SE 6361.001
Phase 1 Project
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Team Navigation
Team URL:

https://github.com/RealSao/CS-SE-6361.001

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Project Description:

The project involves developing a smartphone application, called Theia, to assist blind individuals in navigating indoor spaces safely and efficiently. The app will provide step-by-step navigation, detect and communicate obstacles, and offer emergency assistance when needed.

Functional Requirements:

1. **Navigation Assistance**

- **1.1** The system shall allow users to input the destination location manually or select from suggestions based on user routines or schedules.
- **1.2** The system shall compute and communicate possible routes to the destination and accept user preferences.
- **1.3** The system shall guide the user step-by-step by specifying actions such as:
    - **1.3.1** Distance to walk (e.g., "Walk for 2 minutes or 30 steps").
    - **1.3.2** Stop points (e.g., "Stop and turn right").
- **1.4** The system shall suggest the next actions based on user schedules or habits.

2. **Obstacle Detection and Collision Avoidance**

- **2.1** The system shall detect obstacles using smartphone sensors.
- **2.2** The system shall notify the user with instructions to avoid collisions (e.g., "Move to the left").

3. **Emergency Assistance**

- **3.1** The system shall detect falls and notify emergency contacts automatically.
- **3.2** The system shall allow users to manually trigger an emergency call or message if needed.

Non-Functional Requirements:

1. **Safety and Reliability**

- **1.1** The system shall ensure safe navigation indoors by accurately detecting obstacles.
- **1.2** The system shall reliably deliver emergency alerts with minimal delay.

2. **Usability and Accessibility**

- **2.1** The system shall provide voice-guided instructions for visually impaired users.

- **2.2** The system shall allow customization of alert volume and frequency.
- **2.3** The system shall support multiple languages for accessibility.

3. **Performance**
- **3.1** The system shall compute routes and detect obstacles with a response time of less than 2 seconds.

4. **Battery Life**
- **4.1** The system shall minimize battery consumption by optimizing background processes.
- **4.2** The system shall notify users when battery levels are low, suggesting power-saving options.

5. **Extensibility**
- **5.1** The system shall allow future integration of new sensors and features without significant redesign.

Issues with Preliminary Definition Given

2.1.1 Issue: Route Selection for Blind Users

Issue Description

The definition states that the app will give the user a route that they feel most comfortable with. However, since the users are blind, it is unclear how they would evaluate and choose a preferred route.

Options

1. The system provides the fastest route by default.
2. The system allows the user to define preferences based on past navigation patterns.
3. The system provides route recommendations based on environmental factors like fewer turns or familiar paths.

Decision and Rationale

Option 2 is selected. The system will learn from the user's past routes and recommend routes accordingly. This ensures a balance between familiarity and efficiency while accounting for individual comfort.

2.1.2 Issue: Lack of Clear Emergency Escalation Path

Issue Description

The definition mentions emergency assistance but does not specify the priority levels for different types of emergencies (e.g., fall detection vs. getting lost).

Options

1. Treat all emergency cases equally and trigger the same response.
2. Assign priority levels based on severity (e.g., a fall immediately triggers emergency calls, while being lost first prompts user verification).
3. Allow users to set preferences for emergency responses.

Decision and Rationale

Option 2 is chosen. Prioritizing emergency response based on severity ensures that urgent situations receive immediate attention, while minimizing unnecessary emergency contacts.

2.2 Issues with II.2 Software System Requirements: Functional Requirements

2.2.1 Issue: Navigation in Bathrooms

Issue Description

Navigating in bathrooms presents unique challenges, as it would require the app to use the smartphone camera to detect obstacles, which might raise privacy concerns.

Options

1. Use LiDAR or ultrasonic sensors instead of the camera for obstacle detection.
2. Disable navigation in bathrooms and rely on prior knowledge or external assistance.
3. Allow users to input known layouts of frequently used bathrooms for guidance.

Decision and Rationale

Option 1 is chosen. LiDAR or ultrasonic sensors ensure privacy while still enabling effective navigation.

