CptS 484: Software Requirements

WRS Evolution

Requirements Elicitation

10/15/2021

Team CARZ

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Table of Contents

Revision History

Date	Version	Changes	Editor

[1] Introduction

1.1.Purpose

The application being built is for aiding blind individuals in navigating indoors and across multiple floors of a building.

1.2.Scope

Our application will be an offline android application built for Android version 5.0 or later (Lollipop or later) utilizing standard sensors and the standard back facing camera. It will seek to build an easy to use navigation and collision system for blind individuals with some assistance from non-blind individuals.

1.3.Objectives and Success Criteria

1.3.1. Objectives

1. Help blind individuals successfully navigate indoors.
2. Help blind individuals successfully avoid obstacles indoors.

1.3.2. Success Criteria

1. Build a working prototype that utilizes at least one positioning system to achieve a reasonably accurate indoor navigation system in an arbitrary predefined environment.
2. Build a working prototype that utilizes a camera to accurately determine the position of at least one obstacle in the blind individual's path.

1.4.Definitions, Acronyms, and Abbreviations

Bluetooth: A standard for the short-range wireless interconnection of mobile phones, computers, and other electronic devices.

IPS: Indoor Positioning System.

LiDAR: Light Detection and Ranging, a remote sensing method using a special kind of camera to measure distances.

Likert Scale: A psychometric scale used to rate agreement with statements.

Magnetometer: An instrument used for measuring magnetic forces, especially the earth's magnetism.

SME: Subject Matter Expert.

SQA: Software Quality Assurance

Wifi: A facility allowing computers, smartphones, or other devices to connect to the internet or communicate with one another wirelessly within a particular area.

1.5. Overview

This project is intended to create a general navigation aid Android application for the use of blind people with limited assistance of seeing people. It will result in the delivery of three deliverables which will include presentation(s), code, and documentation by December 15th, 2021.

[2] Preliminary Definition

2.1. Preliminary Domain

PD_ID	Preliminary Domain Description
PD1	People with impaired vision
PD2	People assisting those with impaired vision (such as caretakers or friends)
PD3	Indoor navigation capable of handling multiple floors in a building
PD4	Mobile Device (Android Phone) Application

2.2.Preliminary Functional Requirements

P FR_ ID	Preliminary FR Description
PFR1	Accepts a destination from the user
PFR2	Finds routes to each destination
PFR3	Communicates to the user to walk
PFR4	Communicates to the user to stop and turn at the correct place
PFR5	Detects obstacles and tells the user what to do in order to avoid collision
PFR6	Places emergency calls and messages, possibly after detecting a fall or when the system has lost its current location
PFR7	Figures out what the user's next actions will be and anticipates them with suggestions

2.3.Preliminary Non-Functional Requirements

PNFR_ ID	Preliminary NFR Description
PNFR1	The system helps the user safely navigate indoors
PNFR2	The system leads the user through the fastest route

PNFR3	The system leads the user through the route that is most comfortable
PNFR4	The system is usable for blind people
PNFR5	The system is ubiquitous
PNFR6	The system is customizable to every user
PNFR7	The system is easily extensible to accommodate the variations in interface, language, definitive needs of the user, new features, new sensors, and new hardware

[3] Issues with the Preliminary Definition Given

3.1.Domain Issues

Domain Issue ID	Domain Issue Description	
DI1	PD_ID	PD1. People with impaired vision
	1. Ambiguous and overbroad. Impaired vision can range from requiring glasses to being unable to see light and dark. 2. Unsound. A severely blind person will likely struggle to use a phone app, which typically requires vision to open.	
	Option 1	Design the app to be usable for non-blind individuals to quickly help the blind user to select their destination and open the app.
	Option 2	Use speech recognition to detect what destination they would like to select.
	Option 3	Allow the user to tell the app how blind they are on a scale and then customize the app to accommodate their level of blindness.
	Choice	Option 1 and 3
	Rationale	The first option is the easiest option to design around. The basic functionality of the application will already be hard for us to develop and it takes priority over non-essential features. Applications are already hard to access when a user cannot see, so even with accommodation, they are likely to need assistance opening the application. It is very easy to add another option to a settings menu.
Revised wording		

<table>
<tr><th>Domain Issue ID</th><th colspan="2">Domain Issue Description</th></tr>
<tr><td rowspan="8">DI2</td><td>PD_ID</td><td>PD2. People assisting those with impaired vision (such as caretakers or friends)</td></tr>
<tr><td colspan="2">1. Potentially unreliable. Sometimes it may be hard for a blind person to find someone to help them use the application.
2. Many of those assisting the person will not be experienced with using the application and could find it hard to use.
3. Individuals unfamiliar with the device may have issues finding the application.</td></tr>
<tr><td>Option 1</td><td>Provide a resource in the application for blind people to find those who can assist them.</td></tr>
<tr><td>Option 2</td><td>Design the application to be usable for new users. Test user experience with people with no experience with the application.</td></tr>
<tr><td>Option 3</td><td>Provide links to external resources that blind people can use to access assistance.</td></tr>
<tr><td>Option 4</td><td>Make the application icon very unique and easy to describe. Tell the blind person how to describe the application icon to a non-blind person.</td></tr>
<tr><td>Choice</td><td>Option 2 and 4</td></tr>
<tr><td>Rationale</td><td>Most severely blind people already have access to assistance due to preexisting necessity. Therefore the best use of our focus is to improve ease of use. Customizing the icon to be easy to find is relatively low effort and improves ease of use for new users.</td></tr>
<tr><td>Revised wording</td><td></td><td></td></tr>
</table>

