Final Year Project

Software Requirement Specification

For

BlindAssist: Machine Learning Enhanced Object Recognition, GPS tracking, and Speech Feedback

BSCS

By

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1. Introduction

This document serves as a comprehensive guide to the BlindAssist project, detailing its purpose, features, and implementation. The main objective of BlindAssist is to develop an innovative assistive technology solution tailored for individuals with visual impairments. By integrating machine learning-enhanced object recognition, GPS tracking, and speech feedback functionalities, BlindAssist aims to significantly enhance navigation and accessibility for users. This document will provide a detailed overview of the project's features and how they are implemented to create the product.

1.1 Purpose

The purpose of the BlindAssist project is to create a revolutionary assistive technology solution tailored specifically for individuals with visual impairments. By leveraging machine learning-enhanced object recognition, GPS tracking, and speech feedback functionalities, BlindAssist aims to revolutionize the way visually impaired individuals navigate their surroundings. Utilizing a purely hardware-based cane design, BlindAssist integrates seamlessly with Raspberry Pi 4 and specialized modules for GPS tracking and speech feedback. Through this innovative approach, BlindAssist seeks to empower visually impaired individuals with enhanced autonomy, safety, and overall quality of life, offering them newfound independence in their daily lives.

1.2 Document Conventions

Throughout this document, standard conventions and formatting will be followed to ensure clarity and consistency. This includes the use of clear and concise language, consistent terminology, and standardized notation for requirements and specifications. Acronyms and abbreviations will be spelled out upon first use, followed by their abbreviated form in parentheses.

1.2.1. Chapter Heading

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1.2.2. Main Section Heading

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1.2.3. Main Section Sub-heading

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1.2.4. Other Text Explanations

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1.2.5. Figures

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1.3 Intended Audience and Reading Suggestions

The BlindAssist application is primarily designed to cater to individuals with visual impairments, offering them enhanced navigation and accessibility features. However, it can also be utilized by a wide range of users, including:

- **Visually impaired individuals:** Who require assistance in navigating their surroundings and accessing real-time information.
- **Caregivers or support personnel:** Who may assist visually impaired individuals and utilize the application to provide guidance and support.
- **Stakeholders:** Such as family members, friends, or healthcare professionals, who may need to be informed of the user's location or receive updates on their well-being.
- **Developers and designers:** Who are involved in the ongoing development and improvement of the BlindAssist application.
- **Community organizations:** That work with visually impaired individuals and seek to provide them with tools and resources for independent living.

Through its innovative design and inclusive approach, BlindAssist aims to empower visually impaired individuals while also catering to the diverse needs of its user base, enhancing navigation, safety, and overall quality of life for all users.

1.4 Product Scope

The scope of the BlindAssist entails the development of a purely hardware-based cane solution. Equipped with Raspberry Pi 4 and specialized modules for GPS tracking and speech feedback, BlindAssist is tailored to assist visually impaired individuals in navigating their surroundings effectively and independently.

Key aspects of the product scope include:

- **Hardware-Based Cane:** BlindAssist is designed as a cane device integrated with hardware components, including a camera and GPS capability, to provide enhanced navigation assistance.

- **Machine Learning Object Recognition:** Utilizing machine learning algorithms, BlindAssist identifies obstacles, landmarks, and relevant environmental elements to facilitate safer navigation for users.

- **GPS Tracking Functionality:** BlindAssist incorporates GPS tracking functionality to offer accurate location information.

- **Speech Feedback Features:** The device delivers real-time auditory feedback about the user's surroundings, providing essential information through speech synthesis technology.

BlindAssist is engineered to be versatile and adaptable for use in various indoor and outdoor settings, encompassing urban environments, public spaces, and indoor facilities. With a focus on user-friendliness, reliability, and accessibility, BlindAssist caters to individuals with diverse levels of visual impairment, empowering them to navigate with confidence and independence.

