
SOFTWARE DESIGN DOCUMENT SPECIFICATION

for

NAVATAR

Version 2.0 approved

**Prepared by Matthew Berger, Liam Gomez, and
Connor Parkinson**

**Advised by Professor Eelke of the
UNR CSE Department**

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Revision History

Name	Date	Reason For Changes	Version
Matthew Berger	11/29/16	Created document	1.0.0
Matthew Berger	4/19/17	Created document revision	2.0.0

1 Overview

1.1 Abstract

Navatar is an indoor navigation system for visually impaired students. Unlike existing systems that rely on expensive equipment, Navatar only requires an Android smartphone. The phone's GPS and accelerometer are used to approximate a user's location and movements and the phone's speaker is used to provide auditory directions to rooms within a building. Buildings on University campuses often have the GIS maps and the design required for Navatar's accelerometer based localization, which is why students are the intended audience for the project. With the application's open source status and modular design, crowdsourcing efforts can be used to integrate maps for buildings on any campus.

The application's improvements are nearing completion and Team 6 has worked on a variety of new features alongside other open source contributors. Currently, the features completed are as follows: Geo-Fencing, Gesture Detection, Optimization for Google Talkback, Route History, and Route Reversal. Geo-Fencing is determining the building a user might be in based on their current GPS coordinates and some mathematics. The gesture detection system allows the user to operate the application during navigation so that custom actions may be added. Google Talkback is used to control the application when a navigation is not currently in progress, and the application is now optimized for the easiest possible use with Google Talkback so that blind users who are familiar with navigating apps via Talkback will have a seamless experience. Route history allows users to select routes from past navigations. Route reversal allows users to take a route that they have already taken, except in reverse. This is effective for navigating back to a starting location after a class ends, etc. In addition to this, code cleanup was performed and any piece of the codebase that was touched was improved as a rule.