Domain Issue ID	Domain Issue Description	
DI3	PD_ID	PD3. Indoor navigation capable of handling multiple floors in a building
	1. No universally used single method of handling accurate indoor position identification like there is with outdoor position identification (GPS). 2. Some floors of buildings could lose signal with certain methods of positioning systems.	
	Option 1	Provide options for the user to control the positioning system they find the most reliable to use (magnetometer, bluetooth, or wifi based).
	Option 2	Develop a Magnetometer based indoor positioning system.
	Option 3	Develop a Bluetooth based indoor position system.
	Option 4	Develop a WiFi based indoor position system.
	Option 5	Develop magnetometer, bluetooth, and WiFi based positioning systems for a short time, then review our success on each option and choose our most successful option.
	Choice	Option 5
	Rationale	None of our engineers have experience with any indoor positioning systems, either using or creating. We need to find out for ourselves the positives and negatives of using and developing each system. However, we want to eventually focus our efforts.
Revised wording		

Domain Issue ID	Domain Issue Description	
DI4	PD_ID	PD4. Mobile device (Android phone) application
	1. Android does not have accurate hardware (e.g. LiDAR scanner) normally used for collision detection built into most phones. 2. Not every blind person has access to an Android device.	
	Option 1	Develop for iOS instead. Specifically for devices with Apple’s inbuilt LiDAR camera.
	Option 2	Provide users with LiDAR hardware or provide information on where they can acquire a LiDAR scanner.
	Option 3	Use machine learning on camera data to estimate distances.
	Choice	Option 3
	Rationale	The third option does not require expensive hardware. It also allows the team to work only on one well-known platform which reduces the workload.
Revised wording		

3.2.Functional Requirements Issues

FR Issue ID	**Description**	
FRI1	PFR_ID	PFR1. Accepts a destination from the user
	1. Ambiguity. There are a lot of ways of accepting a destination 2. Ambiguity. There are many possible positions that are not in themselves destinations. There are therefore many ways of determining what a destination is.	
	Option 1	Use speech recognition to search for the destination.
	Option 2	Use a non-blind person's help to operate a search bar to search for the destination.
	Option 3	Categorize destinations for the user to filter (example categories: restroom, kitchen, cafeteria, office, lounge, bedroom, etc.).
	Option 4	Communicate walking distance from the destination to help the user select the right destination.
	Choice	Option 2 & 3
	Rationale	User assistance from non-blind people is already expected before route selection, so developing a speech recognition system is an unnecessary difficulty. Walking distance, while helpful, is hard to calculate. Categorization of destinations is relatively easy and helps make search fast for new users.
Satisfied by		

FR Issue ID	Description	
FRI2	PFR_ID	PFR2. Finds routes to each destination
	1. Unclear method. Does it look up predefined routes or search the traversal space?	
	Option 1	Have a set of predefined routes to specific locations and choose the route that has a navigation point closest to the starting point.
	Option 2	Construct an internal graph representing each building. Perform A* graph search from the starting point to the destination to find the route.
	Choice	Option 2
	Rationale	There are too many routes to manually create all of them.
Satisfied by		

FR Issue ID	Description	
FRI3	PFR_ID	PFR3. Communicates to the user to walk
	1. Unclear. There are many possible ways of communicating to the user to walk. 2. Incompleteness. Does it communicate just to walk or should it also tell the user how far to walk?	
	Option 1	Use computer speech to dynamically create audio that directs the user to walk for a certain distance before turning.
	Option 2	Use pre-recorded audio to tell the user to walk forward, without telling them precise distance.
	Choice	Option 1
	Rationale	Computer speech is very ubiquitous. Text-to-speech has been built into Android since API version 4. Once a text-to-speech system has been established it will give us flexibility with what information we want to communicate.
Satisfied by		

FR Issue ID	Description	
FRI4	PFR_ID	PFR4. Communicates to the user to stop and turn at the correct place
	1. Unclear. There are many possible ways of communicating to the user to stop and turn. 2. Incompleteness. Should it warn the user the turn is coming up so that they can more reliably turn at the right place? 3. Ambiguity. Not all turns are 90 degrees. Should it communicate the angle of the turn?	
	Option 1	Use tonally distinct beeps to quickly communicate which direction to turn when the turning point is reached. Beeping speed being used to indicate the angle with computer speech confirmation (e.g. “You are now going in the right direction”) used to inform the user when the angle they are going is correct.
	Option 2	Use pre-recorded messages for a right and left turns as well as approximate angle (e.g. right, slight right).
	Option 3	Use computer speech to communicate direction and angle.
	Choice	Option 1
	Rationale	Beeps are simple to code and pitch makes them very quickly distinguishable. Beeping speed is likely to be more intuitive than an angle number.
Satisfied by		

