February 11th, 2013

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6 Canada

Re: ENSC 305/440 Functional Specification for an Indoor Direction Finder for the Visually Impaired

Dear Dr. Rawicz:

The attached document, "Functional Specification for an Indoor Direction Finder for the Visually Impaired", outlines our design expectations in our capstone project in ENSC 305/440. We seek to design and implement an indoor system of signal beacons that enable the blind and visually impaired to navigate safely and effectively to their destinations with a portable device. We named this system the **WhereTo**.

The purpose of the functional specifications is to define the goals and requirements of the **WhereTo** system in its proof-of-concept prototype and production states. This document will serve as a guide throughout our design and development phases to ensure that our product is functional, usable, safe, and reliable.

Envied Solutions consists of four talented engineering students near graduation: Alan Fang, Phillip Peach, Shaham Shafiei, and I, Wilson Chen. For any questions or concerns you may have, please contact me by phone at 778.386.3284 or by email at wilson_chen@sfu.ca.

Sincerely,

Wilson J. L. Chen
President and CEO
Envied Solutions

Enclosure: Proposal for Indoor Direction Finder for the Visually Impaired
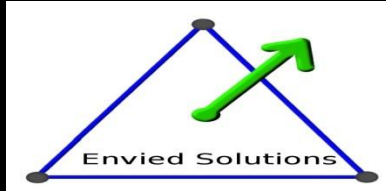
WhereTo

Functional Specification for an

Indoor Direction Finder for the Visually Impaired

Project Team

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Executive Summary

Standard building way-finding is primarily visual. It consists typically of things like signs, arrows, paths painted on walls or floors, and other methods which are of minimal or no use to the visually impaired. In an unfamiliar building, this can leave these people at a distinct disadvantage. The WhereTo system by Envied Solutions aims to alleviate this disadvantage.

To use the WhereTo system, the building owner installs a number of beacons throughout the building. These beacons are programmed during set-up with their location inside the building and are used by the handheld unit to determine the user's position. The user can then use a WhereTo handheld unit (either their own or one that the building owner lends out to visitors) to navigate to a destination within the beacon coverage. To best serve the target market, all interaction with the handheld unit is audio based. The user commands the system by voice and is given directions over a pair of headphones. As a bonus, along the way, the handheld can alert the user to any obstructions detected again through an audio warning.

Development is currently on-going. Detailed design and construction of a prototype system consisting of three or more beacons and a single handheld unit is expected to begin by the middle of February 2013. The prototype system is planned to be ready to demonstrate in April 2013.

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Glossary

Beacon	The part of the WhereTo system affixed to buildings
CSA	Canadian Standards Association
ESD	Electrostatic Discharge
FCC	Federal Communications Commission (USA)
Handheld Unit	The portable part of the WhereTo system carried by the user
ISO	International Organization for Standardization
NEMA	National Electrical Manufacturers Association (USA)
SCC	Standards Council of Canada
UI	User interface
USB	Universal Serial Bus

Introduction

Envied Solutions' **WhereTo** Direction Finder system is designed to facilitate navigation in unfamiliar buildings, in particular, to assist the visually impaired. The system consists of a set of fixed beacons installed in buildings which convey positioning information to the user's handheld unit. The handheld unit will then direct the user to their destination. This document lays out the functional requirements of the **WhereTo** system.

Scope

The requirements in the functional specification must be met for the **WhereTo** system to be properly implemented. These requirements will be at the fore-front of the design process at all times. Some requirements will be limited to either the prototype or full production model; these requirements will be noted as such.

Intended Audience

This specification is intended for use by the members of Envied Solutions. The requirements laid out will be used by engineers to guide their design and implementation of the WhereTo system. Furthermore this document will serve as a standard against which the system will be tested. In addition the management of Envied Solutions will use this specification to determine the success of the project.

Conventions

The requirements of the system are denoted in the following format: **[Req-#s]**.   **#** is the number of the requirement and **s** is an optional suffix:

- **F –** for a requirement which is only applicable to the final production model.

System Requirements

The **WhereTo** system has two primary components: the fixed beacons and the user's handheld device.
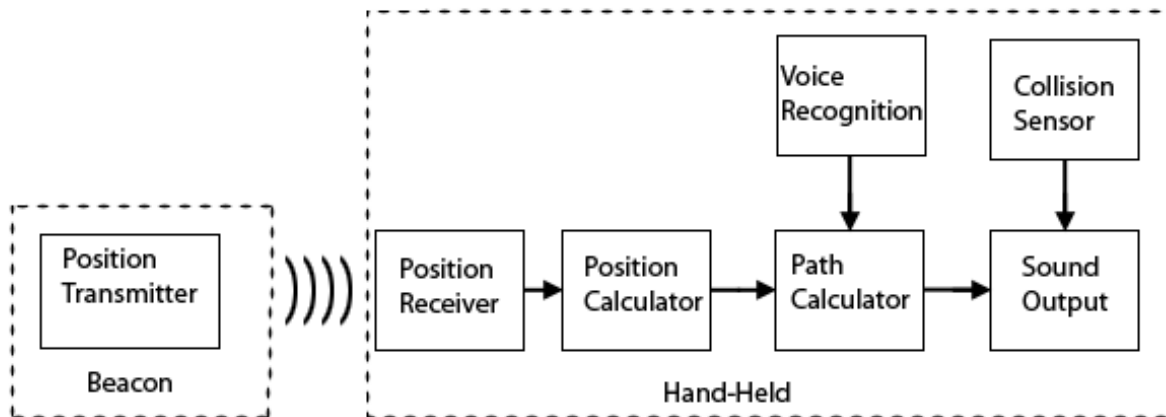
System Overview