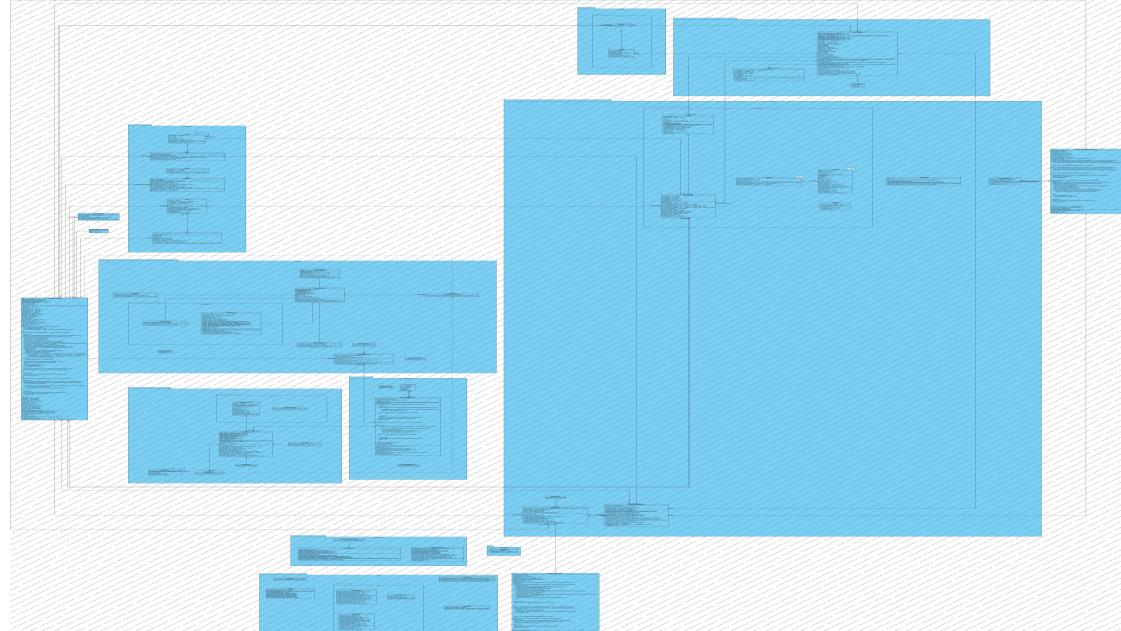
1.2 Introduction

The main goals and objectives of this project are to help blind people navigate indoor environments using a mobile phone and open source software which allows for a very low overall cost. Most people already have a cell phone, and mobile phones have a wide array of sensors available for environmental information. Accessibility is a major issue for many students with disabilities, and the technology necessary to ease the burden of some tasks that can be needlessly complicated is available and waiting to be utilized. Currently, there is no free and open source software capable of gathering environmental information and assisting students with indoor navigation for an entire college campus. The high level requirements of this software include being simple to use, low-cost, scalable, maintainable, and efficient in its assistance to blind users. The intended audience of this project, as stated, is blind students and partially blind students. Existing and familiar environments will be conquered through the use of landmarks and bookmarks. A bookmark in this case would be a landmark that the user sets manually, that gets stored specifically for that user. The reason behind this is that many partially-sighted and blind users remember details that sighted people may not utilize or need, such as a metal strip on the floor, that help them remember where they are in an indoor setting relative to where they want to go. The project itself currently exists as a repository on GitHub that contains a mobile android app. The members Team 6 all currently have a fork and are working on learning the code base to facilitate the development of new features. The future of this software depends greatly on what we are capable of achieving in the time-frame provided, but we plan on implementing many features. The first planned enhancement is the implementation of geofencing to determine what building the user is in. Possible future enhancements include the ability for users to declare and input their own landmarks, third party device integration to improve usability and accuracy (i.e. smart watches, Bluetooth earpieces), using additional environment information such as wifi SSIDs, making the app more scalable, improving map conversion and creation, user profile learning, stride detection, and gesture-based UI/UX improvements.

2 Design

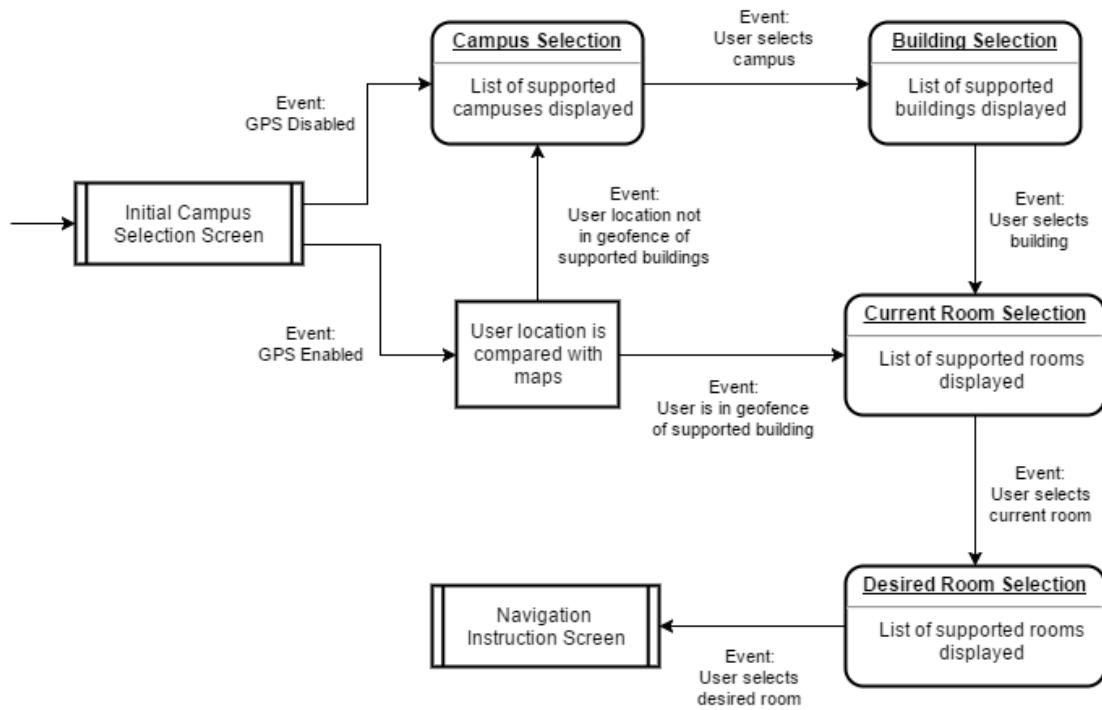
2.1 Navatar Software Architecture

This can be found in an attachment with this document, since the diagram is rather large.