FR Issue ID	Description	
FRI5	PFR_ID	PFR5. Detects obstacles and tells the user what to do in order to avoid collision
	1. Unclear method. How will it detect obstacles? 2. Walking in a building full of other students. How do you differentiate an obstacle vs. a person? Are people obstacles? 3. Telling the user how to avoid collisions is unclear. Will the app notify the necessary path/direction to take? What detail will it give in object avoidance directions? 4. Unclear Timing. How fast must the system detect obstacles? On a related note, how fast must the user be relayed the information?	
	Option 1	Detect obstacles using external LiDAR camera to and run velocity estimation between frames of capture to estimate what objects have a chance of coming too close (within 4 feet of camera position)
	Option 2	Detect obstacles using machine learning on camera data to estimate distances and run velocity estimation between frames of capture to estimate what objects have a chance of coming too close (within 4 feet of camera position)
	Option 3	Communicate using text-to-speech approximate object size to the user.
	Option 4	Tell the user simple instructions like “obstacle ahead, move left 2 steps”.
	Option 5	Provide users with real-time location traffic (people) density to help them understand how busy a hallway is so they can slow down
	Option 6	Communicate the location of obstacles relative to the user's position instead of communicating how to avoid them. Communicate using computer text to speech. Allow the users to determine how they want to avoid the obstacle.
	Option 7	Communicate to the user any instructions needed to prevent a collision with an obstacle as soon as the obstacle is identified via text to speech.

	Choice	Option 2, 3, 5, 6, and 7
	Rationale	A LiDAR camera would make our technology less accessible than a normal camera. It would improve our distance estimation accuracy, but we do not need extremely accurate distance estimation. If we can estimate objects positions then we can simply inform the user if there are a lot of them so they can slow down. Communicating the position and size of objects is easier because it decreases ambiguity to the users of where the objects are and how to avoid them. Collision detection and reporting potential obstacles as soon as possible is necessary for the user to avoid colliding with the obstacles in as close to real time as possible.
Satisfied by		

FR Issue ID	Description	
FRI6	PFR_ID	PFR6. Places emergency calls and messages, possibly after detecting a fall or when the system has lost its current location
		1. Detecting falls may be inaccurate (trip vs fall). 2. Measuring the severity of the fall. 3. Placing emergency calls and messages for immediate assistance may not be available. 4. Placing an emergency call is too extreme of a response if it is unnecessary. Emergency services do not appreciate having too many unimportant calls because it makes it harder to respond to important calls.
	Option 1	Initial app set up. Ask the user for primary and secondary emergency contacts.
	Option 2	Make the user turn on emergency calling and inform them about what it means to turn it on.
	Option 3	Speech recognition. Ask the user if they have fallen, and if they need immediate assistance. If no response within 5 seconds, help will be sent.
	Option 4	Create the system in such a way that it can predict a user entering a dead-zone or situation before it happens then calls and notifies the user. The user can say “disregard” if they are in a known area they are comfortable with.
	Choice	Option 1, 2, 3
	Rationale	Having configuration options for emergency calls allows the user to determine for themselves the risk they want to take if a fall is detected when it either does not occur or is not a problem. Speech recognition is built into most major phone operating systems now and is therefore not as hard to operate. Dead-zones are likely very hard to predict without a lot of data.
Satisfied by		

FR Issue ID	Description	
FRI7	PFR_ID	PFR7. Figures out what the user's next actions will be and anticipates them with suggestions
	1. 'Figures out' is unclear. There could be several different ways to anticipate the user's next actions. 2. Unclear method for giving 'suggestions' to the user.	
	Option 1	Built-in scheduling functionality for the app. Connect with the calendar application. Upon repeated routes on the same calendar event at around the same time, ask the user using speech recognition for their answer if they want to go on that route. If they say no, wait until they repeat the pattern more times to ask again.
	Option 2	Create a predictive machine learning algorithm based on anticipated action versus actual action.
	Option 3	Base suggestion methods based on real world data being inputted (based on collision detection and navigation).
	Choice	Option 1
	Rationale	The first option is easiest to implement. It doesn't require advanced machine learning to function. Users are unlikely to care about suggestions as the most important feature of the app, so it is not worth too much development time for a marginal improvement.
Satisfied by		

3.3.Non-Functional Requirements(NFR) Issues

NFR Issues ID	Description	
NFRI1	PNFR_ID	PNFR1. The system helps users safely navigate indoors.
	1. How do we define safe navigation? 2. Should navigation “update” (e.g., Google Maps rerouting a driver if they miss their turn off)? 3. What is meant by “helps”?	
	Option 1	Manually recorded routes.
	Option 2	Ask for / generate floor plans of the building(s) the visually impaired individual will be accessing, and generate a route based on the shortest path.
	Option 3	Use collision detection/avoidance software/hardware to navigate the visually impaired individual.
	Option 4	Use predictive software to anticipate and differentiate potential collision objects.
	Option 5	Obtain feedback from users about the route taken and if the system is helpful with their navigation.
	Choice	Options 2, 3, and 5.
	Rationale	Using collision detection/avoidance hardware/software we can help a user navigate hallways and buildings with more ease. If we are able to get a floor plan of a building with distinguishable rooms, we can then create a fast and safe route through the building. User feedback on routes through a building can then be used to further optimize the suggested routes.
Satisfied by		