2. Overall Description

2.1 Product Perspective

BlindAssist represents an innovative approach to addressing the unique needs of individuals with visual impairments. Unlike existing systems that may offer fragmented functionality or lack seamless integration between essential features, BlindAssist stands out as a comprehensive and user-friendly solution that combines multiple functionalities in a single, integrated platform.

Context and Origin:

BlindAssist emerges as a direct response to the challenges faced by visually impaired individuals in navigating their surroundings independently and safely. While existing systems may provide partial solutions or require users to rely on separate applications for different functionalities, BlindAssist consolidates these features into a cohesive and accessible platform. By leveraging cutting-edge technologies such as machine learning, GPS tracking, and speech feedback, BlindAssist enhances the autonomy and quality of life for individuals with visual impairments.

Relation to Existing Systems:

BlindAssist represents a significant advancement over existing assistive technologies for the visually impaired. Rather than serving as a mere replacement for certain existing systems, BlindAssist introduces a new, self-contained product that integrates state-of-the-art technologies to provide a more comprehensive solution. However, BlindAssist may interface with external systems or services, such as for GPS functionality or speech synthesis services for speech feedback, to enhance its capabilities and user experience further.

Component of a Larger System:

While BlindAssist is primarily a standalone product, it can also be viewed as a crucial component within a larger ecosystem of assistive technologies and accessibility services. By positioning BlindAssist within its broader context and origin, stakeholders can better appreciate its significance and the transformative impact it offers in improving accessibility and independence for individuals with visual impairments.

2.2 Product Functions

BlindAssist: Machine Learning Enhanced Object Recognition, GPS tracking, and Speech Feedback, a purely hardware-based cane utilizing Raspberry Pi 4 and specialized modules for GPS tracking and speech feedback, is designed to provide essential functionalities to assist visually impaired individuals in navigating their surroundings effectively and independently. The major functions of BlindAssist include:

2.2.1. Object Recognition:

Utilizing advanced machine learning algorithms, BlindAssist swiftly identifies obstacles, landmarks, and environmental elements in real-time. This capability enhances user safety and awareness by promptly detecting and notifying users of potential hazards or notable points of interest along their path.

2.2.2. GPS Tracking:

BlindAssist ensures precise location tracking and navigation guidance by leveraging GPS technology. This feature empowers users with accurate positioning information and personalized route guidance, facilitating confident and efficient navigation through unfamiliar environments.

2.2.3. Speech Feedback:

Through intuitive speech feedback functionality, BlindAssist audibly communicates vital information about the user's surroundings and delivers clear, concise navigation instructions. This verbal guidance enhances user autonomy and accessibility, providing real-time assistance to visually impaired individuals as they navigate their surroundings with ease and confidence.

These functions collectively aim to empower visually impaired individuals to navigate their surroundings independently and confidently, enhancing their quality of life and fostering greater autonomy in daily activities.