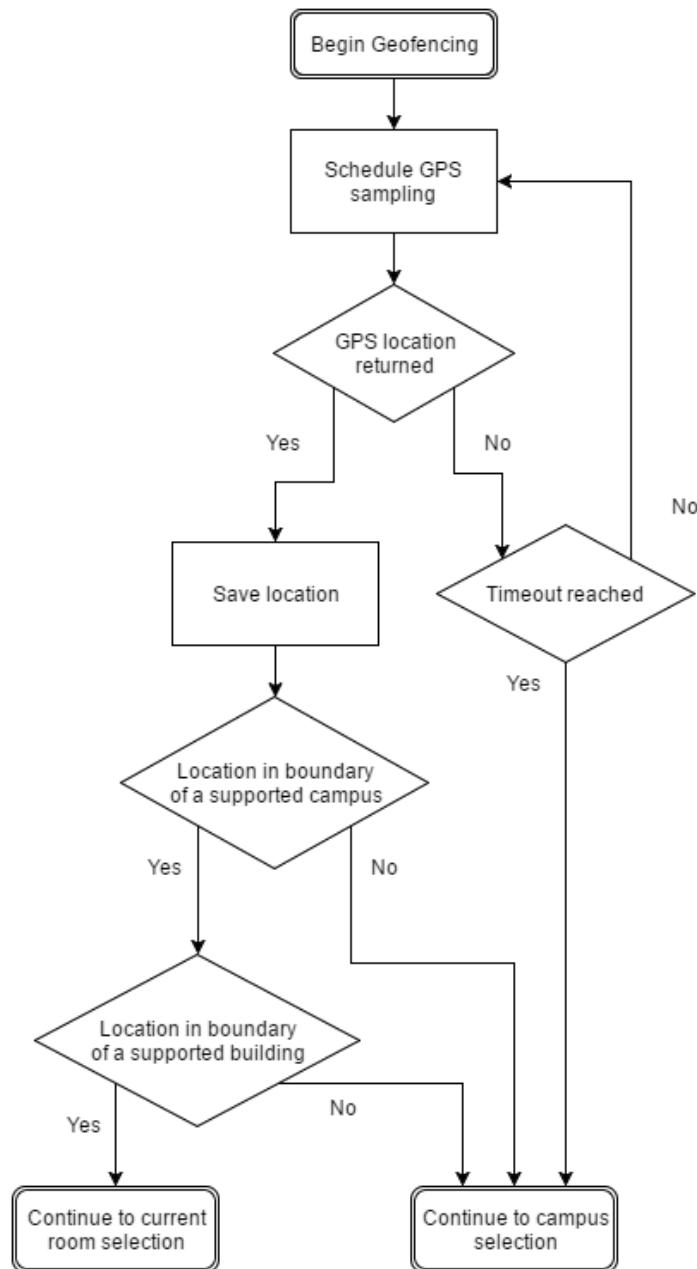


2.2 Detailed Design

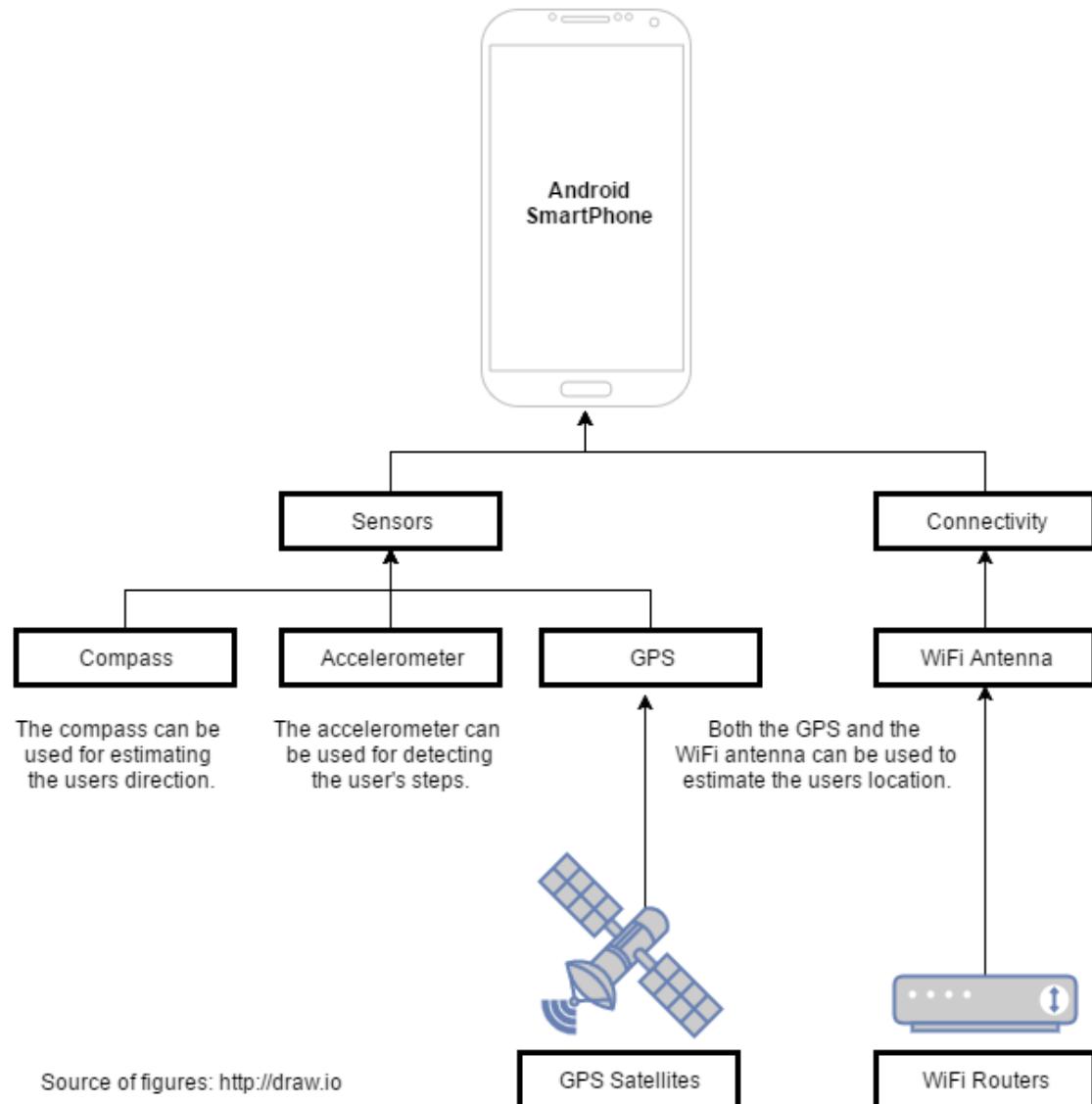
2.2.1 Manual and Geofence Building Selection



2.2.2 Geofencing



2.3 Initial Hardware Design



3 Snapshots

3.1 User Interface Design

These screenshots demonstrate intended user interface design of the software. The software is meant for blind users however, so the UI demonstrated here would be navigated with audio cues or swiping gestures in the final application.