NFR Issues ID	Description	
NFRI2	PNFR_ID	PNFR2. The system leads the user through the fastest route
	1. Should the fastest route also be the safest route? 2. What should happen if the system loses connection with the source providing route information? 3. How do we decide the fastest route (e.gs., stairs may be faster than an elevator in some cases but that may not be the safest route for individuals with complete blindness)?	
	Option 1	Assume the safest route is also the fastest route as a safety first approach (ex. we use elevator instead of stairs).
	Option 2	Have back-up options in place to have the system swap between (magnetometer, wifi, bluetooth, etc.).
	Option 3	Give users multiple routes to choose from based on approximate time taken to complete the route paired with potential elevator/stair usage.
	Choice	Options 1 and 2.
	Rationale	Assuming the safest route is also the fastest route will ensure that the visually impaired individual gets to their destination as hassle-free as possible. Having back-up options in place for the system to switch between will help ensure the system continues to run in areas where some of the systems components may not be functioning.
Satisfied by		

NFR Issues ID	Description	
NFRI3	PNFR_ID	PNFR3. The system leads the user through the route that is most comfortable
	1. How to determine a comfortable route? 2. How to relay information to the user? 3. How does the system “lead” the users? (e.g., Auditory cues following a system of steps like mapquest?)	
	Option 1	Relay relevant information via auditory queues (speakers, earbuds, etc., paired with audible blips or scripts) and vibration to grab the user’s attention.
	Option 2	Assume the safest route is the most comfortable route only.
	Option 3	Assume a user's familiar routes are the most comfortable routes only.
	Option 4	Assume a user’s familiar route is the safest and most comfortable route.
	Option 5	At system set-up, obtain information from users about their comfortability in using stairs, elevators, and populated areas.
	Option 6	Confirmation auditory cues when a user correctly follows the navigation prompt.
	Choice	Options 1, 4, 5
	Rationale	Being able to notify the user of the system is important thus being able to relay auditory queues is also important. Using the phone’s built-in vibration features can help to notify the user that there is a new instruction to be relayed. Also, assuming the user’s most frequented routes are the safest will help ensure a user is comfortable with a route as we do not want to guide a user through an area they are uncomfortable approaching. Obtaining the

		user’s preferences on stair/elevator usage will help the system to provide better route recommendations.
Satisfied by		

NFR Issues ID	**Description**	
NFRI4	PNFR_ID	PNFR4. The system is usable for blind people
	1. How is a blind individual using the system? 2. Does the blind individual using the system need to interact with the system manually (e.g., incorporate slide/shake detection for the system)?	
	Option1	Auditory and vibration queues for navigation and collision avoidance.
	Option2	Simple swiping commands (e.g., swipe from right to left to get the next step in navigation).
	Option3	Assume a caretaker is always present to handle the device.
	Choice	Options 1 and 2
	Rationale	We need auditory and vibration queues since blind people might not be able to see the phone screen that well or at all. Additionally, an ability to use en route may be possible with an auditory question and a swipe right for yes and swipe left for no. This assumes that a caretaker is not present en route as that would nullify the purpose of using the system.
Satisfied by		

NFR Issues ID	Description	
NFRI5	PNFR_ID	PNFR5. The system is ubiquitous
	1. What is meant by ubiquitous? 2. What should be done if the user enters a “dead zone” (i.e., WiFi, BlueTooth nodes, and GPS is unavailable)	
	Option 1	Notify the user that they have entered a dead zone via auditory cues.
	Option 2	Notify local accessibility personnel about the users traversal into a deadzone when a user loses connection (with the users last known coordinates).
	Option 3	Obtain information from the user about their preferences in areas of low signal to guide the systems reaction (i.e. should they be told they are entering a deadzone)
	Option 4	Give an option for a user (aided by a non blind individual) to map a building that is not in the system so that they can use it for future routes.
	Choice	Option 1, 3, and 4
	Rationale	If we cannot use our IPS devices then that is easy to detect and easy to inform the user of. It is really easy to add another customization option in settings and will prevent the user from getting annoyed with the application as quickly. Without being able to scan a building manually the application would be very limited in the locations it can handle.
Satisfied by		

<table>
<tr><th>NFR Issues ID</th><th colspan="2">Description</th></tr>
<tr><td rowspan="6">NFRI6</td><td>PNFR_ID</td><td>PNFR6. The system is customizable to every user</td></tr>
<tr><td colspan="2">1. Does this include individuals who are not visually impaired?
2. Should the system be updatable (e.g., if someone gets laser eye surgery or goes through dilation, should they be able to adjust their settings)?
3. Ambiguity. What is customizable?</td></tr>
<tr><td>Option 1</td><td>The only customizable options will be Quality of Life improvements for visually impaired individuals.</td></tr>
<tr><td>Option 2</td><td>Gather information about the user’s blindness levels (from self or caretaker) upon installation which can be modified within the application. Depending on the blindness level, only tell them about small enough objects such that they may not see them.</td></tr>
<tr><td>Choice</td><td>Options 1 and 2</td></tr>
<tr><td>Rationale</td><td>We are expecting that there will be multiple different non-blind people helping the impaired person to use the application, therefore customization of the visual component is not likely to be meaningful. It can be frustrating for not fully blind people to hear information that they already know. However, It can be important for fully blind people to hear that information.</td></tr>
<tr><td>Satisfied by</td><td colspan="2"></td></tr>
</table>

