Integrating a Pedestrian Guidance and Tracking System with the Advance Accessible Pedestrian System

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**Background**

Smart Signals research started in 2004 investigating opportunities to apply concepts of distributed computing to create an enabling technology for traffic controls. Based upon advice from experts in traffic industry, our research directed its attention toward providing better access and safety for pedestrians. In 2008, we conducted research on using a Nokia smart phone to remotely operate a pedestrian button and monitor a pedestrian’s position in the intersection. A device was built that was able to give the operator information that would provide assistance to stay within the crosswalk using GPS as a pedestrian tracking and guidance system. Should the pedestrian stray out of the crosswalk into the traffic area, the Smart Signals System would alert the pedestrian, provide guidance information and, if necessary send a signal to the traffic controller to put the signals in a state that would protect the pedestrian. A patent was recently awarded to the University of Idaho for this concept.

A number of workshops that we sponsored through NIATT were attended by researchers, advocates for the low vision community, traffic engineers, and traffic equipment manufacturers who helped direct our research efforts. After reporting on successes and challenges of using the pedestrian tracking technology, it was decided that the there was insufficient widespread infrastructure to support the technology at this time. Therefore, we focused on developing the Advanced Pedestrian Signals Systems (AAPS) that uses high speed network communications to implement a distributed control and sensor system. The resulting AAPS has been licensed to the Campbell Company in Boise, ID and subsequently, the system has been installed in over 400 intersections in the US and Canada. The AAPS provides the needed infrastructure that makes it possible to realize a pedestrian tracking and guidance.

**Justification**

In light of the AAPS that we developed through our research that includes advanced interfaces for pedestrians who are blind or have poor vision, one may ask if the pedestrian tracking and guidance capability is needed. The feedback that we have received from workshop attendees representing the blind pedestrians indicates a very positive response to this technology.
For blind pedestrians, silence is not always golden. Blind pedestrians use the noise surge of the parallel traffic to provide guidance cues to help keep them orientated in the crosswalk. However, the absence of traffic at low volume intersections presents guidance problems without an aid. Other automotive technology advances such as hybrid and electric cars have added to the need for pedestrian guidance and tracking since these quiet vehicles no longer provide the blind with audible cues. At intersections where ambient noise can mask beacon signals or where such signals disrupt the local community, the pedestrian tracking and guidance system can provide a valuable service.

**Challenges**
The areas that present the challenges that must be addressed in order to bring this technology to the street are the following.

1. A way of accurately determining the pedestrian’s position in real time.
2. The proper way to communicate guidance information to a blind pedestrian without obstructing the conventional sensory inputs the blind use. This includes information for navigating to the crosswalk access point (i.e., curb cutout), as well as safely crossing the street.
3. Short range radio communications that allow the AAPS to communicate the pedestrians personal communication device.
4. A mechanism to program the intersection geometry into the AAPS. In the event that the intersection is undergoing maintenance or repairs – ranging from painting the stripes to tearing up the roadbed, it must be simple for the work crew to inform the system so that there can be a graceful and safe reduction in the levels of service.
5. Expanding the scope of pedestrian assistance

**Addressing Challenges:**
1. A way of accurately determining the pedestrian’s position in real time.

One concept that we exploring is narrow spatial and temporal windowing to allow pseudo differential GPS referenced to the pedestrian button location. Quality of service metrics will need to developed to establish minimum performance levels and ways to transition from reliable to unreliable tracking and guidance operations.

A possible way to do this would be to create a mobile way-finding application that can perform location-based searches using the GPS coordinates of the phone and a downloaded or internet map service that contains information on crosswalk locations and AAPS availability. The user can be alerted to nearby crosswalk locations with haptic (vibration) and auditory outputs. The service can relate attribute information for the crosswalk to the user, such as the width of the crosswalk, how wide the connecting sidewalk is, and what type of curb makes up the sidewalks in that intersection (i.e. curb cutout) using text-to-speech, alert tones, or coded vibrations. Phones with digital compass capabilities can cull crosswalk information that falls outside the direction the device is pointed.
Information on crosswalk locations can be derived from city planning databases, or created and updated using open-source tools. Robust and mature API frameworks for geospatial applications allow integration with existing navigation data, such as overlaying nearby crosswalks with street maps layers to get current information on road condition and traffic levels. A basic crosswalk application could be extended to include or work with additional geospatial layers that contain information on sidewalks and other paths. Such an integrated system could provide information on path conditions in the immediate proximity, conditions ahead, and alerts about nearby features such as bus shelters, businesses, and other services.