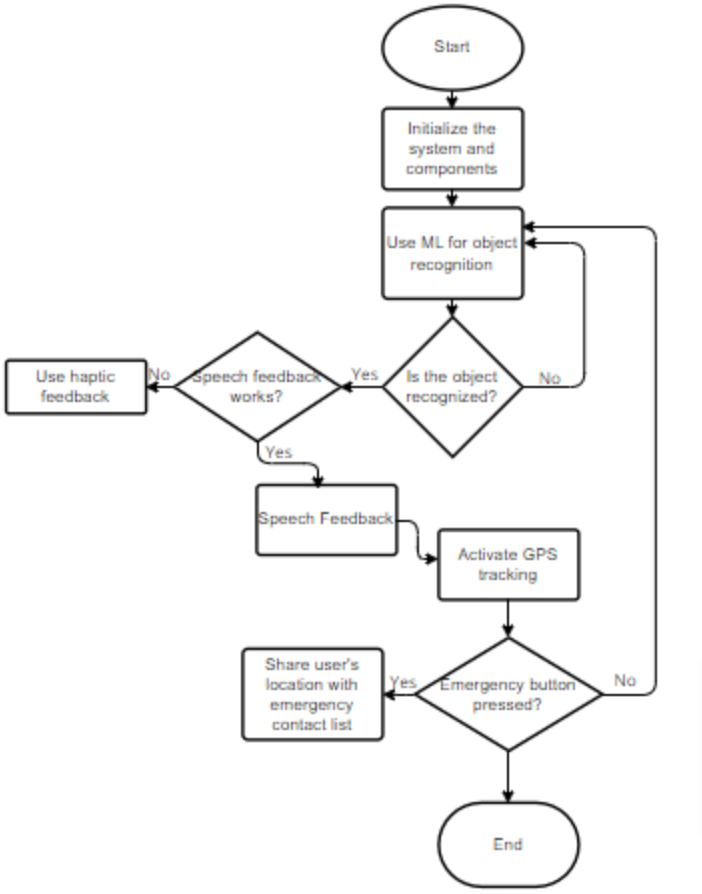

Figure 1 BlindAssist's Flow Diagram

2.3 User Classes and Characteristics

BlindAssist is designed to cater to the needs of various user classes, each with distinct characteristics and requirements. These user classes include:

1. **Visually Impaired Individuals:**
    - *Characteristics:* Users who are visually impaired and rely on assistive technologies for navigation.
    - *Benefits:* Enhanced independence and safety while navigating indoor and outdoor environments using BlindAssist's object recognition, GPS tracking, and speech feedback functionalities.

2. **Sighted Guides or Helpers:**
    - *Characteristics:* Individuals who provide assistance to visually impaired users during navigation.

- *Benefits:* Improved communication and collaboration with visually impaired individuals by utilizing BlindAssist to convey location-specific information and provide navigation guidance.

3. **Developers and Engineers:**
    - *Characteristics:* Technical experts responsible for the development, maintenance, and enhancement of BlindAssist hardware and software components.

    - *Benefits:* Opportunity to contribute to the advancement of assistive technology by designing and implementing innovative features and improvements in BlindAssist.

4. **Healthcare Professionals:**
    - *Characteristics:* Professionals such as rehabilitation therapists or orientation and mobility specialists.

    - *Benefits:* Access to valuable data and insights collected by BlindAssist to assess user progress, tailor interventions, and provide personalized support for visually impaired individuals.

5. **Researchers and Educators:**
    - *Characteristics:* Individuals involved in research or education related to assistive technology and visual impairment.

    - *Benefits:* Access to BlindAssist for research purposes, facilitating the study of user interaction, effectiveness, and usability of assistive technologies for visually impaired individuals.

Each user class stands to benefit from BlindAssist's unique features and functionalities tailored to address the specific needs and challenges faced by visually impaired individuals. By catering to a diverse range of users and use cases, BlindAssist aims to promote inclusivity, independence, and accessibility for individuals with visual impairments.

2.4 Operating Environment

BlindAssist is designed to operate in the following environment:

1. **Hardware Platform:**
- *Raspberry Pi 4:* The primary hardware platform for BlindAssist, providing the computational power and connectivity required for object recognition, GPS tracking, and speech feedback functionalities.
- *Sensor Modules:* Additional hardware components such as cameras for object recognition, GPS modules for location tracking, and audio output for speech feedback are integrated with the Raspberry Pi 4.

2. **Operating System:**
- *Raspbian OS:* The official operating system for Raspberry Pi devices, based on the Debian Linux distribution. BlindAssist is compatible with Raspbian OS versions supported by Raspberry Pi 4.

3. **Software Components:**
- *Machine Learning Libraries:* BlindAssist utilizes machine learning libraries such as TensorFlow for object recognition capabilities. These libraries are compatible with Raspbian OS and Raspberry Pi 4.
- *Speech Synthesis Libraries:* Speech feedback functionality in BlindAssist relies on speech synthesis libraries compatible with Raspbian OS and Raspberry Pi 4.
- *GPS Software:* BlindAssist interfaces with GPS software or APIs to provide accurate location tracking and navigation guidance.

4. **Interoperability:**
- The BlindAssist application is designed to peacefully coexist with other software components or applications running on the Raspberry Pi 4. It does not interfere with the operation of other applications or services on the device.

