The Crosswatch Traffic Intersection Analyzer: A Roadmap for the Future

James M. Coughlan and Huiying Shen

The Smith-Kettlewell Eye Research Institute, San Francisco, CA
{coughlan,hshen}@ski.org

Abstract. The "Crosswatch" project is a smartphone-based system developed by the authors for providing guidance to blind and visually impaired pedestrians at traffic intersections. Building on past work on Crosswatch functionality to help the user achieve proper alignment with the crosswalk and read the status of Walk lights to know when it is time to cross, we outline the direction Crosswatch should take to help realize its potential for becoming a practical system: namely, augmenting computer vision with other information sources, including geographic information systems (GIS) and sensor data, to provide a much larger range of information about traffic intersections to the pedestrian.

Keywords: visual impairment, blindness, assistive technology, traffic intersection, pedestrian safety.

1 State of the Art and Related Technology

Crossing an urban traffic intersection is one of the most dangerous activities of a blind or visually impaired person's travel. Several types of technologies have been developed to assist blind and visually impaired individuals in crossing traffic intersections. Most prevalent among them are Accessible Pedestrian Signals, which generate sounds signaling the duration of the Walk interval to blind and visually impaired pedestrians [2]. In addition, Talking Signs® [4] allow blind travelers to locate and identify landmarks, signs, and facilities of interest, at intersections and other locations, using signals from installed infrared transmitters that are converted to speech by a receiver carried by the traveler.

However, the adoption of both Accessible Pedestrian Signals and Talking Signs® is very sparse, and they are completely absent in most cities. More recently, Bluetooth beacons have been proposed [3] to provide real-time information at intersections that is accessible to any user with a standard mobile phone, but like Talking Signs® this solution requires special infrastructure to be installed at each intersection.

The current version of the prototype Crosswatch system provides information to a visually impaired traveler using computer vision to interpret existing visual cues, such as crosswalk patterns and Walk signal lights, which has the advantage of not requiring any additional infrastructure for each intersection. Experiments with blind subjects are

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reported in [5,6], and also in a related project using a similar smartphone-based system [1], demonstrating the feasibility of the computer vision-based approach for helping visually impaired travelers find and align themselves to crosswalks and detect the status of Walk signals.

2 Proposed Approach

We propose extending the Crosswatch system to obtain a broader range of information about traffic intersections, which may be categorized as "what", "where" or "when" information:

- "What" information includes not only the presence of crosswalks in an intersection and the type of intersection (e.g., four-way or T-junction) but also the presence of any signal lights (which may include traffic lights), important signs such as Stop signs, walk buttons, median strips and a variety of other important features.
- "Where" information includes the location of any crosswalks or other features listed above, which can be obtained from smartphone sensors in absolute geographic terms (i.e., latitude/ longitude coordinates and bearing relative to North). To be useful to the traveler, it must be translated in terms relative to the user's location and bearing at each moment (e.g., to guide him/her to the entrance of the crosswalk).
- "When" information specifies the real-time status of "Walk" lights or other traffic lights.

Previous work on Crosswatch has attempted to answer some of the "what" and "when" questions on a smartphone platform using computer vision algorithms. However, many "what"-type features are extremely challenging to determine solely through computer vision alone. For instance, walk buttons appear in a great variety of forms: some are small, recessed buttons while others are large and protruding; the signs labeling them appear in different colors and may contain text, graphics or both. Similarly, a median strip is hard to discern without detailed knowledge of the three-dimensional surface geometry (since the strip is elevated relative to the road surface but otherwise looks similar to the road surface), and failure to detect the median strip can cause gross confusion about the length of the crosswalk. We note that complex intersections pose the biggest challenge to visually impaired pedestrians – and these are also the intersections where assistive technology such as Crosswatch is most needed. Unfortunately, it is precisely these intersections that pose the biggest challenge to computer vision algorithms!

Accordingly, we plan to focus on augmenting computer vision with other information sources, especially geographic information systems (GIS), which associate data with a given geographic location, and sensor data. For instance, given the pedestrian's current location (GPS specifies location with enough accuracy to determine the nearest intersection) and bearing (indicated by the smartphone compass), a GIS can look up a host of information associated with that specific intersection, such as the intersection layout (including crosswalk lengths and directions), the presence and location of signs, crosswalks, signals, walk buttons and median strips (or other specific features). We are currently researching the types of GIS data already available about traffic intersections (e.g., through municipal/transit data sources, Google Maps and other commercial sources). Crowd-sourcing approaches may be the most practical way of adding to this data in the future, which would allow volunteers to contribute information about the intersections they are familiar with (and to focus on the intersections that are the most challenging to navigate).

Computer vision is still indispensable for certain information provided by the system, specifically, the pedestrian's orientation relative to the crosswalk (i.e., detailed location information which GPS resolution is insufficient to determine), and the status of a Walk (or traffic) light, for which no reliable non-visual cues exist. The detailed location information provided by computer vision can also be combined with GIS and sensor information to deduce information such as where the user is standing relative to the walk button, and thereby help the user find the button.

3 Conclusion

We propose to extend the functionality of Crosswatch to encompass a wide range of "what," "where" and "why" information about traffic intersections. This information can be obtained by augmenting computer vision with other information sources, including GIS and smartphone sensor data. Ongoing testing with blind and visually impaired volunteer subjects will be needed to devise effective user interfaces for obtaining the desired information, and for communicating it to users.

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