An issue that may need to be addressed with this methodology is that the application may not be able to determine which direction the pedestrian wishes to travel when they are at corners with multiple crosswalk directions. Phones with gyroscopes may be able to provide a direction vector that can select crosswalks in the direction the phone is pointed. Another possibility is that the application could identify which roads lie in which direction based on the route taken by the pedestrian to get to the crosswalk. It would follow the principle that a way finder identifies a route and can change the route as obstacles or changes to the route occur.

2. Communicating with the Pedestrian

Several ideas have been brainstormed to determine the best way to convey the guidance information to a blind pedestrian. Using the smart phone as a pathway to transfer the signal to the user, pertinent information can be given to the pedestrian in need without interrupting the regular signals to other users. The idea involves providing a tactile signal through the smart phone. With an extended press on the pedestrian button, the phone will receive information about the intersection. The pedestrian will then use their phone to get signals about the state of the system and whether or not they are veering out of the crosswalk. To begin, the pedestrian will place their thumb (or other finger) in the middle of the touchscreen. At the beginning of the walk cycle, the phone will vibrate to indicate the walk signal is on. This vibration will stop within 1 to 2 seconds and act as a vibro-tactile ped button would. As the pedestrian crosses the intersection, the phone will provide no signal as long as the pedestrian is on a safe path. As soon as the pedestrian starts to veer off path, the center of the touchscreen will vibrate to indicate they need to correct their direction. The signal will vibrate on either the left or right of the screen to let them know which way to correct. It is still to be determined if it is best to vibrate to indicate the side they are off path or the side they should move towards. In addition to the vibration, the phone would send a signal to the AAPS that would provide a beacon tone to help further reorient the pedestrian. The limitation on the beaconing would not interfere with the community as it would only be implemented on an as-needed basis instead of a continuous “nuisance”.

An additional thought would be to allow only one blind pedestrian in a single crosswalk at a time. This would provide personal guidance to those that need it most. This would work by the AAPS recognizing that it had already received a smart phone
request from a prior user. The next user (that arrives while the previous user is still engage with the system) would then get a message that they must wait one cycle before using the system. They pedestrian could then decide to wait to use the smart phone assistance or cross anyway without it. This idea will help ensure there are not conflicting messages given to the users and that the AAPS does not confuse two phones that are close together.

The hope is that this technology could be for any phone so that those that are in-attentionally blind (those texting and talking while walking) is also kept safe.

3. Short range radio communications that allow the AAPS to communicate the pedestrian’s personal communication device.
   a. There are various wireless technologies available for communications. RF bandwidth is a precious resource and the challenge is to use only the spectrum necessary to cover the space needed. Near field and short range RF must be carefully chosen to provide the necessary reach but not over reach. Possible technologies include DSRC, NFC, ZigBee, Bluetooth and WiFi. Concerns to be addresses are appropriate data rates, signal strength, shared bandwidth, security, power requirements and reliability.
   b. It was recently pointed out that the communications technologies do not necessarily need to be supported by commercially available smart phones. Conversations with blind individuals who make substantial use of high tech devices for mobility assistance suggest that audible messages while crossing street is less favored because it interferes with listening for conventional audible cues. Although some researchers have investigated the use smartphones for navigation assistance, the low vision user’s hands may be otherwise occupied handling a guide dog and a white cane. Vibra tactile sensing holds significant promise to providing guidance assistance for low vision pedestrian. It has been suggest that wearing a special vest or wrist watch may be appropriate devices in addition to audible cues that are strategically coordinated may prove to provide benefit that is greater than when each are used independently.

4. Expanding the scope of pedestrian assistance
   a. Investigate the opportunities to be much more inclusive in the design and also to reach a broader audience than low vision and blind, especially the Deaf-Blind and cognitively impaired population.
   b. Investigate the opportunities generated by using a generic interface. Current focus is on cell phone technologies. Alternate human interface may need to be something embedded in a glove, cane, or other piece of apparel that frees the user’s hands or encumbers the user’s mobility.
   c. Investigate potential advantages of modifications to the physical infrastructure such as readily detectible cues to aid in crosswalk orientation and the toe of the curb. This is a significant challenge, especially on curb cuts that are located on large radius curves (these are often higher speed roadways with trucks) – that in itself would be a great problem to tackle.
   d. Development of survey instruments targeted at specific user groups