2.2.2 Issue: Differentiating Falls from Other Movements

Issue Description

The document doesn't specify how the system should differentiate between a fall and other sudden movements (e.g., sitting down quickly or dropping the phone).

Options

1. Implement a combination of accelerometer, gyroscope, and barometer sensors to detect impact and velocity changes.
2. Use machine learning models trained on real-world fall detection datasets.
3. Require user confirmation after a suspected fall before triggering emergency alerts.

Decision and Rationale

Option 1 is selected as the primary method, with an option for user confirmation (Option 3) to reduce false positives. This approach ensures accuracy while minimizing unnecessary emergency notifications.

2.3 Issues with II.3 Software System Non-Functional Requirements

2.3.1 Issue: Data Privacy and HIPAA Compliance

Issue Description

The document does not specify how user data will be protected, particularly concerning compliance with privacy regulations like HIPAA.

Options

1. Implement end-to-end encryption and strict access controls.
2. Store data only locally on the user's device, minimizing cloud storage.

3. Follow industry best practices, including anonymization and explicit user consent for data collection.

Decision and Rationale

Option 1 is chosen, combined with Option 3 for regulatory compliance. This ensures that sensitive navigation data remains secure while providing necessary transparency.

2.3.2 Issue: Voice Recognition Capabilities

Issue Description

The document mentions voice recognition but does not define its capabilities. Should it support multiple languages, speech impediments, or different accents?

Options

1. Use a basic voice recognition system with standard English support.
2. Implement multilingual support with customization for speech patterns.
3. Use an AI-driven speech recognition model that adapts to individual users over time.

Decision and Rationale

Option 3 is selected. AI-driven voice recognition ensures inclusivity by adapting to each user's speech pattern, improving usability for diverse populations.

WRS

3.1 W

3.1.1 Problem

Blind people have trouble navigating UTD campus buildings safely and efficiently, as canes, guide dogs and other aids have limitations

3.1.2 Goal

Create a smartphone app that helps blind people navigate using sensors, voice guidance and other emergency features

3.1.3 Improved Understanding of 2.1

Domain: Indoors

Stakeholders: Blind people, family, friends, caretakers, accessibility services, emergency assistance, and other people

Functional Objectives: indoor navigation, alternate route suggestions, emergency assistance, collision detection

Non-Functional Objectives: Safe, fast, accurate and user-friendly navigation, customizable features

3.2 RS

3.2.1 Functional RS – Improved understanding of 2.2 Software System Requirements: FRs

1. System shall allow the user to navigate indoors at UTD.
2. System shall allow for user to input destination.
3. System shall detect obstacles and potential collisions and warns the user.
4. System shall have a way of detecting if the user falls.
5. System shall have a of allowing the user to contact caretaker if they're lost.
6. System shall call emergency services or contact caretaker if needed.
7. System shall provide hazard alerts.
8. System shall allow the user to navigate bathrooms without the use of phone cameras.
9. System shall give the user directions to direct them to their desired location.
10. System shall give the user multiple routes.
11. System shall tell the user to walk the correct distance.
12. System shall tell the user to turn at the right place.
13. System shall figure out the user's schedule or habit to make route suggestions.
14. System shall accept voice commands for searching destinations and interacting with the system.
15. System shall provide the user with audio instructions regarding directions and collision detection.
16. System shall be able to detect the user's current position.
17. System shall be customizable for user.

3.2.2 Non-functional RS – Improved understanding of II.3 NFRs

1. System shall ensure that the navigation is safe, accurate and fast.
2. System shall provide a user friendly interface.
3. System shall keep the user safe.
4. System shall be customizable .
5. System shall be easily modifiable for future changes.
6. System shall respond to route changes quickly.
7. System shall be responsive with minimal latency.
8. System shall keep the User's data secure.
9. System shall minimize battery consumption.
10. System shall provide multiple language options.
11. System shall be compatible with IOS and Android.

Improved Understanding:

Clarified Preliminary Definition:

Theia helps blind individuals navigate indoor spaces safely and efficiently. The original definition had gaps, such as how users would pick a comfortable route. Since they cannot see their surroundings, Theia will learn from past navigation patterns and suggest familiar routes. Bathroom navigation was another issue, as cameras raise privacy concerns. Instead, Theia will use LiDAR or ultrasonic sensors to detect obstacles.