NFR Issues ID	Description	
NFRI7	PNFR_ID	PNFR7. The system is easily extensible to accommodate the variations in interface, language, definitive needs of the user, new features, new sensors, and new hardware
	1. How do we anticipate future hardware and technologies? 2. How do we create a UI such that visually impaired individuals can navigate? 3. Are new sensors going to be built-in to devices or will they be attached via the charging port? 4. Will potential hardware upgrade(s) be affordable / accessible? 5. How to define specific user needs for varying levels of blindness? 6. Would we accommodate an individual who is also hearing impaired? 7. How do we create an intuitive UI design to help users change language preferences? 8. How to notify users of software updates?	
	Option 1	*Keep it simple*: Develop the application for currently existing technology, assuming the user is only visually impaired.
	Option 2	At system set-up, gather information about the user's level of blindness.
	Option 3	Allow options for the hearing impaired. (Vibrations and sound).
	Option 4	Check device language settings and verify language preference at set-up.
	Option 5	Auditory cue that an update is available on the system opening.
	Choice	Options 1, 2, 4, 5
	Rationale	Keeping the system within the realms of what is currently available will help keep the monetary

		cost of the system relatively low, as we do not want to put a financial burden on the users. Gathering information about a user is a relatively easy process. Once gathered, it can help guide the system into being exactly what the user needs. To ensure that the user understands the language that will relay information, the system should check the device settings and confirm the language selected on system initialization. As visually impaired individuals may not be able to see the screen, it is important to find some medium to notify them of any potential software updates that may be needed to provide better, safer navigation outside of having a caretaker notice that the system requires an update.
Satisfied by		

[4] WRS

4.1.W

We will be developing the application for Android 5.0 or later (Lollipop and above) using Android Studio v2020.3.1 in Java.

4.1.1. Problem

Problem ID	Problem Description	Corresponding Goals
P1	Blind individuals have difficulty navigating indoors with traditionally used navigation systems.	G1
P2	Blind individuals have difficulty avoiding static and dynamic obstacles in environments.	G2
P3	Blind individuals have a hard time using traditional smart-phone applications and communicating both to and from the application.	G3, G4

4.1.2. Goals

Goal ID	Goal Description	Backward Traceability	Forward Traceability
G1	Help blind individuals navigate indoors across multiple floors of a building.	P1	FO1, FO2, FO3, FO4, FO7, NFO1, NFO2
G2	Help blind individuals navigate stationary and moving obstacles.	P2	FO1, FO5, NFO1, NFO3
G3	Make an application which is easy for inexperienced non-blind individuals to assist with the function of.	P3	FO1, FO3, FO5, FO6, FO7, NFO3, NFO5

G4	Provide blind individuals with auditory computer speech feedback from the application.	P3	FO1, FO3, FO5, FO6, FO7, NFO3, NFO4, NFO5, NFO6, NFO7

4.1.3. Improved Understanding of Domain, Stakeholders, Functional, and Non-Functional Objectives

4.1.3.1. Improved Domain

Improved Domain ID	Improved Domain Description
ID1	The app shall provide functions that allow a person suffering from varying levels of blindness to modify navigations settings as listed in 3.1 DI1. Theia shall also provide functions that make it easier for a partially or fully blind individual to receive outside help as listed in 3.1 DI1.
ID2	The app shall provide features that improve usability for inexperienced non-blind individuals to quickly aid in app operation as listed in 3.1 DI2.
ID3	The app shall provide multi-floor navigation capabilities using best methods derived from an ensemble of methods as described in 3.1 DI3.
ID4	The app shall use a standardized assumption of Android specific device hardware as listed in 3.1 DI4. It will only assume the use of a standard camera and standard sensors (WiFi, Bluetooth, Magnetometer, Accelerometer, Gyroscope).

4.1.3.2. Stakeholders

- Developers (Alec, Charlie, Riley, Zach)
- End-users (blind community, carers for blind individuals)
- Google (for making the phone / running the app store)
- Product Manager (Bolong Zeng)
- Project Manager (Alec Yeasting)
- Hardware Lead (Riley Hunter)
- Requirements Analysts (Charlie Wong, Alec Yeasting, Riley Hunter, Zach Gherman)
- Software Engineers (Charlie Wong, Alec Yeasting, Riley Hunter, Zach Gherman)
- Hardware Engineer (Riley Hunter)
- Test Engineers (Charlie Wong, Alec Yeasting, Riley Hunter, Zach Gherman)
- Quality Assurance Engineer (Zach Gherman)

- Subject Matter Expert (Rod Moag)

4.1.3.3. Improved Functional Objectives

Based on the above information and our goals, the functional objectives of the app are:

Improved FR Objective ID	Objective Description	Alleviates Problems	Achieves Goals
IFRO1	The app will accept a destination through the aid of a categorized search bar usable by a non-blind helper as described in 3.2 FRI1.	P1, P2, P3	G1, G2, G3, G4
IFRO2	The app will find a route to a destination through the use of A* search performed on the search space as described in 3.2 FRI2.	P1	G1
IFRO3	The app will communicate directions to a blind user through the use of computer speech as described in 3.2 FRI3.	P1, P3	G1, G3, G4
IFRO4	The app will communicate to the user when to stop and turn through the use of tonally distinct beeps as described in 3.2 FRI4.	P1, P3	G1
IFRO5	The app will detect obstacles and communicate relevant information to the user used to avoid them as described in 3.2 FRI5.	P2, P3	G2, G3, G4
IFRO6	The app will include settings both in and after initial app setup to control whether or not emergency calls can be made in the app. If emergency calling is turned on the device will prompt the user via computer speech for whether they want to perform an emergency call or not as described in 3.2 FRI6.	P3	G3, G4
IFRO7	The app will attempt to predict user routes through using built-in scheduling functionality and calendar application integration. It will also use speech recognition to communicate with the blind user as described in 3.2 FRI7.	P1, P3	G1, G3, G4