Figure 1- High-Level Diagram of the WhereTo System

As seen in **Figure 1- High-Level Diagram of the WhereTo System**, the beacon has one primary functional component, a transmitter which periodically transmits location information. The handheld unit contains a receiver which takes all the transmissions from all the beacons within range and passes that information to the position calculator. The position calculator in turn takes this information and computes a position and makes that information available to the path calculator. The path calculator uses the current position and the user's desired destination to compute the path and then generate a series of spoken directions, such as "turn right" through a pair of head phones. The user interacts with the handheld system including setting the destination via a voice recognition system with audio feedback.

The general work flow is as follows. The user puts on a set of headphones attached to the handheld device and presses the power button to bring the handheld out of standby. The handheld will give an audio cue that it is ready. At this point the user can ask the system to "list destinations" or if they already know where they want to go they can command the unit to "go to X" where X is their destination. At this point, the unit begins giving directions. At any time, the user can select a new destination.

Additionally future models may include a sensor to detect and warn the user of obstructions.

General Requirements

[Req-1F]   The handheld unit shall be compact and comfortable to grip and use.

[Req-2F]   The handheld unit shall be inexpensive for users to purchase.

[Req-3]   The handheld unit shall be simple to configure for different buildings.

Environmental & Sustainability Requirements

[Req-4]   The system shall operate in environments with temperatures of 0 to 30 degrees Celsius.

[Req-5]   The handheld unit shall be able to operate indoors and in dry outdoor conditions.

[Req-6]   The beacons and handheld unit shall not be making any noise when not in use.

[Req-7]   The handheld shall only produce sound through headphones when in use.

[Req-8F]   The system shall be made out of recycled plastic.

[Req-9]   The beacons shall not emit any light.

[Req-10]   The handheld units shall not emit any light unless in use (power button only).

Standards

[Req-11F]   The system shall conform to CSA - C22.2 No.60065A-03 standard for audio safety. [1]

[Req-12F]   The system shall conform to CSA - ISO/IEC 26907-10 standard for ultra-wideband if applicable. [2]

[Req-13F]   The system shall conform to CSA -C22.2 No. 61010-1-12 standard for ultrasonic if applicable. [3]

[Req-14F]   The system shall conform to FCC radio frequency devices standards [4].

[Req-15F]   The system shall meet CSA requirement CSA-ISO/IEC 7816-12-06 for USB data communication if applicable. [5]

Reliability & Durability Requirements

[Req-16F]   The handheld unit shall be easily debugged and software updated via a standard connector.

[Req-17F]   The system shall be able to operate for at least a year between recalibrations.

[Req-18]   The error in location shall not exceed a tolerance of +/- 5%.

[Req-19F]   The handheld unit shall last for at least whole day on a fully charged battery.

[Req-20F]   The battery pack shall retain over 50% charge for up to one week on standby.

[Req-21F]   The beacons shall be operational for at least 10 years continuously with minimal downtime.

Safety Requirements

[Req-22]   The beacons shall emit signals only at wavelengths and power levels that are safe for continuous exposure.

[Req-23F]   The handheld unit enclosure shall prevent overexposure electric-magnetic radiation

[Req-24F**]**   The handheld unit enclosure shall be properly shielded to prevent electric shocks (ESD) and leakage.

[Req-25]   The output audio volume shall not exceed 70 dB.

Usability Requirements

[Req-26]   The handheld unit shall have buttons for on/off and UI selection.

[Req-27F]   The handheld unit shall beep/vibrate when turning on/off or low on battery with different sounds for each.

[Req-28F]   The handheld unit shall be easy to troubleshoot in case maintenance is required.

Luxury Functions

[Req-29F]   The handheld unit shall perform collision detection to avoid obstacles in the user's path.

Handheld Device

The primary functions of the handheld unit are:

- to determine the position of the user from information provided by the beacons,
- to guide a visually impaired user to a destination.

General Requirements

[Req-30F]   The handheld unit shall be easy to carry.

[Req-31F]   The handheld unit shall be able to detect obstructions at least 2 meters away if applicable.

[Req-32]   The handheld unit shall be able to determine its location to within 30 cm.

[Req-33]   The handheld unit shall be able to guide the user to a destination within the same building as it is within the installed coverage area.

Physical Requirements

[Req-34F]   The handheld shall have a mass of no more than 300 grams.

[Req-35F]   The handheld shall have maximum dimensions of 15 cm by 15 cm by 1.5 cm.