The system also needed a better way to distinguish falls from normal movements. Theia will use accelerometers, gyroscopes, and barometers to detect real falls and avoid false alarms. Emergency response was unclear, so Theia will now assign priority levels. Falls will trigger an automatic emergency call, while being lost will first prompt user confirmation. Voice recognition was not well-defined, so Theia will support multiple languages and adapt to different speech patterns, including accents and impairments. These updates make Theia a smarter, safer, and more accessible navigation tool.

Clarified Domain Description:

Theia operates within indoor environments, such as multi-floor buildings with classrooms, offices, washrooms, lounges, and elevators. These areas present unique challenges for blind individuals, including navigating hallways, avoiding obstacles, and determining the correct location for turns and stops. The primary users are blind individuals who require guidance to move between locations safely. Secondary stakeholders include family members and caretakers, who may assist in setup or emergency situations, accessibility service providers responsible for supporting blind individuals, emergency responders who handle critical incidents, and building management teams that maintain infrastructure for accessibility.

The indoor setting requires a navigation system that does not rely on visual cues but instead provides clear audio instructions and tactile feedback. Since these spaces often change—such as furniture rearrangements or temporary obstructions—the system must adapt in real-time to detect and communicate these changes effectively.

Clarified System Description:

Theia is a smartphone application that assists blind individuals in navigating indoor spaces by providing step-by-step voice guidance, obstacle detection, and emergency support. Users can manually input their destination or allow the system to suggest locations based on their routine behavior. Theia will then compute the safest and most efficient route while considering environmental factors and past user preferences.

The app will use LiDAR and ultrasonic sensors to detect obstacles, ensuring that navigation in sensitive areas, such as bathrooms, remains private and secure. In case of emergencies, Theia will detect falls using motion sensors and determine the appropriate response based on severity. For navigation, the app will provide detailed walking instructions, including distance measurements and turn notifications. Voice recognition will allow users to interact with the system using spoken commands, with support for multiple languages and different speech patterns.

The system will also be designed for high performance and efficiency. Navigation requests will be processed within two seconds, and background processes will be optimized to reduce battery consumption. To protect user privacy, Theia will implement end-to-end encryption and comply with HIPAA standards. The app will be available on both iOS and Android, making it accessible to a wide range of users.

Traceability Between Clarified Domain and System Description:

The system features directly address indoor navigation challenges. Since blind users cannot rely on sight, Theia focuses on voice guidance and real-time obstacle detection. Because indoor spaces have complex layouts, Theia gives detailed walking instructions and alternative routes.

Emergency handling is crucial since falls and getting lost can happen indoors. Theia detects falls using motion sensors and prioritizes emergency responses. Privacy is also key, so Theia avoids cameras and uses LiDAR and ultrasonic sensors instead.

To enhance accessibility, Theia supports multiple languages and adapts to different speech patterns. Customization options allow users to adjust volume, navigation speed, and alert frequency. Since users may have different devices, Theia works on both iOS and Android. By

aligning system features with domain needs, Theia ensures safe, accessible, and reliable indoor navigation.

Meeting Minutes:

Date	Location	Attendees	Topics	Work

			Discussed	**Assigned**
1/25/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Worked on Preliminary Project Plan and completed it	Review project details more in depth and prep for start of project work
2/2/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Created and started Phase 1 Document	Get understanding of starting work with project requirements
2/9/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Added FRs and NFRs to document	Look into issues section of project(As-Is, To-Be)
2/16/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Completed issues portion of the document	Planned to work on 3.1 and 3.2 of the WRS

				document and get ready to start mockup
2/23/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Completed improved understanding section and setup Figma workspace	Work on mockup prototype on Figma
3/2/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Worked on prototype in Figma	Finalize prototype and move on to presentation content
3/10/25	Discord	Ajay Rao Tonghong Sun Farrel Raja	Finalized presentation submission	Prep for presentation