4.1.3.4. Improved Non-Functional Objectives

Improved NFR Objective ID	Objective Description	Alleviates Problem	Achieves Goal
INFRO1	The app will help users safely navigate indoors through generated positioning maps, collision detection, and user feedback as described in 3.3 NFRI1.	P1, P2	G1, G2
INFRO2	The app will lead the user through the fastest route through assuming the safest route is a prerequisite for speed and having backup positioning systems in case one fails as described in 3.3 NFRI2.	P1	G1
INFRO3	The app will receive information from the user to generate the most comfortable routes to the user as described in 3.3 NFRI3.	P2, P3	G2, G3, G4
INFRO4	The app will allow blind individuals to be able to use the system using non-visual command input systems as described in 3.3 NFRI4.	P3	G4
INFRO5	The app will relay information on the app's limitations and how they can, with the help of a non-blind person, expand the functionality in order to make the application capable of ubiquity as described in 3.3 NFRI5.	P3	G3, G4
INFRO6	The app will gather information on the blind user's blindness levels and give customization options for navigation as described in 3.3 NFRI6.	P3	G4
INFRO7	The app will assume that the only impairment in the primary user's ability is in sight, will verify language preference on setup, and use auditory cues to inform them of available updates as described in 3.3 NFRI7.	P3	G4

4.2.RS

4.2.1. Functional Requirements

FR ID	Description
FR1	If a user makes a sound to the system, the system shall make a sentence from the detected sound.
Satisfies Functional Requirement Issue	FRI1, FRI4
Satisfies Objectives	IFRO1, IFRO3
Satisfied by prototype feature	Not yet implemented.

- This has to be further refined in terms of specification(s).

FR ID	Description
FR2	If a user wishes to submit a review of some functionality of the application, the system shall provide an easy solution for submitting a review.
Satisfies Functional Requirement Issue	
Satisfies Objectives	IFRO6
Satisfied by prototype feature	Not yet implemented.

- This has to be further refined in terms of specification(s).

FR ID	Description
FR3	The application must have a way to contact authorities, a care facility, or family member.
Satisfies Functional Requirement Issue	FRI6
Satisfies Objectives	IFRO6
Satisfied by prototype feature	Not yet implemented.

- This has to be further refined in terms of specification(s).

FR ID	Description
FR4	The application must relay information to the user in a timely and efficient manner.
Satisfies Functional Requirement Issue	FRI1, FRI2, FRI3, FRI4, FRI5, FRI6
Satisfies Objectives	IFRO1, IFRO2, IFRO3, IFRO4, IFRO5, IFRO7
Satisfied by prototype feature	Soundpool and Soundmanager are features that can be used and called upon an event occurring.

- This has to be further refined in terms of specification(s).

4.2.2. Non-Functional Requirements

NFR ID	Nonfunctional Requirement 1	
NFR1	The system shall be secure, which means confidentiality.	
Operationalized Functional Requirements		The system shall provide a login function with a user created password.
Satisfies Nonfunctional Requirement Issue		
Satisfies Non-functional Objective		
Constrains	Development Time, Usability	
Satisfied by prototype feature	Login	

NFR ID	Nonfunctional Requirement 2	
NFR2	The system shall be easily usable by users, this implies Usability.	
Operationalized Functional Requirements		

Satisfies Nonfunctional Requirement Issue	NFRI4, NFRI6
Satisfies Non-functional Objective	INFRO5
Constrains	Flexibility
Satisfied by prototype feature	UI Mock-up

NFR ID	Nonfunctional Requirement 3	
NFR3	The system shall work in most environments, this means Reliability.	
Operationalized Functional Requirements		
Satisfies Nonfunctional Requirement Issue	NFRI5	
Satisfies Non-functional Objective	INFRO1, INFRO5, INFRO6, INFRO7	
Constrains		
Satisfied by prototype feature	Magnetometer, Accelerometer	

NFR ID	Nonfunctional Requirement 4	
NFR4	The system shall provide correct information to the users, this means Accuracy.	
Operationalized Functional Requirements		
Satisfies Nonfunctional Requirement Issue	NFRI1, NFRI2, NFRI3	
Satisfies Non-functional Objective	INFRO1, INFRO2, INFRO3, INFRO5, INFRO7	
Constrains		
Satisfied by prototype feature	Testing	

NFR ID	**Nonfunctional Requirement 5**	
NFR5	The system shall adhere to the blueprints set forth in documents, this means Documentation.	
Operationalized Functional Requirements		
Satisfies Nonfunctional Requirement Issue	NFRI7	
Satisfies Non-functional Objective	INFRO5, INFRO6, INFRO7	
Constrains	Flexibility	
Satisfied by prototype feature	Documentation (WRS document, Preliminary planning Document, etc.)	