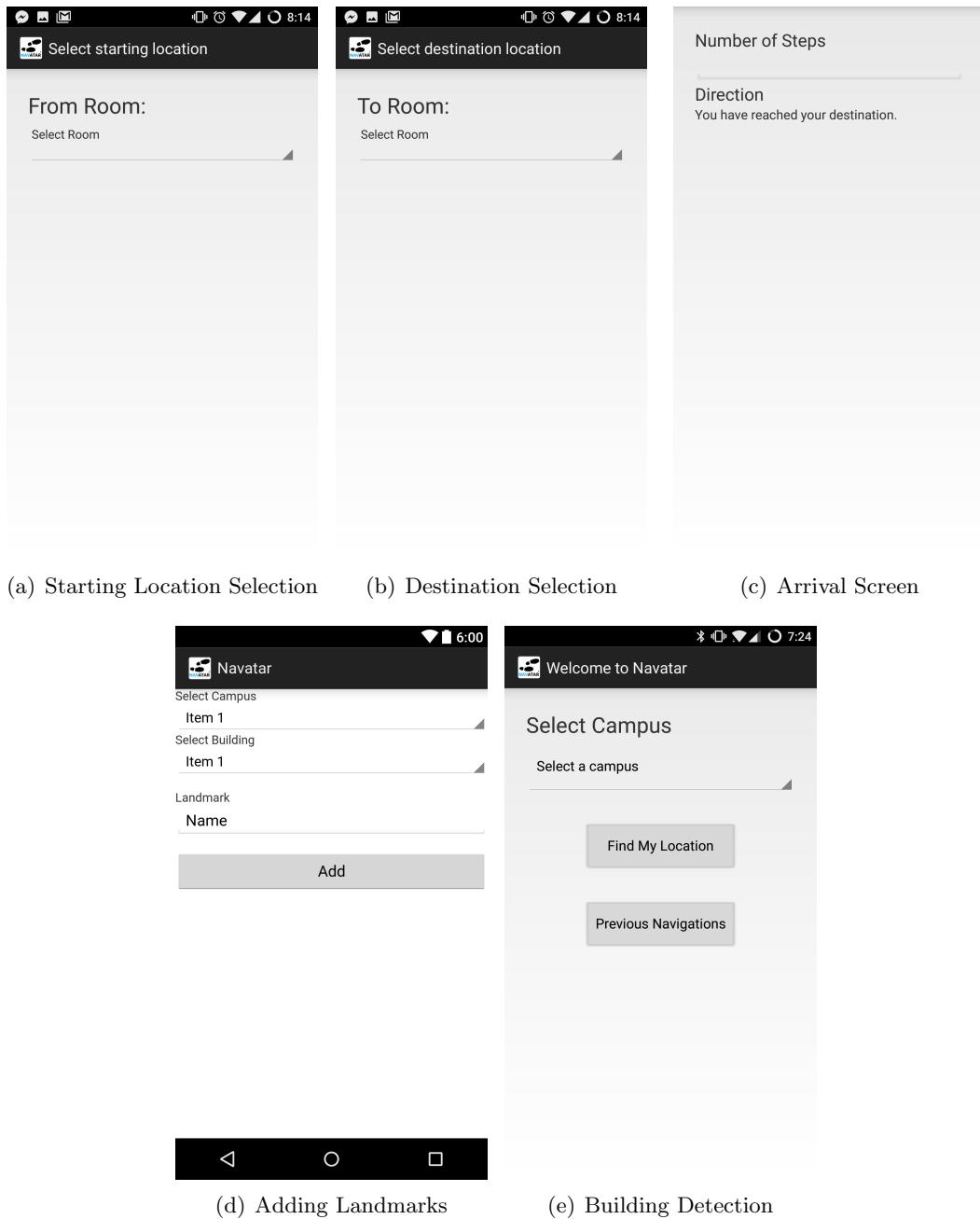
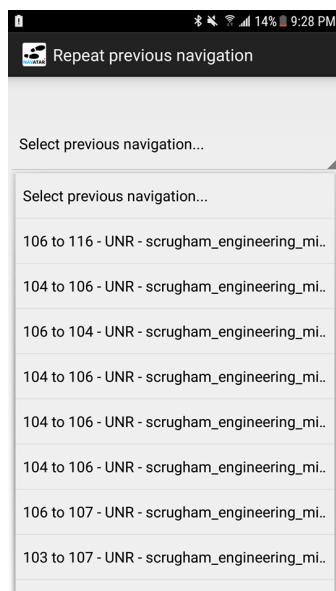


Figure 3.1: User Interface Screenshots

3.2 Layout



(a) Route History Screen

Update: Route history screenshot added.

Figure 3.2: Layout Screenshots

4 References

4.1 Feasibility of Interactive Localization

Ilias Apostolopoulos, Navid Fallah, Eelke Folmer, Kostas Bekris. Feasibility of Interactive Localization and Navigation of People with Visual Impairments, Proceedings of 11th Intelligent Autonomous Systems Conference, Pages 22-32, Ottawa, Ontario, August 2010.

Summary: Investigates various solutions to the problem of indoor navigation for the visually impaired. Describes the issues that make indoor localization systems difficult to implement, and weighs the pros and cons of solutions that are currently available. These solutions include using RFID tags, cameras, or range finders to provide locational information. These solutions are quite expensive due to high installation and equipment costs. The article proposes the use of common smartphone sensors in combination with user interaction and user provided landmarks to provide navigational information to the user. Provides technical specifications for estimating a user's location.

4.2 Results from Initial User Experiments of Navatar

Ilias Apostolopoulos, Navid Fallah, Eelke Folmer, Kostas Bekris, Integrated Online Localization and Navigation for People with Visual Impairments using Smart Phones, IEEE International Conference on Robotics and Automation (ICRA), Pages 1322 -1329, Minnesota, MN, May, 2012.

Summary: Discusses the results from initial user experiments with the Navatar prototype, providing detailed statistical data and analysis. In depth description of Navatar's path planning algorithm and accuracy. Shares some of the user's experiences and feedback. The user's experiences were all positive, saying that directions were clear and that the application did have potential to prevent the user from getting lost in new buildings. The users did suggest some possible improvements, including accuracy improvements, saving and repeating directions, and making the application hands free.