BlindAssist is optimized to run efficiently on the Raspberry Pi 4 hardware platform and is compatible with the specified operating system and software components, ensuring seamless operation and performance in its intended environment.

2.5 Design and Implementation Constraints

BlindAssist faces several design and implementation constraints that may limit the options available for development. These constraints include:

1. **Machine Learning Model Complexity:** Developing and implementing machine learning algorithms for object recognition requires significant computational resources and expertise. We need to balance model complexity, accuracy, and computational efficiency to ensure optimal performance on resource-constrained devices like Raspberry Pi 4.

   2. Hardware Limitations: BlindAssist operates on portable hardware devices with limited processing power, memory, and battery life. Developers must optimize the application to run efficiently on Raspberry Pi 4 while providing real-time object recognition and navigation guidance.

   3. Privacy and Security Concerns: BlindAssist collects and processes sensitive user data, like location information. Robust security measures must be implemented to protect user privacy and ensure data security.

   4. Regulatory Compliance: BlindAssist may be subject to regulatory requirements related to accessibility standards, data protection laws, and medical device regulations. Developers must ensure compliance with relevant regulations and standards to guarantee the application's legality and safety.

   5. Localization and Internationalization: BlindAssist may be used by users worldwide, necessitating support for multiple languages, cultural preferences, and regional variations. We need to implement localization and internationalization features to adapt the application to diverse user populations.

By effectively addressing these design and implementation constraints, developers can ensure the successful development and deployment of BlindAssist, providing visually impaired users with a robust and accessible assistive technology solution for enhanced navigation and independence.

2.6 User Documentation

The user documentation for BlindAssist will include the following components:

1. User Manual:

- A comprehensive guide detailing the setup process, operation instructions, and troubleshooting tips for BlindAssist.
- Delivery Format: Printable PDF and a manual.

2. Quick Start Guide:

- A condensed version of the user manual providing step-by-step instructions for quick setup and initial usage of BlindAssist.
- Delivery Format: Printable PDF and a quick start guide booklet.

3. Accessibility Documentation:

- Information on accessibility features and options available in BlindAssist to accommodate users with different needs and preferences.
- Delivery Format: Included in the user manual and documentation.

The user documentation will adhere to standard formatting and writing conventions to ensure clarity, accessibility, and ease of use for BlindAssist users.

2.7 Assumptions and Dependencies

2.7.1. Assumptions

1. Hardware Compatibility: It is assumed that the hardware components of BlindAssist, including sensors for object recognition, GPS modules for tracking, and audio output for speech feedback, are compatible with the Raspberry Pi 4 platform and the specialized modules used for GPS tracking and speech feedback.

2. Sensor Accuracy: The assumption is made that the sensors utilized for object recognition and GPS tracking meet the specified requirements for accuracy and reliability. Any deviations or inaccuracies in sensor data may impact the effectiveness and usability of BlindAssist.

3. Speech Feedback Integration: It is assumed that the selected speech feedback modules or components can seamlessly integrate with the Raspberry Pi 4 platform and provide clear, audible instructions and feedback to users.

4. Power Management: BlindAssist is assumed to efficiently manage power consumption on the Raspberry Pi 4 platform to ensure optimal battery life and device longevity, considering the resource constraints of portable devices.

2.7.2. Dependencies

1. GPS Module Dependency: BlindAssist relies on third-party GPS modules or components for accurate location tracking. Any changes or limitations in these components could affect the functionality and reliability of GPS tracking in BlindAssist.

2. Speech Feedback Module Dependency: The speech feedback functionality in BlindAssist depends on third-party speech synthesis modules or libraries for generating audible instructions and feedback. Compatibility issues or changes in these modules could impact the quality and reliability of speech feedback.

3. Software Development Tools: The development of BlindAssist depends on the availability and compatibility of software development tools, compilers, and programming environments suitable for the Raspberry Pi 4 platform and the development of hardware-based solutions.