4.2.3. Specifications

Functional Specification ID	**Functional Requirement**
FS1	
Satisfies Functional Requirement	
Satisfies Objectives	
Satisfied by prototype feature	

[5] Preliminary Prototype

Our preliminary prototype consists of a simple mock-up of the user interface for the application and a basic flow of UI elements. It also contains the basics of accessing the relevant hardware sensors and camera; as well as the basics of audio management through the use of SoundPools and AudioManager classes in Android Studio. The sensors are managed by Android's SensorManager system and the camera is managed by the Camera Manager with a separate positioning class acting as the callback functions for handling sensor updates. The audio for the system is currently being managed by the SoundPool class and AudioManager class which are accessed when an event or interaction between the user and the system occurs (e.g., a button being pressed) which will be refined on specific actions taken by the user in later iterations of the system. The specifics (Code) can be found on the team's GitHub repository, not all of it is on the main branch due to some of it being split between different development branches.

[6] Prototype Interface Mock-up

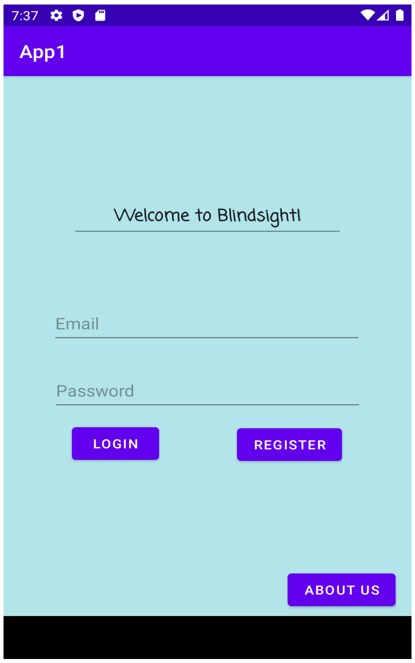


Figure 1: Application home page for user login and registration

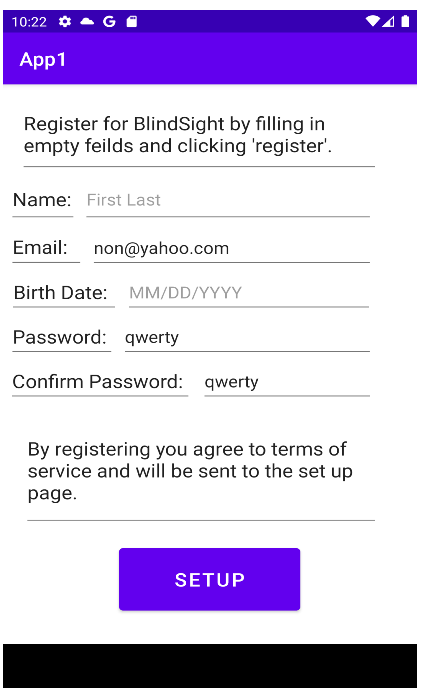


Figure 2: Setup page for user registration and login credentials

Figure 3: Setup page for user questionnaire

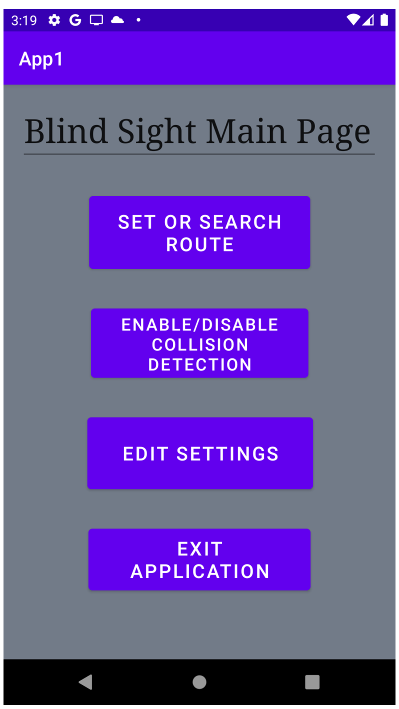
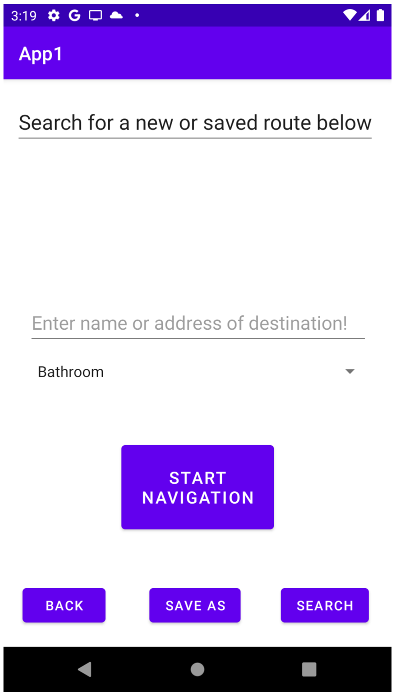


Figure 4: Main application page


3:19
App1
Search for a new or saved route below
Enter name or address of destination!
Bathroom
START NAVIGATION
BACK
SAVE AS
SEARCH

[7] User Manual

How to install Blindsight

Make sure you own an Android device, go to the Google Play Store and search for Blindsight.

