SmartPath: A pedestrian safety alert system
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Kamla Kant Tripathi and Pratik Navale
Department of Computer Science
Old Dominion University
Norfolk, VA 23529
{ktripath, pnavale}@cs.odu.edu

Abstract—Walking across a road in an urban area is highly risky for pedestrians. While crossing the road in urban areas, every year many pedestrians get hit by vehicles due to some distraction of hand-held devices like a mobile phone. To solve this problem, we propose SmartPath - a Bluetooth Low Energy (BLE) based alert system for pedestrian safety through a smartphone application. In SmartPath system, unaware pedestrians get alert from their smartphone while crossing a road intersection.
Keywords: Pedestrian safety, Bluetooth, AltBeacon, Smartphone, Proximity.

1 Introduction

Pedestrian safety is a matter of contention that is often overlooked. It is even more distressing at a time when cities are getting smarter by rapidly adopting latest infrastructure and technology to improve living standards of people, but no breakthrough implementation has solved the problem of increasing pedestrian fatalities each year [1]. We observe that rise in pedestrian fatalities correspond to increased smartphone usage by pedestrians on phone [1]. We believe the answer to this problem is a smartphone application.

We introduce SmartPath, a pedestrian safety system that alerts distracted pedestrians on their smartphone when they are about to cross a road.

2 Related Work

Attempts to develop a pedestrian safety system has been of interest to the researchers in past years. To prevent pedestrian-vehicle accidents, Grubb, G. et al. [2] presented a 3D passive stereo vision sensing system for improved pedestrian safety. This system aims to detect pedestrians having most possibility of getting injured i.e. most closer to the approaching vehicle. Shubham Jain et al. [3] explore pedestrian safety by providing an alert system "LookUp" to the pedestrian with the use of shoe-mounted inertial sensor. Trisha et al. [4] develop a test algorithm for sensing unsafe pedestrian movement by introducing a path prediction technique using legged locomotion devices. Wang T. et al. [5] use machine learning algorithms implemented on the phone to detect the front views and back views of moving vehicles using back camera of mobile phone. Most of these pedestrian safety systems require additional hardware and tools like camera, sensor, GPS, and compass. SmartPath a low resource required system, basically aims to provide pedestrian safety only utilizing smartphones Bluetooth and BLE beacons.

3 Applications and challenges

3.1 Applications

When developed to its full potential, SmartPath will alert distracted pedestrians on their smartphone when they are about to cross a road. It will be smart enough to alert a user through on-screen notification and/or audible alert signal depending on whether the user is using another application (like texting, email, browsing) or whether the user is listening to music, or is on a phone call.

Final project report submitted by Kamlakant and Pratik to the instructor Dr. Shubham Jain

SmartPath can be further developed into a fully expansive pedestrian monitoring system without needing a significant hardware upgrade of existent infrastructure. The system will seamlessly monitor and deliver to a system that develops statistics on pedestrian traffic, peak time, jaywalkers, etc.

3.2 Challenges

The basic requirements with developing any safety application are functionality and accuracy. Especially when working with Bluetooth beacons that were originally as used as tags for locating and tracking near-field objects that do not necessarily require to be functional always; and where some latency is acceptable. The walking speed of pedestrians is a challenge. Latency is not acceptable if a pedestrian is running and SmartPath fails to alert when it is too late. Likewise, high volume of pedestrians (peak time) is a challenge for SmartPath. As SmartPath calculates distance of an installed Bluetooth beacon and the smartphone based on the transmitted power (Tx) and Received Signal Strength (RSSI) values, signal reflection and obstruction can lead to false positives and true negatives. Another challenge is with placing beacons such that it is always in line-of-sight of a pedestrians smartphone.

4 System design and methodology

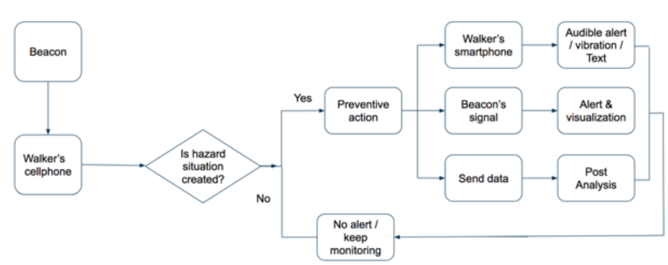

Fig. 1. Basic control flow of SmartPath

4.1 Bluetooth Low Energy Beacons

Bluetooth beacons we used in our initial implementation are RadBeacon Dot proximity beacons by Radius Networks. The beacons were configured to function with AltBeacon Bluetooth protocol. The beacons can be recognized by SmartPath with their UUID, Major and Minor identifiers. The transmission power (Tx) of a beacon can be changed to vary the range of emitted Bluetooth signal. The maximum range for RadBeacon Dot is about 50 meters. Likewise, the frequency (or advertising rate) of the beacon can be set to emit packets at a faster or slower rate. We used the highest advertising rate 10 data packets per second for attaining highest accuracy. The beacons need to be calibrated before initial use for a standard measure to get most accurate distance values.

