December 29, 2025

Navisense 2025/2026

Product Requirements 1.0

Members
Michael Scholl | xxx
Mila Backbier | 2050021
Egor Pereviazkin | xxx
Lucas Iovdij | 2005107
Client
Juan Pintado

Abstract

Contents

1 | Introduction

Navigation through complex and dynamic indoor environments heavily relies on visual ques like colors, markings or signs, and is often perceived as challenging by visually impaired individuals. As a result, they need assistance when visiting public spaces like hospitals, often causing a feeling of dependency on others, reduced autonomy or anxiety. For hospitals, limited accessibility for visually impaired individuals reduces the patient experience of this specific client group. As extra employment of assistance staff is not the most effective solution, a device that supports indoor navigation for visually impaired individuals is needed.

1.1 Scope

The scope of the current work to be done for NaviSense this year is to provide the most crude and essential parts of the functionalities of the overall product. As we will outline in more detail, the goals for this Honors year should entail the translation of the research done in the past two years into the implementation of both mapping of an indoor space, and localization in the indoor space. When it comes to the interface, feedback, administration, and user-specific functionalities that have to come into play as a part of the overall business case of NaviSense, these will be passed upon in this development duration, and instead, NaviSense will focus on the most bare use-case of finding oneself in the space based on camera feed reliably, and navigating towards a point in the space.

2 | General description

Indoor navigation in complex environments, like hospitals, can be challenging for visually impaired individuals. To support safe and independent mobility, the NaviSense project aims to develop an indoor navigation system that guides visually impaired people through dynamic hospital environments. The product allows the user to select a destination to which the user is guided by way of effective feedback. Operating reliably and consistently, the system ensures the safety and autonomy of its target user.

2.1 Product perspective

The proposed product consists of both hardware and software parts that cooperate to support indoor navigation of visually impaired individuals. The user's phone will be used to capture environmental data, that the system utilizes to estimate it's position in a mapped indoor space. Based on the determined location, the software can calculate a suitable route to the selected destination. The user will then be guided in the right direction through effective feedback, for instance haptic signals. The system functions as a stand-alone mobile application that interacts directly with the user, without requiring input from any external devices, apart from the sensors integrated into the users phone, to function properly.

2.2 General capabilities

This section outlines the general capabilities of the NaviSense navigation system. This includes localization of the user, determination of the route to the desired destination, continuous feedback that navigates the user to the target destination, and recognition of dynamic objects in the environment. The system will be testable by means of a digital twin.

2.2.1 Localization

The system's primary function is accurate localization within a mapped indoor environment. Through employment of Computer Vision algorithms, the system will process immediate environmental data, captured by the user's phone, to place the user on a two- or three-dimensional map of the indoor space. As the user moves, the system must continuously update the estimated position and maintain sufficient stability to support reliable navigation.

2.2.2 Path determination

Using the estimated user position and target destination on a map of the indoor environment, the system will employ a path planning algorithm to calculate the optimal path to the destination. The optimal path can be defined as the path that does not only propose a time-effective route, but also considers safety and complexity. In case the user deviates from the path, due to unforeseen obstacles or incorrect interpretation of the navigation feedback, the route should be re-evaluated and possibly changed.

2.2.3 Navigation Feedback

The system combines the dynamic position of the user and the calculated path to provide continuous navigational feedback to the user. The feedback has to be conveyed in a clear manner and should respect the user's natural sensory environment.

2.2.4 Obstacle detection

As a stretch goal, the system will be able to employ a computer vision algorithm that recognizes obstacles and alerts the user when necessary. In dynamic hospital environments, unexpected obstacles could occur along the path to the destination. To ensure safe navigation of the visually impaired individual, the system should recognize obstacles and warn the user in a timely manner.

2.2.5 User interface and interaction modalities

The system will be available as a mobile application that runs on consumer smartphones. As the application should be easy to use for visually impaired individuals, it includes a simplistic interface that allows the user to start navigation. Other components include a physical feedback mechanism. This could be vibration of the phone, a wearable module or a haptic attachment.

2.3 User characteristics

The primary users of the NaviSense navigation tool are visually impaired individuals visiting the hospital. They interact directly with the device to select a destination and rely on the system's feedback for safe navigation.

Visually impaired users depend on non-visual feedback and often use additional mobility aids such as a cane or guide dog. Therefore, assistive technologies should not require continuous handheld operation and must be usable with one hand. Since navigation complex public environments is already cognitively demanding, interactions must remain minimal during walking and should not distract the user. Feedback should be subtle and easy to interpret, as hospital environments may cause stress and reduce the user's cognitive capacity.

2.4 Environment description

The navigation tool will be used in a complex and dynamic indoor environment, consisting of a complex layout of hallways, junctions and rooms of varying sizes. Some rooms, like waiting areas, are not clearly separated from the hallway. Additionally, hospital departments are often labeled as areas rather than specific room numbers. When the patient arrives in the general area of the department, they have to find a help desk where they are provided with the number of the waiting area and room.

Even though the general layout of a hospital is consistent, it includes many moving obstacles. Additionally, hospitals are public spaces and can be crowded at times, which provides extra obstacles and can disrupt the audio feedback.

2.5 Assumptions and dependencies

The NaviSense navigation tool will be developed based on a set of assumptions and dependencies that are discussed in this section.