4. Regulatory Compliance: BlindAssist may be subject to regulatory requirements related to assistive technologies, medical devices, or accessibility standards. Compliance with these regulations and standards is a dependency that may influence the development and deployment of BlindAssist.

3. External Interface Requirements

3.1 User Interfaces

BlindAssist, being a hardware-based cane with integrated modules for GPS tracking and speech feedback, primarily interacts with users through physical and auditory interfaces. While there is no traditional graphical user interface (GUI) as in software applications, there are still logical characteristics to consider for the interaction between the device and its users:

1. Physical Interface:

- The cane itself serves as the primary physical interface between the user and BlindAssist.
- It features ergonomic design elements for comfortable handling and maneuverability.
- The placement and accessibility of buttons or switches for activating and controlling BlindAssist's functionalities, such as turning the device on/off or toggling between modes, are carefully considered.

2. Auditory Interface:

- BlindAssist utilizes speech feedback to communicate information and instructions to the user audibly.
- Clear and natural-sounding speech synthesis is employed to ensure effective communication with visually impaired users.
- Auditory cues and prompts guide the user during navigation, object recognition, and other interactions with BlindAssist.

3. Haptic Feedback (Optional):

- Some versions of BlindAssist may incorporate haptic feedback mechanisms, such as vibrating alerts, to provide additional sensory feedback to the user.
- These haptic feedback features enhance the user experience by providing tactile cues for navigation and interaction.

4. Feedback Mechanisms:

- BlindAssist includes mechanisms for providing feedback to the user about the status of the device, such as battery level, connectivity status, or error alerts.
- Auditory or haptic feedback signals indicate successful activation of features, completion of tasks, or system errors that require attention.

5. User Assistance:

- Instructions for device setup, usage, and troubleshooting may be provided through user manuals, online guides, or tutorials.
- Users may have access to a help button or feature for obtaining assistance or additional information about BlindAssist's functionalities and operation.

While BlindAssist lacks a traditional GUI, its logical characteristics and interface considerations prioritize ease of use, accessibility, and effective communication with visually impaired users through physical and auditory interaction mechanisms.

3.2 Hardware Interfaces

1. **Raspberry Pi 4:**
   - BlindAssist utilizes a Raspberry Pi 4 single-board computer as its core processing unit.
   - The interface includes connections for power supply, input/output (GPIO) pins, USB ports, HDMI output, and audio output.
   - The Raspberry Pi 4 manages data processing, sensor interfacing, and communication with external modules.
2. **GPS Module:**
   - The GPS module interfaces with the Raspberry Pi 4 to provide accurate location information for navigation.
   - It communicates with the Raspberry Pi 4 via serial communication protocols such as UART or I2C.
   - Data from the GPS module includes latitude, longitude, altitude, and satellite signal strength.
3. **Speech Synthesis Module:**
   - The speech synthesis module interfaces with the Raspberry Pi 4 to provide auditory feedback to the user.
   - It may utilize digital or analog communication interfaces such as I2S, SPI, or PWM.
   - Data sent to the speech synthesis module includes text strings representing navigation instructions or environmental feedback.
4. **GSM Module:**
   - The GSM module interfaces with the Raspberry Pi 4 to enable cellular communication capabilities.
   - It communicates with the Raspberry Pi 4 via serial communication protocols such as UART.
   - The GSM module facilitates features such as sending SMS alerts.

- Data exchanged with the GSM module includes text messages.

5. **Object Recognition:**
    - Object recognition sensors interface with the Raspberry Pi 4 to detect obstacles and landmarks in the environment.
    - Sensor data is transmitted to the Raspberry Pi 4 through digital or analog interfaces, depending on the sensor type.
    - Data from object recognition sensors includes, object classifications, and recognition.

BlindAssist's hardware interfaces facilitate seamless communication and interaction between the software product and the hardware components of the system, ensuring reliable operation and delivery of essential functionalities for visually impaired users.

