers with varying levels of technological experience.
* **Simple and Responsive Interface:** The user interface needs to be highly responsive, uncluttered, and designed to minimize user interaction complexity while driving. This includes ensuring large, easily identifiable buttons, clear information presentation, and short response times (under a minute).
* **Minimized Driver Distraction:** The application should prioritize minimizing distractions for drivers. This can be achieved by avoiding intrusive sounds, maintaining a clean UI layout, and minimizing user input requirements (e.g., auto-closing pop-ups after a reasonable time).

**4. Security and Privacy:**

* **Data Protection:** The application must employ robust security measures to protect user data privacy, including location information, notification preferences, and any user-generated content.
* **Data Encryption:** Sensitive data should be encrypted both in storage and during transmission to minimize the risk of exposure in case of potential security breaches.

**5. Maintainability and Scalability:**

* **Modular Design:** The application architecture should be modular to facilitate future maintenance, updates, and feature additions.
* **Scalable Infrastructure:** The backend infrastructure supporting the application should be designed with scalability in mind to accommodate a growing user base and data volume.

## 5.3 Acceptance Criteria:

Clear benchmarks for success for each prioritized requirement. By establishing clear acceptance criteria, you **can ensure that the application meets your functional and non-functional requirements and provides a valuable experience for users.**

Here are  acceptance criteria for prioritized requirements:

* **Real-time Road Sign Recognition:**
* The application shall achieve an accuracy of **90%** for a defined set of commonly encountered road signs (e.g., stop signs, speed limit signs, yield signs) under good lighting conditions.
* The application's response time for sign recognition should be less than **1 second** after capturing an image or receiving a video frame.
* **Traffic Light and Sign Detection:**
* The application shall correctly identify and display the current state (red, yellow, green) of traffic lights with an accuracy of **95%** in well-lit environments.
* The application shall achieve an accuracy of **85%** for detecting and displaying a defined set of high-priority signs (e.g., stop signs, yield signs) within the camera frame.
* **Real-time Processing:**
* The application shall maintain a frame rate of at least **15 frames per second (FPS)** during live camera feed processing to ensure minimal delays in information display.
* **Accurate Navigation Information:**
* The application's location information displayed on the map shall have a horizontal accuracy of less than **10 meters** (95% of the time).
* **Minimized Interruptions:**
* The application allow users to customize notification preferences (e.g., audio vs. visual) to further minimize distractions. Critical alerts (e.g., red light warnings) should be clear and non-intrusive.
* **Broad User Accessibility:**
* The application interface should be usable by individuals with varying levels of technical experience. The interface should be intuitive and easy to navigate.
* **Data Protection and Data Encryption:**
* All user data, including location information, notification preferences, and user-generated content (if applicable), must be encrypted both at rest and in transit using industry-standard encryption algorithms.

# Conclusion:

A thorough requirements analysis ensures the Road Sign and Road State Mobile Notification Application addresses user needs, prioritizes critical features for safety, and leverages technology effectively.

By following these recommendations and building upon the comprehensive requirements analysis, you can develop a Road Sign and Road State Mobile Notification Application that empowers drivers in Buea with real-time information, enhances road safety, and provides a valuable tool for navigating the city's unique roads. Remember, continuous user feedback and adaptation to Buea's specific context will be key to the application's success.