4.3 Navatar's Localization Architecture

Ilias Apostolopoulos, Navid Fallah, Eelke Folmer, Kostas Bekris. Integrated Online Localization and Navigation for People with Visual Impairments using Smart Phones, ACM Transactions on Interactive Intelligent Systems 3:4, Pages 1-25.

Summary: More in depth descriptions of Navatar's localization architecture, giving the actual algorithms used for sampling, as well as the transition and observation models. Shows how the K-Means algorithm can be used to adapt Navatar's localization system to the unique stride lengths of a given user. Discusses potential limitations due to the computational ability of smartphones, proposes an offline training process using better hardware to solve this problem. Briefly describes Navatar's user interface design and the UI's accessibility to those with visual impairments.

4.4 Indoor Navigation System for the Blind

Scientists design indoor navigation system for blind. (2016). Phys.org. Retrieved 8 November 2016, from <http://phys.org/news/2012-05-scientists-indoor.html>

Summary: A high level overview of indoor localization systems, describing how Navatar uses a combination of GIS maps and readily available smartphone sensors to help visually impaired users navigate buildings. Contains some interview questions answered by Eelke Folmer about Navatar, and the potential benefits it could have. Folmer discusses some of the obstacles that had to be overcome in the development of Navatar, as well as his motivation for the creation of Navatar.

5 Contributions

These contributions took place over the course of the Fall 2016 semester through to the end of the Spring 2017 semester at UNR. Because the features were large and self-contained, all of the time utilized was spent ensuring the necessary functionality was implemented and that the desired code cleanup was performed.

5.1 Matthew Berger

- Created LaTeX document.
- Created cover page and table of contents.
- Completed software architecture diagram.
- Designed, prototyped, and implemented the gesture detection system.
- Established a reproducible Vagrant development environment.

5.2 Connor Parkinson

- Completed abstract and introduction.
- Created detailed design diagrams.
- Created initial hardware design diagram.
- Designed, prototyped, and implemented the Geo-Fencing feature.
- Handled team management and project coordination responsibilities.
- Performed optimizations for Google Talkback.

5.3 Liam Gomez

- Created mockups for the user interface changes needed for the new features.
- Updated the references relevant to this assignment.
- Added new terms to the glossary.
- Designed, prototyped, and implemented the Route Reversal feature.
- Designed, prototyped, and implemented the Route History feature.

6 Glossary

Term	Definition
Android	An operating system for mobile devices and smartphones. Navatar currently only supports this operating system.
Android Studio	An integrated development environment (IDE) for developing mobile applications for the Android operating system.
Dead-Reckoning	A localization technique that estimates a user's location using an old estimated location as the starting point, using various data from sensors and other environment information to improve estimations.
Direct Sensing	A localization technique that uses physical identification tags to provide the current location of a user. Direct sensing requires the installation of these tags in the environment, which can be quite expensive.
Geofencing	Using global positioning systems to create geographical boundaries around an area, useful for determining what building a user of Navatar might be entering.
Geographic Information System (GIS)	a system used to store, manipulate, and present geographical data. Geographic information system maps are used by Navatar to load the layout of a given building.
Github	A web based service that hosts Git repositories to provide source control for software development purposes.
Global Positioning System (GPS)	A network of navigation satellites that provides geolocation information to a GPS receiver. GPS can be unreliable in indoor environments due to signal interference from the environment.
Landmark-based Navigation	Navigation using physical landmarks and a physical or mental map of the environment.
Localization	Adaptation of a product or service to meet the needs of a given language, culture, or population.
Pattern Recognition	Localization technique that uses previously stored environment data as a basis for determining a user's location. A user then wears sensors that collects similar environment data which can be compared stored data to determine the user's location.
Protobuffers or Protocol Buffers	A method of serializing, or converting data, to a storable format. Used by Navatar to store the GIS map data for buildings.
Radio Frequency Identifier Description (RFID)	Uses radio frequencies to uniquely identify an object or provide information about an object. RFID tags are used in some direct sensing localization systems to provide navigational information indoors.
Source Control	Also known as version control, is a system used to manage revisions to a software application's codebase. The history of all revisions is stored, allowing any previous revisions to be rolled back.
Service Set Identifier (SSID)	The name or identifier of a given network. Can be analyzed by Navatar to provide additional location information to be used during navigation.