3.3 Software Interfaces

BlindAssist interacts with software components running on the Raspberry Pi 4 and potentially external systems for data processing, communication, and integration. Specific software interfaces include:

1. **Operating System:**
    - BlindAssist interfaces with the operating system running on the Raspberry Pi 4, such as Raspbian or other Linux distributions.
    - This interface facilitates system-level operations, file management, and process scheduling.
2. **Application Software:**
    - BlindAssist includes custom application software developed using programming language such as Python.
    - This software interfaces with hardware components, processes sensor data, implements navigation algorithms, and generates speech feedback.
3. **Communication Protocols:**
    - BlindAssist utilize communication protocols such as UART, I2C, SPI, or Bluetooth for interfacing with external modules and peripherals.
    - These protocols enable data exchange between the Raspberry Pi 4 and GPS modules, speech synthesis modules, and other hardware components.
4. **Development Tools and Libraries:**
    - BlindAssist relies on development tools and libraries for machine learning, sensor interfacing, speech synthesis, and other functionalities.
    - These tools and libraries provide pre-built functions for implementing specific features within BlindAssist.

The software interfaces of BlindAssist facilitate seamless interaction between hardware components, software modules, and external systems to deliver its enhanced object recognition, GPS tracking, and speech feedback functionalities.

3.4 Communications Interfaces

BlindAssist: Machine Learning Enhanced Object Recognition, GPS tracking, and Speech Feedback, being a purely hardware-based cane utilizing Raspberry Pi 4 and specialized modules for GPS tracking and speech feedback, requires specific communication interfaces to function effectively. These interfaces include:

1. **GPS Communication Protocol:**

   BlindAssist communicates with GPS modules using standard communication protocols such as NMEA (National Marine Electronics Association) or UART (Universal Asynchronous Receiver-Transmitter). This ensures seamless data exchange between the Raspberry Pi 4 and GPS modules for accurate location tracking.

2. **Speech Feedback Output**:

   The speech feedback functionality of BlindAssist communicates with audio output devices or speakers using standard audio communication interfaces such as I2S (Inter-IC Sound) or PWM (Pulse Width Modulation). This allows BlindAssist to provide audible instructions and feedback to users based on real-time environmental data.

3. **Data Transfer Rates:**

   The communication interfaces of BlindAssist must support sufficient data transfer rates to ensure real-time processing and feedback. High-speed communication protocols or optimized data transfer mechanisms may be required to handle the processing demands of machine learning algorithms and GPS tracking data.

4. **Security Considerations**:

   BlindAssist may involve the transmission of sensitive user data, such as location information. Therefore, communication interfaces must incorporate security measures such as encryption and authentication to protect user privacy and prevent unauthorized access to data.

By ensuring robust communication interfaces that meet the requirements of data transfer, security, and compatibility with hardware components, BlindAssist can effectively provide

enhanced object recognition, GPS tracking, and speech feedback functionalities to assist visually impaired individuals in navigating their surroundings.

4. System Features

4.1 Object Recognition

4.1.1 Description and Priority

This feature employs machine learning algorithms to identify obstacles, landmarks, and environmental elements in real-time. It is of High priority as it directly impacts user safety and navigation.

4.1.2 Stimulus/Response Sequences

- *Stimulus:* User activates BlindAssist.
- *Response:* System captures images through the camera module.
- *Stimulus:* Camera captures environmental data.
- *Response:* System processes images using machine learning algorithms for object recognition.
- *Stimulus:* Identified obstacles or landmarks detected.
- *Response:* System provides auditory alerts or feedback to the user.

4.1.3 Functional Requirements

1. The system shall capture images at regular intervals using the camera module.
2. The system shall preprocess captured images to enhance clarity and remove noise.
3. The system shall utilize machine learning algorithms to analyze captured images for object recognition.
4. The system shall maintain a database of known objects and their corresponding auditory alerts or feedback.
5. The system shall provide real-time auditory alerts or feedback when obstacles or landmarks are detected.
6. The system shall prioritize the identification of obstacles to ensure user safety.
7. The system shall have a mechanism to adjust sensitivity levels for object detection.
8. The system shall provide a user interface to configure object recognition settings.

