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UTC Spotlight

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Smartphone-Based System Improves Safety and Mobility for Visually Impaired Pedestrians

Crossing a street isn't risk free for any pedestrian, but it's especially challenging for those who are blind or visually impaired. To help these pedestrians safely cross signalized intersections, researchers at the University of Minnesota have developed a smartphone-based system that uses GPS, Bluetooth, and other technologies.

Pedestrians who are blind or visually impaired face a number of unique challenges, such as difficulty locating the edge of the street or crosswalk and interpreting signal and traffic patterns. These issues can be especially daunting when traveling in unfamiliar locations or through work zones.

Center for Transportation Studies, University of Minnesota

When developing the smartphone-based system, the researchers worked with potential users to understand their needs.

Senior systems engineer Chen-Fu Liao led the development of an intersection-crossing system, which was subsequently expanded to help visually impaired pedestrians navigate through work zones.

As part of their work, the researchers interviewed individuals with vision impairment to better understand what types of information they use at intersection crossings and what additional information would be most helpful to them. To maximize the system's effectiveness, the researchers wanted to be sure that it would build on—but not replace—the orientation and mobility skills that these pedestrians have already learned. "Engineers can design great, fancy stuff, but if nobody wants to use it, it's not useful at all," Liao says.

The smartphone-based system goes above and beyond existing crosswalk aids by placing the assistive technology directly in the hand of the user. Unlike traditional systems—which require visually impaired pedestrians to deviate from their preferred path in search of push-button signals—the smartphone-based system provides relevant audio information at the tap of a touchscreen.

When using the system, a visually impaired pedestrian can point a smartphone in the direction he or she wants to cross when standing at an intersection. By tapping the smartphone's touchscreen once, the user can call up information about the intersection geometry and the signal phase. Tapping twice confirms the desired crossing direction and sends a request for a crossing signal to the traffic signal controller. Throughout the process, the user gets audio messages from a text-to-speech interface.

To expand the system for use in work zones, the research team incorporated Bluetooth beacons that communicate with the GPS receiver on a user's smartphone. These beacons can be temporarily attached to signs, posts, or construction barriers in a work zone. When a user's smartphone detects a beacon, the phone vibrates and provides a corresponding audio message.

The audio message includes the pedestrian's current location information, the location of the work zone, and suggested routing instructions. The user can tap the smartphone to repeat the message, if needed.

The researchers integrated the work-zone component with the intersection crossing information provided by the previously developed smartphone app. If a Bluetooth

beacon contains both work-zone and intersection information, the app provides the work-zone message followed by the intersection information, based on the direction the smartphone is pointing.

Moving forward, the researchers plan to work with MnDOT and local cities to access real-time traffic signal information and work-zone construction information on a larger scale. Prior to the release of the app, additional human-subject testing will also be conducted.

Chen-Fu Liao

Bluetooth beacons can be installed on signs, posts, or barriers to communicate work-zone information to app users.

In addition, the research team has received funding from the Roadway Safety Institute, the current Region 5 UTC, at the University of Minnesota, to expand the project by creating a "condition aware" infrastructure that can be integrated with the smartphone app. The goal is a system that can self-monitor and keep the information it broadcasts to app users as up-to-date as possible.

The project will include the development of a stand-alone Bluetooth low-energy (BLE) device that can be installed anywhere, such as on a light post at an intersection or on a construction barricade or traffic cone. These devices, which will be able to sense other BLE devices within their range, will work with a positioning and mapping algorithm to create a local map of the environment. A database that contains the location and corresponding message of each BLE device will be integrated with the smartphone app to provide situation awareness and corresponding navigation information to visually impaired pedestrians.

"This mapping methodology will ensure that correct audio information is provided to app users at the right location," Liao says. "It could be used anywhere—at traffic intersections, skyways, or underground tunnels—to provide directions for travelers."

About This Project

Chen-Fu Liao, senior systems engineer at the Minnesota Traffic Observatory at the University of Minnesota, is the project's principal investigator and led the development of the intersection-crossing system, which began in 2009 with funding from the Intelligent Transportation Systems Institute, the UTC at the University of Minnesota from 1991–2013. In subsequent work, funded by the Minnesota Department of Transportation (MnDOT), the system was expanded to help visually impaired pedestrians navigate through work zones. A new project funded by the Roadway Safety Institute, the current Region 5 UTC, will further expand the system's capabilities. Former University of Minnesota graduate students Kaustubh Duraphe, Kaushiki Nag, and Sowmya Ramesh assisted with software development, system testing, and field experiments.