2.5.1 Assumptions

User-related assumptions

- Users have a smartphone with the required sensors.
- Users are familiar with basic smartphone interaction.
- Users will follow the navigation instructions as given.
- Users have their own assistive tools available as support if needed.

Environment assumptions

- The hospital indoor environment is accurately mapped and map data is available to the system.
- Hallways and rooms are accessible in accordance with the map.
- Lighting conditions are within usable range for the depth camera.

Technical assumptions

- The smartphone has decent battery capacity and is sufficiently charged at the start of use.
- The mobile system allows access to required sensors.

3 | General constraints

This section mentions the constraints of the NaviSense navigation tool for visually impaired individuals. These constraints rise as a consequence of some of our research and the laid out descriptions of the problem as briefly outlined in the previous chapter.

3.1 Hardware constraints

The application will run on consumer smartphones. This provides the following restrictions:

- Consumer smartphones have limited processing power.
- The application should have restricted battery consumption, as consumer smartphones have to be used throughout the day.
- Smartphone depth cameras have limited (spatial and temporal) resolution and accuracy.
- Drift of integrated IMU sensors affects the system's accuracy.

3.2 Environmental constraints

The overall goal is that the system is able to be employed in a complex, dynamic and social hospital environment. This evokes the following environmental constraints:

- Overcrowding in the public environment can occlude camera vision, negatively impacting the system's performance. The system has to retain proper performance in such crowded environments.
- The hospital environment can consist of many similar hallways. Distinction of the position along the hallway and definition of the orientation within the hallway can be challenging. The system has to perform well in monotone environments.
- In the indoor environment the lighting conditions may vary, which may affect the performance of the computer vision algorithm. The system has to perform will in different indoor conditions, like inconsistent lighting.
- Within a hospital environment, dynamic obstacles occur. The system should be flexible and perform well in dynamic environments.

3.3 Design constraints

Based on the Project Description and collected responses on what suits visually impaired people, we give the following constraints that stand for principles that the end-user would want the product to adhere to:

- Non-visual users should be able to interact with the system.

- The system must give comprehensive feedback that respects the user's natural sensory environment, and should avoid overwhelming the user.
- The feedback should not disrupt other patients or hospital staff.
- The device should be usable with one hand at most.
- The device should be discrete. It should not make it's user look unusual or require unusual behavior.

3.4 Performance constraints

Because the product will have to be able to be run on a mobile device, and necessitates accurate, immediate feedback granted to the user in real-time, we give the following constraints:

- Localization must be updated at a minimum frequency of 5 Hz.
- The localization error should be smaller than one meter.
- Feedback latency must be smaller than 500 ms.

4 | Requirements

This chapter contains the specific requirements that NaviSense will adhere to. The requirements are prioritized using the [**moscow**] prioritization method:

Priority	Abbreviation	Description
Must have	M	These are the requirements that are critical for the system to fulfill its core purpose. The system is considered non-functional without them.
Should have	S	These are requirements that are important and add significant value, but are not vital for initial functionality. The system can function without them, albeit with reduced usability or capability.
Could have	C	These are desirable, nice-to-have requirements that will be implemented if time and resources permit after all Must and Should requirements are completed.
Won't have	W	These requirements are explicitly out of scope for the current project iteration but may be considered for future versions.

4.1 Capability Requirements

This section gives the capability requirements, which describe what the product should be able to do, what functionalities it will give to the user.

4.1.1 Mapping

ID	Priority	Description
FR - 001	M	The system's toolchain shall be capable of generating a mapping of a single room of an indoor space.
FR - 002	M	The system shall allow the generation of a navigable map (e.g., a Navigation Mesh) across multiple rooms
FR - 003	M	The system shall accounts for static obstacles like walls and large furniture in the generated map.
FR - 004	C	The system shall support the addition of multiple floors of navigable maps.
FR - 005	M	The system's mapping toolchain shall allow the addition of named, specific destination points within the generated map.
FR - 006	S	The system's mapping toolchain shall allow destination point's name, location or delete it altogether.
FR - 007	M	The end-user application shall allow users to download new or updated building maps from a remote repository for offline use.

4.1.2 Localization

ID	Priority	Description
FR - 008	M	The system shall determine and update the user's position within the pre-mapped space in real-time, using the device's camera feed.
FR - 009	M	The system shall determine and update the user's orientation within the pre-mapped space in real-time.
FR - 010	M	Given the user's current location and a selected destination, the system shall compute an obstacle-avoiding path along the navigable map.
FR - 011	C	The system shall be able to detect and navigate around dynamic, non-permanent obstacles (e.g., people, temporary carts).

4.1.3 User Interface

ID	Priority	Description
FR - 012	M	The system's localisation features shall be available to be used by means of a native application on a modern phone.
FR - 013	M	The system shall provide an accessible interface for the user to select their desired destination from a list of available points on the current map.
FR - 014	S	The system allows the user to select a destination using a voice command.
FR - 015	S	The system provides a settings menu where users can adjust feedback parameters, such as vibration intensity or the verbosity of audio cues.

4.1.4 Feedback

ID	Priority	Description
FR - 016	M	The system shall provide directional feedback using the device's haptic engine (vibration).
FR - 017	M	The feedback provided shall be discrete.
FR - 018	M	The system shall provide a distinct notification (haptic and/or audio) when the user has arrived at their selected destination.
FR - 019	S	The feedback provided shall be unambiguous.
FR - 020	S	The system should provide a distinct haptic alert if it detects the user has significantly deviated from the computed path.