4.2 GPS Tracking

4.2.1 Description and Priority

This feature enables accurate location tracking and navigation guidance using GPS technology. It is of **High** priority as it is essential for providing users with real-time location information and route guidance.

4.2.2 Stimulus/Response Sequences

- *Stimulus:* User activates BlindAssist.
- *Response:* System initializes GPS tracking functionality.
- *Stimulus:* User requests navigation to a specific destination.
- *Response:* System calculates the optimal route and provides auditory instructions.

4.2.3 Functional Requirements

1. The system shall interface with GPS modules to retrieve accurate location data.
2. The system shall continuously update the user's location in real-time.
3. The system shall calculate optimal routes based on user destination and current location.
4. The system shall provide auditory instructions for navigation, including turn-by-turn directions.
5. The system shall offer alternative routes in case of obstacles or road closures.
6. The system shall provide distance and estimated time of arrival information to the user.
7. The system shall support user-initiated location sharing with trusted contacts.
8. The system shall have a mechanism to recalibrate GPS coordinates for improved accuracy.

4.3 Speech Feedback

4.3.1 Description and Priority

This feature generates clear and concise verbal instructions and feedback based on real-time environmental data. It is of **High** priority as it enhances user autonomy and accessibility through auditory guidance.

4.3.2 Stimulus/Response Sequences

- *Stimulus:* User activates BlindAssist.

- *Response:* System initializes speech feedback functionality.
- *Stimulus:* Object or landmark detected.
- *Response:* System provides auditory description or alert.

4.3.3 Functional Requirements

1. The system shall convert environmental data into verbal instructions or feedback using speech synthesis.
2. The system shall provide audible descriptions of detected objects or landmarks.
3. The system shall offer clear and concise navigation instructions to the user.
4. The system shall adjust speech output volume based on ambient noise levels.
5. The system shall support multiple languages for speech feedback.
6. The system shall provide customizable speech preferences for users.
7. The system shall have a mechanism to pause or resume speech feedback based on user input.
8. The system shall provide error messages or alerts in case of speech synthesis failures.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

1. **Object Recognition:**
    - *Response Time:* The system should recognize and alert users about obstacles or landmarks within 2 seconds of detection.
    - *Accuracy:* Object recognition should achieve a minimum accuracy rate of 95% under typical environmental conditions.
    - *Resource Utilization:* Object recognition processes should not consume more than 50% of the available CPU resources on the Raspberry Pi 4.
2. **GPS Tracking:**
    - *Location Update Frequency:* The system should update the user's location on the map every 5 seconds to provide real-time tracking.
    - *Accuracy:* GPS tracking should achieve a positional accuracy of within 5 meters in open sky conditions.
    - *Satellite Acquisition Time:* The system should acquire satellite signals and calculate the user's location within 30 seconds of activation.
3. **Speech Feedback:**
    - *Speech Synthesis Speed:* The system should generate speech feedback within 1 second of receiving input data.
    - *Clarity:* Speech feedback should be clear and understandable, with a minimum intelligibility rating of 90%.
    - *Resource Utilization:* Speech synthesis processes should not consume more than 30% of the available CPU resources on the Raspberry Pi 4.

These performance requirements ensure that BlindAssist operates effectively and efficiently, providing users with timely and accurate information for navigation and obstacle detection.

5.2 Safety Requirements

1. Obstacle Detection Accuracy:

- Requirement: The object recognition feature must accurately detect obstacles with a minimum accuracy of 95% to prevent collisions and ensure user safety.
- Safeguard: In case of inaccurate obstacle detection, the system should provide additional warnings or prompts to alert the user.

2. Real-time Response:

- Requirement: The system must provide real-time feedback for navigation instructions and obstacle detection to enable quick user responses.

- Safeguard: Any delays in system response beyond predefined thresholds triggers an immediate alert to the user to avoid potential hazards.