[Req-36]   The handheld shall have a 3.5 mm headphone jack and 3.5 mm microphone jack

[Req-37F]   The handheld unit shall have a clamp designed for attaching the unit to the white cane used by a visually impaired person.

[Req-38F]   The handheld shall be water resistant enough to function with damp/wet hands.

[Req-39F]   The handheld shall be shock resistant enough to withstand a fall from at least 2 meters.

Electrical Requirements

[Req-40]   Power shall be supplied by a rechargeable battery pack supplying at least 5 volts.

[Req-41]   The handheld unit shall be able to calculate an accurate position if it can receive the signal of three beacons within 30 metres.

[Req-42]   The handheld unit shall operate and calculate a position with good accuracy using beacons within 30 metres away and should still function with beacons up to 50 metres away.

 [Req-43]   The magnetometer shall measure the current orientation with less than 5% error.

Signal Beacons

The primary functions of the beacons are:

- to serve as path markers which are fixed in location relative to the building,
- to broadcast signals appropriate for the handheld unit to decipher into position data.

General Requirements

[Req-44F]   The beacons shall be easily adjustable after installation to maximize signal quality.

Physical Requirements

[Req-45F]   The beacons shall be compact and lightweight enough for mounting onto walls and ceilings.

[Req-46F]   The beacons shall have high visibility to serve secondarily as way markers.

Electrical Requirements

[Req-47]   The signals of multiple beacons shall coexist with one another.

[Req-48]   The signals shall be of good quality for at least 30 meters from its source.

[Req-49]   The beacons shall use power from conventional NEMA 5-15 wall sockets with a backup source that lasts for at least 5 hours.

User Interface

Due to the primary market, the user interface will have to be usable with no visual output or feedback. In order to meet this goal, the primary user input will be through spoken word into a microphone and primary user output will be spoken output and audio cues delivered through a pair of headphones.

Handheld Unit User Input

[Req-50F]   There shall be a button that will bring the unit out of stand-by mode if it is in that mode. In normal mode this button will also repeat the last statement or query from the unit to the user.

[Req-51F]   The handheld unit shall be able to interpret up to thirty distinct command words or phrases.

[Req-52F]   The commands shall include:

- A command to list destinations.
- A command to output the current location.
- A command to set a destination.
- A command to access built in help.

[Req-53F]   The voice recognition system shall be able to distinguish speech with a background noise level of 65 dB.

[Req-54F]   The voice recognition system shall have an error rate of less than 5% for valid input phrases.

[Req-55]   The voice recognition shall be able to correctly able to decode speech when the microphone is 5 cm or less from the user's mouth.

[Req-56]   The microphone for the voice recognition system shall connect using a standard 3.5 mm jack.

Handheld Unit User Output

[Req-57]　　　Output to the user shall be produced as audio through headphones connected to a standard 3.5 mm headphone jack.

[Req-58F]　　　The audio output system shall be able to mix at least 2 output channels together.

[Req-59F]　　　The audio output system shall have the ability to produce at least 100 distinct words.

[Req-60]　　　The audio output system shall generate spoken directions from the output of the way-finding system. The system shall be capable of generating a spoken output every 3 seconds or less.

[Req-61]　　　The audio output system shall repeat the last spoken direction if it is still valid every 5 seconds.

[Req-62F]　　　The audio output system shall generate a beep when an obstacle is closer than 5 metres where the beep rate shall increase as the obstacle gets closer.

System Test Plan

The test plan consists of individual module tests to ensure all modules function correctly and overall system integration tests to ensure the whole system performs as expected.

Beacon Transmitter

Each beacon will have its position signal characteristics verified. Each beacon will need to meet the minimum signal strength requirements when powered as specified. The beacons will be tested to ensure they do not interfere with each other.

Position Calculator

The position calculator inside the handheld unit will be tested with several simulated valid signal inputs to verify that the positioning system is correctly implemented. The position calculator will be tested with simulated degraded, non-ideal and invalid inputs to verify that the position remains within tolerance in realistic conditions and does not crash or otherwise go into a fault condition with momentary bad input.

Path Calculator

The path calculator will be tested with a variety of simulated positions and destinations to ensure a valid path is generated and the correct directions are sent as output.

Collision Detection

The collision detection sensor will be tested to verify that the distance to the nearest obstacle is correctly computed.

Voice Recognition

The hardware and software for the voice recognition system will be tested against speakers of a variety of ages, accents and gender to determine if it meets the accuracy requirement.

Sound Output

The sound output system will be tested with inputs for direction and collision avoidance both individually and together. The testing will ensure that the correct outputs are produced and that conflicts are prioritized correctly.

System Integration

The full system will be tested to ensure that the beacons and handheld unit meet their physical and electrical specifications when fully assembled. The positioning and path-finding functions will be exercised.

Conclusion

This specification clearly delineates the functional requirements which need to be implemented for the Envied Solutions WhereTo system. Development of a prototype is commencing soon. This prototype device will meet all requirements which are general or marked prototype only but may not contain the requirements marked final only or in the luxury section. This prototype system is scheduled to be completed in April 2013.

References

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