Fig. 2. RadBeacon Dot BLE beacon

4.2 Mobile Application

We developed an Android platform based mobile application that alerts pedestrians when they are within “alert distance” (about 5 m) from the crosswalk intersection. It implements open source Android Beacon Library. The application keeps running in the background on a smartphone. It keeps monitoring for beacons in range. It detects the beacons if they are in range and gives a count of beacons in range. When a beacon is in range, it keeps calculating the distance of the smartphone from the beacon. If the smartphone logs a distance equal to or less than “alert distance”, a LookUp notification pops up. To avoid false detections, the “alert range” can be set based on the area of the crosswalk intersection.

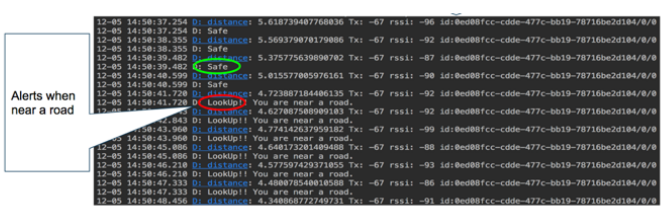

Fig. 3. SmartPath triggers alert message

5 Experiments and data collection

To evaluate accuracy of SmartPath, we conducted an experiment indoors in an open space of a library. A tape measure was used to first mark distance and place mark for every meter. A starting point was also marked where the smartphone running SmartPath was placed with its back facing the beacon. For every subsequent trial, the beacon was moved farther at each distance mark, was turned on and SmartPath application was run. Each trial was recorded for 60 seconds worth of log values from the application.

The logged data from Android Studio for SmartPath application was exported to a text file which was converted to a CSV file. Likewise, we obtained a data file for each trial. Each data entry in the file had the column values: timestamp, distance, transmission power (Tx), RSSI and UUID.

We used a OnePlus 3 (A3003) smartphone that was running Android version 8.0 (Oreo). RadBeacon Dot Bluetooth beacon was used in our experiment. It was configured to emit at -53 dBm transmission power at a rate of 5 data packets per second.

6 Evaluation

We plotted a line chart Distance vs. Mean RSSI from the aggregated data files for trials at various distances to observe that there is more deviation of actual RSSI at longer distance.

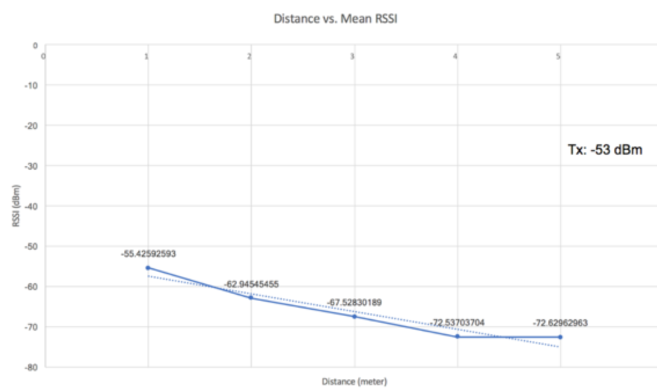

Fig. 4. Mean RSSI- more deviation at longer distance

To further evaluate the accuracy of SmartPath with distance, we plotted a boxplot from which we observed that SmartPath works best at close-proximity.

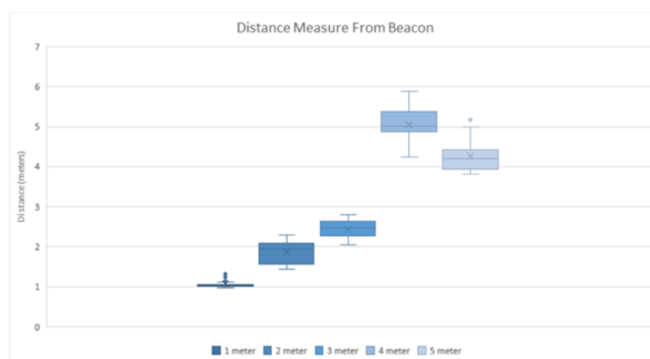

Fig. 5. Distance measure from beacon for various distance values

7 Conclusion

In summary, we have developed a smartphone application that alerts distracted pedestrians when they are about to cross a road. We conducted experiments to evaluate the functionality and accuracy of SmartPath and found that it works best in close-proximity. It is acceptable as the pedestrian will be alerted within 5 meters proximity to the beacon. If we use beacons that transmit at high transmission power, high frequency and are better calibrated with SmartPaths distance approximating algorithm, we believe SmartPath can achieve better functional and accuracy levels.

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