To find and install Blindsight app for android:

1. On your Android phone, open **Google Play**
2. Tap the search icon to search for apps & games
3. Enter *blindsight* in the search field
4. Select **Blindsight** in the search results and go to the app page
5. Follow the standard installation procedure

Signing into your account

To use the app, you need to login using your email address and password of your Blindsight account. After successfully logging in, you'll be directed to the Blindsight main page.

If you do not have an existing Blindsight account yet, click **Register** and follow the instructions for 'Registering your account.'

Click on **About us** to learn more about our team, goals, and plans for Blindsight.

Registering/Setting up your account

To register for Blindsight, fill out the following empty fields:

1. Name - first and last
1. Email address
2. Birthday - MM/DD/YYYY
3. Password & Confirm password

Click on **Setup** on the bottom of the page to continue registration.

You will be asked to fill out a questionnaire regarding the individual's severity of disability, and levels of confidence. Once finished, click **Finish Setup**.

Navigating the Main Application

Once the account has been registered, and the setup questionnaire or the valid login info has been submitted, the application redirects the user to the main page. The main page has 5 main options for the user as followed:

Set or Search New Route

Search New Routes: For new routes the user must input the full address of the new destination into the search bar, and/or search by category using the dropdown menu, selecting the destination from a list dropping from the search bar.

Save Routes: To save a new route, the new destination must be selected. Then the user can press the save as button which creates a pop up that allows one to save the route as a nickname given by the user.

Search Old Routes: Old saved routes can be found by entering the destination's nickname. The user might enter "Sam's house" for instance, into the search bar.

Start Navigation: Once a route is selected the user can select start navigation sending the user to the map page where navigation directions will be given by audio, much like google maps. This feature is not 100% reliant on GPS however.

Go Back: The user can go back to the main page by pressing the "Back Button".

Enable/Disable Collision Detection

Requires various collision detection hardware. This button acts as an on/off switch. Users can press a button or say "Enable/Disable Collision Detection" at any point while navigating or just on the main page (not navigating). Note: This is subject to change.

Edit Settings

From the main application one can also edit the settings, ergo they can edit the questionnaire they did on the setup. This is the fourth button down, alternatively the user can say the phrase "Edit Settings".

Exit Application

The last option is to exit the application, returning to the login page. The button is on the bottom called "Exit Application", which is also the speech to text option for users.

Account Settings

For the BlindSight application there are many fields within the settings which fall under two categories; general settings, and the user specific settings. These settings get stored into a database.

General Settings

General settings include those that are absolutely required for registration as opposed to optimizing the application. These are the questions on the registration page however login information can be modulated in the "Edit Settings" option in the main application page.

- Name - first and last
- Email address
- Birthday - MM/DD/YYYY
- Password & Confirm Password

User Settings

User settings include those that optimize the user's satisfaction for the application. Because these contain sensitive information one could bypass it; not answering the questions which would default to "a middle of the road" option for each of the settings. These settings will affect potential routes such as with the "elevators versus stairs" example as well as how detailed (not word I want) the collision detection system is. These questions may include but are not limited to (let's try and think of five for now):

Question 1: For each option, please rate how comfortable you are using the following on a scale of 1-5: a ramp, elevator, stairs, or an escalator?

Outcome 1: The navigation will opt to use what is most comfortable and most direct for the user between the options for a safe secure travel.

Question 2: On a scale of 1-5, 1 being totally blind and 1 being near good vision but still legally blind, how do you rate your visual awareness?

Outcome 2: If the user rates a lower level of visual awareness, the collision detection system would alert the user even for very large collision risks. Versus the higher end of the scale, where the user would be only alerted of small but potentially hazardous collision risks (example: a Canis lupus familiaris, more commonly known as a dog).

Question 3: On a scale of 1-5, 1 being poor and 5 being excellent, how would you rate your confidence level when walking in a crowded vicinity?

Outcome 3: Based on the users confidence level, if the rates provided are on the lower end of the spectrum (low confidence), the detection system will alert the user when building capacities are high; additional precautions when navigating will be given via the notification system.

Question 4: On a scale to 1-5, 1 being poor and 5 being excellent, how would you rate your ability to travel independently?

Outcome 4: Based on the users confidence level, if the rates provided are on the lower end of the spectrum (low confidence), the application notification system will frequently provide relevant information when navigating the route; e.g.

Question 5: On a scale to 1-5, 1 being never and 5 being very often, how often do you fall?

Outcome 5: Based on the user's confidence level, if the rates provided are on the lower end of the spectrum (low confidence), the application will automatically give the user access to emergency calls.

Question 6: On a scale to 1-5, 1 being poor and 5 being excellent, how would you rate your aural awareness?

Outcome 6: If the user has poor hearing, answering a 1; the application will default more into a vibration/braille-like notification. If the user rates aural awareness as a 5, then speech only will be defaulted as the notification system.

[8] Traceability

[9] References

[1] Erickson, W., Lee, C., & von Schrader, S. (2012). 2010 Disability Status Report: United States. Ithaca, NY: Cornell University Employment and Disability Institute(EDI).

[2] Erickson, W., Lee, C., & von Schrader, S. (2012). 2011 Disability Status Report: United States. Ithaca, NY: Cornell University Employment and Disability Institute(EDI).

[3] L. Chung (2014). *CS/SE 6361 Advanced Requirement Engineering, Spring 2014, Project Phase 1: Requirements Elicitation: Initial Understanding.* [Online]. Available: [material url]

Appendix I: Process Details