3. Reliability of GPS Tracking:

- Requirement: GPS tracking should maintain a consistent connection and accurate location updates to prevent users from getting lost or navigating to incorrect destinations.
- Safeguard: In case of GPS signal loss or inaccuracies exceeding predefined thresholds, the system sends an alert message to the user selected emergency contacts.

4. Speech Feedback Clarity:

- Requirement: Speech feedback provided by the system must be clear and intelligible to ensure users receive accurate navigation instructions.
- Safeguard: If speech feedback becomes unclear or distorted due to environmental factors or system errors, the system provides haptic cues as alternative communication methods.

These safety requirements aim to mitigate potential risks associated with the use of BlindAssist, ensuring user safety and maintaining the integrity of the system in various operating conditions.

5.3 Software Quality Attributes

1. Reliability:

- *Requirement:* BlindAssist must operate reliably under various environmental conditions and usage scenarios, ensuring consistent performance without unexpected failures.
- *Metric:* Mean Time Between Failures (MTBF) of at least 1000 hours, measured through rigorous testing and validation processes.

2. Usability:

- *Requirement:* BlindAssist should be intuitive and easy to use for individuals with visual impairments, requiring minimal training or prior technical knowledge.
- *Metric:* Usability testing results showing at least 90% user satisfaction rating and an average completion time of tasks not exceeding 5 minutes.

3. Maintainability:

- *Requirement:* BlindAssist's hardware and software components should be designed for ease of maintenance and updates, allowing for timely bug fixes and feature enhancements.
- *Metric:* Average time to implement software updates or patches should not exceed 24 hours from the release of the update.

4. Portability:

- *Requirement:* BlindAssist's software should be portable across different hardware platforms and operating systems, ensuring flexibility and interoperability with future technologies.
- *Metric:* Successfully deploy BlindAssist on at least two different hardware platforms (e.g., Raspberry Pi 4 and Arduino) and demonstrate consistent performance.

5. Robustness:

- *Requirement:* BlindAssist must gracefully handle unexpected inputs, errors, or adverse conditions, ensuring uninterrupted operation and user safety.
- *Metric:* Conduct stress testing scenarios where BlindAssist is subjected to extreme environmental conditions or simulated hardware failures, with no critical system failures observed.

6. Adaptability:

- *Requirement:* BlindAssist should be adaptable to evolving user needs and technological advancements, allowing for future enhancements and modifications.
- *Metric:* Demonstrate the ability to integrate new features or functionalities into BlindAssist within a reasonable development timeframe (e.g., 3 months).

These software quality attributes ensure that BlindAssist delivers a reliable, user-friendly, and adaptable solution to meet the needs of visually impaired individuals, while also facilitating ease of maintenance and future improvements.

5.5 Business Rules

1. Data Privacy:

- *Rule:* BlindAssist must protect the privacy of user data such as location information and emergency contacts.
- *Enforcement:* Implement encryption protocols and data anonymization techniques to safeguard user data from unauthorized access or misuse.

2. Emergency Situations:

- *Rule:* In emergency situations, BlindAssist should prioritize user safety and provide immediate assistance or alerts.
- *Enforcement:* Implement emergency response protocols, such as automatic SOS alerts or voice-activated emergency calls, to assist users in distress.

3. Regular Maintenance:

- *Rule:* BlindAssist requires regular maintenance to ensure optimal performance and reliability.
- *Enforcement:* Schedule periodic maintenance checks and updates to address any potential issues and maintain the device's functionality.

4. Compliance with Regulations:

- *Rule:* BlindAssist must comply with relevant regulations and standards governing assistive technologies and accessibility.
- *Enforcement:* Regularly review and update BlindAssist's features and functionalities to ensure compliance with applicable laws and regulations.

5. User Training:

- *Rule:* Users should receive proper training and guidance on how to use BlindAssist effectively and safely.
- *Enforcement:* Provide user manuals, training materials, and instructional videos to educate users on BlindAssist's features and best practices for usage.

These business rules outline the operational principles and guidelines for BlindAssist, ensuring the device operates safely, securely, and in compliance with regulatory requirements while providing valuable assistance to visually impaired individuals.

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