Assistive Navigation Systems for the Visually Impaired

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INTRODUCTION

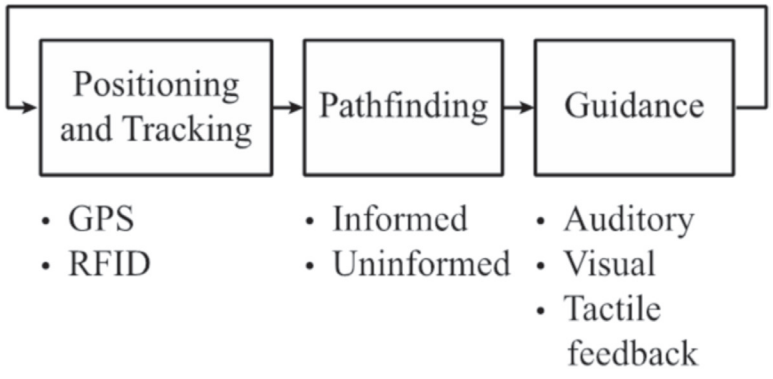
Navigation systems consist of three main components, 1. positioning and tracking, 2. pathfinding, and 3. guidance. (See Figure 1)

The positioning and tracking block determines the position of the user through the use of triangulation or trilateration techniques and tracking is achieved by continuously updating the position of the user. Locating is similar to positioning except that it does not include information on the orientation and direction of the user. This becomes important when working indoors whereby most systems provide location detection rather than the position. The pathfinding block determines routes from between two locations optimised based on traveling time, cost and/or distance. Once the path is determined, the guidance block provides guidance such as turn-by-turn instructions to the user. More advanced systems can determine in real-time the surrounding conditions and guide the user around obstacles.

The most commonly known navigation system currently in use is based on the Global Positioning System (GPS), which rely on a constellation of satellites orbiting Earth for trilateration based positioning. These systems typically provide audio-visual based guidance for the user to traverse the path. Such guidance is not well suited for the visually impaired whose guidance is primarily in the form of audio and tactile feedback (touch).

The next section will describe the technologies commonly used in components of the navigation system used for the visually impaired. Next, the article

Figure 1. General components of a navigation system



DOI: 10.4018/978-1-4666-5888-2.ch030

describe what assistive technologies are available for the visually impaired and compares five different assistive navigation systems for the visually impaired (ANSVI). Then, this article discusses about pathfinding, and reviews two more pathfinding-focused systems. Finally, future research directions are presented before this article concludes.

BACKGROUND

This section will describe technologies and methods that are commonly used in each of the three navigation system components for ANSVI.

Positioning and Tracking

There are three common methods for positioning (or locating) in ANSVI,

1. Global Positioning System (GPS)

The GPS is a satellite based positioning system that while it works well outdoors (to an accuracy of $\pm$3m), does poorly indoors or not at all. This is due to the signals from the satellite not being able to penetrate buildings. One method of overcoming this is to use in- door GPS repeaters. However, these are an additional cost

2. Radio Signal Strength Indicator (RSSI)

The RSSI is a measurement of power present in a received radio signal and it is this signal strength that is used to estimate the user's location. One common source of RSSI data is the 802.11 protocols. Locations with large-scale deployments of wireless access points can benefit from the ease of using the RSSI method for positioning. While this method is highly suited for use indoors, it is inaccurate as the RSSI is highly dependent on factors such as the antenna gain patterns and polarisations, multipath fading and interference from devices in the same frequency. More recent advances in using RSSI is to implement it on a micro-location basis such as those implemented by Bluetooth Low Energy (BLE) beacons.

3. Radio Frequency Identification Devices (RFID)

This method relies on a network of RFID tags or transponders in the area where the user's location is to be determined, forming a grid of checkpoint markers. It is an absolute locating method and the location is determined based on which checkpoint is activated. Accuracy of such systems are dependent on the density of the grid and the sensitivity/range of the transponders. To increase the location detection accuracy:

- A more tightly coupled grid can be used, but the cost will increase
- Transponders with a smaller area of detection can be used, but the person must be standing very close to the transponder. This can be overcome by having a more tightly coupled grid but same cost trade-off applies.

Pathfinding

Pathfinding is the process of finding the optimal route (in terms of distance, time to travel etc.) between two points. Pathfinding can be classified into:

1. Informed (Directed)

In this search, the general direction of the destination from the current position is known. The search is then weighted towards that direction.

2. Uninformed (Undirected)

Unlike the informed search, the direction of the destination is unknown from the current position. This leads to an exhaustive search from the current position until the destination is found.

Algorithms such as the A* search algorithm (Hart, Nilsson, & Raphael, 1968) and the Dijkstra's shortest path algorithm (Dijkstra, 1959) are often used interchangeably in situations, depending on the requirements that the current situation holds, as both algorithms, along with other unmentioned algorithms are made to cater for different pathfinding scenarios.