Look Up!
Positioning-based Pedestrian Risk Awareness

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Pedestrians account for 14% of all traffic fatalities in the US*.

In the last decade, 688,000 pedestrians injured in traffic accidents and 47,700 of them fatalities*.

According to a study, 26% pedestrians text or email, 51% talk on the phone and 36% listen to music when crossing the street.

*U.S. Department of Transportation, Traffic Safety Facts
Existing Awareness Cues

New York City

TIME Magazine, February ‘14
Existing technology-based pedestrian safety solutions

WalkSafe:
A pedestrian safety app for mobile phone users who walk and talk while crossing roads

The Benefits of Dense Stereo for Pedestrian Detection

CAR-2-X and Pedestrian Safety
Motivating smartphone-based awareness

Safe walking tip
Put your arm out at the edge of the road when stepping in the street, before crossing

Purpose
To assert that you are entering the street, and make yourself visible to oncoming cars

Can your phone sense when you are at risk, and warn you or oncoming cars?
Positioning-based risk detection through smartphones

_Distinguishing safe and unsafe walking locations_

Safe walking location: sidewalks
Unsafe walking location: in-street

_How does your phone know where you are?_

Smartphones have in-built positioning technologies and inertial sensors

- Tracks your precise location
- Compares your position to a map
- Detects if you are walking close to the street
- Determines if you are walking in traffic
- Warns you when you are at risk
Applications

- **Virtual Look Up**: Can display an alert on the phone when a distracted pedestrian steps into the street.

- **Driver Pedestrian Awareness**: Announce the presence of the pedestrian to the nearby vehicle over a wireless network.

- **Feedback on Crossing Habits**: Offline analysis of historical traces to monitor and provide feedback on good crossing-habits. *Eg. Allows parents to monitor if children stop to look before intersection and cross at designated intersection*.
Challenges

- **Accurate Positioning**: Existing positioning technologies provide accuracy in the order of meters. Not sufficient for street-sidewalk distinction.

- **Sidewalk Map**: Even with accurate positioning, the position coordinates would need to be compared to a map for distinction.

- **Robustness to environment**: High-rise buildings lead to localization challenges.
Rural/suburban environments

- No sidewalks
- Rare pedestrians; few cars
- Notify all cars approaching pedestrian

Urban environments

- Well developed sidewalks
- Frequent pedestrians; many cars
- Notify cars only when pedestrian in roadway
Heuristics for environment classification

Use road tags from OpenStreetMap: sidewalk and highway

**Sidewalk tag:** Specifies that highway has sidewalks on both sides, on one side or no sidewalk at all

The coverage for the sidewalk tag is variable around the US, being best in Washington DC

Source: http://www.itoworld.com/map/126
System Design Overview

- Notify Drivers on the Same Street
- Notify Drivers Only When Pedestrian Crossing Street
- Crossing Detection
- Environment Classification
  - Rural/Suburban
    - No Sidewalks
  - Suburban/Urban
    - Sidewalks Present
- Street Matching
- Outdoor Activity Detection

- Accelerometer Measurement
- GPS
- Maps Database
GPS-only Crossing Detection Algorithm

- In presence of sidewalks, avoid sending too many alerts to pedestrians and cars
- More fine-grained information required about when pedestrians are actually in street.
- This usually occurs when crossing street
- Predict a pedestrian’s path of motion and check for intersection with nearby streets.
- To predict path, extrapolate heading by a distance $d$
Suburban environment test bed

Test bed layout

Collected GPS trace

Blue trace - phone in hand
Green trace - phone in pocket
Two correct crossing detections

- Actual path walked
- GPS Trace
- Predicted paths
- Street center lines
- Predicted Crossing
A missed detection
A false detection
Performance analysis for suburban environment

Ground truth window = $k$ seconds after the actual entrance
Urban environment test bed

Test bed layout

Sample GPS trace
Performance analysis for urban environment

Ground truth window = $k$ seconds after the actual entrance
Performance comparison for urban and suburban environment
Conclusions

- We identified in-street detection in suburban and urban environments
- Our experiments show promising results for sidewalk-street differentiation in suburban environments
- We see that existing positioning techniques are not sufficient in dense urban environments
- GPS positioning is impaired with large errors and detection delays, rendering it unfit for critical safety applications

Future Work

- To overcome the false positives of the GPS-only prediction algorithm, use inertial sensors on the smartphone.
- GPS fails to capture the sudden changes in path of motion, close to an intersection. Gyroscope can be used to detect these turns.
...Thank You and Be Safe!