A Positioning Methodology Using Bluetooth and Smartphone Technologies to Support Wayfinding for the Visually Impaired

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The Problem
People who are blind or visually impaired usually use a white cane as their primary tool for wayfinding and detecting obstacles. Environmental cues, though not always reliable, are used to support their decision making. But differences in blind pedestrians’ spatial perception compared to that of sighted people means they often encounter physical as well as information barriers along a trip. To improve their mobility, accessibility, safety, and confidence in using our transportation system, it is important to remove both types of barriers.

Objectives
• Develop a smartphone app to integrate GPS and motion sensors on the smartphone and real-time signal information from the traffic controller
• Provide audible messages to pedestrians through a text-to-speech interface
• Use Bluetooth Low Energy (BLE) technology to identify a user’s location in a GPS-unfriendly environment
• Provide traffic information such as signal timing or work zone details to the visually impaired through a smartphone
• Develop a self-monitoring infrastructure to ensure information integrity

Approach
Researchers developed a mobile accessible information system that allows the visually impaired to receive transportation information at key locations where decision making is necessary. To get there, the researchers:
• Conducted surveys at the beginning of the study and incorporated those results into the system design
• Developed firmware that allows each BLE beacon to alternate its operation between scanning and advertising modes
• Developed a “condition-aware, self-monitoring” infrastructure using BLE technology for supporting the location needs of the visually impaired in a GPS-unfriendly environment
• Used a local map as a reference and developed a smartphone-based interface to effectively convey geometry or navigational information
• Interfaced the smartphone app with a geospatial database to identify a traveler’s location and provide the corresponding audible messages via a text-to-speech interface on the phone to support wayfinding and situation awareness

Key Findings
Four BLE beacons were installed at an intersection with nine digitized reference points to validate positioning accuracy.
• Average positioning accuracy at an intersection using 4 BLE beacons (without GPS) is about 4 to 5 m. It can be improved by adding additional tags to the Bluetooth network.
• For self-monitoring, the researchers’ network fingerprinting technique successfully detects the change of a BLE beacon when it was moved over 3 m away.
• The system can use a crowdsourcing approach to monitor the status of BLE beacons and update messages associated with them.

Applications
Rather than undermine the skills and strategies that people with vision impairment have learned for navigating, this system aims to support their wayfinding capability, extend their mobility and accessibility, and improve their safety by providing information on:
• Intersection geometry and signal timing
• Work zone detours or bypasses
• Transit stop locations
• Skyway or tunnel navigation

The same methodologies can also be used to warn sighted but distracted pedestrians to stop looking at their smartphones and pay attention as they approach an intersection.

About the Institute
This research was sponsored by the Roadway Safety Institute, the Region 5 University Transportation Center led by the University of Minnesota. Other consortium members are the University of Akron, the University of Illinois at Urbana-Champaign, Southern Illinois University Edwardsville, and Western Michigan University.

Learn more at www.roadwaysafety.umn.edu

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Single-tap on smartphone screen for orientation and geometry information.

Double-tap on smartphone screen to confirm crossing. The app sends a pedestrian crossing request to the traffic signal controller. The app receives signal timing information, then vibrates and announces signal information when the “walk” phase is on (no second-by-second countdown update).

Self-monitoring Bluetooth Low Energy network to detect if the location(s) of one or multiple BLE tags have changed. Sample BLE network with four beacons, A, B, C, and D (each BLE transmits and receives).

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