Pedestrian Tracking at Intersections using Received Signal Strength Indicator Values from Bluetooth Devices

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Goal: Can we track pedestrians at an intersection using Bluetooth RSSI values?

Research: Creation of Pedestrian Tracking Method

Motivation

- Government agencies such as municipalities and counties seek pedestrian data at their intersections
- Government agencies can improve their operations
Model Inputs

• **MAC Address**

• Bluetooth variable to use for tracking: Received Signal Strength Indicator (RSSI)

• **RSSI**: This variable indicates the power level being received by a Bluetooth antenna. Value of reception between a device and a scanner.
Intersection Experiment

- Location: Intersection at UC Irvine
- Size: Roughly 100’ x 100’
- Bluetooth scanner: Raspberry Pi
- Pedestrian device: iPhone
- Goal: Obtain pedestrian path of a targeted device at the East Peltason/Anteater intersection using RSSI values
Intersection Experiment

• Built-In Bluetooth Range: ~100 feet
• 4 Raspberry Pi’s and portable battery packs were attached to the 4 poles at the traffic signal at 5’ high.
Intersection Experiment

• One person with a Bluetooth enabled iPhone device walked around the entire intersection multiple times while recording the timestamps when they arrived at each corner.

• The 4 Raspberry Pi’s were recording data using the built-in Bluetooth sensor with a python code running on Linux.
Pedestrian Tracking Method

• Python Code
  • RSSI value - 10 times per second
  • Values of RSSI range from 0 to -40
  • The code requires a known device’s MAC address to track it. The MAC address of the device being tracked in the intersection is integrated into the code.

• Data Analysis
  • Moving Average – The RSSI used in data analysis for each timestamp is the average of the previous 10 RSSI values (the previous second’s worth of RSSI values)
  • ΔRSSI – A change in RSSI for each timestamp is the difference between the respective RSSI value and the RSSI value 100 RSSI values before it (RSSI value from 10 seconds before)
Pedestrian Tracking Method

- Absolute value of \(\Delta\text{RSSI}\) above 20 dBm over 10 seconds of device data reveals a strong chance of a pedestrian movement.
- Threshold = 20 dBm

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\begin{align*}
\text{RSSI}_{\text{MA}_{i,j}} &= (\text{RSSI}_{i,j} + \text{RSSI}_{i-1,j} + \text{RSSI}_{i-\text{n+1},j}) \\
\Delta\text{RSSI}_i &= \text{RSSI}_i - \text{RSSI}_{i-100} \\
\text{Decision} &= \begin{cases} 
0 \text{ (no crossing); if } \Delta\text{RSSI}_i < \text{Threshold} \\
1 \text{ (crossing); if } \Delta\text{RSSI}_i > \text{Threshold}
\end{cases}
\end{align*}
\]
Pedestrian Tracking Method

- Data from 4 Raspberry Pi’s will be analyzed together
- Algorithm
- Output – Pedestrian Path
- Testing of random paths will validate system
Pedestrian Tracking Method

If ΔRSSI of Pi A > 20 then ped walking away from sensor
If ΔRSSI of Pi A < -20 then ped walking toward sensor

If absolute value of ΔRSSI of Pi A > 20
Then record time stamp of observations of the absolute value of ΔRSSI > 20

Check ΔRSSI values for the above timestamps/time durations ±10 seconds of Pi B, Pi C, and Pi D

If absolute value of ΔRSSI of Pi B > 20 then for this time stamp ±10 seconds then assume pedestrian is crossing between Pi A and Pi B
If absolute value of ΔRSSI of Pi C > 20 for this time stamp ±10 seconds then assume pedestrian is crossing between Pi A and Pi D
If absolute value of ΔRSSI of Pi D > 20 then for this time stamp ±10 seconds then assume pedestrian is crossing between Pi A and Pi D

Confirm part of path
If one confirmed part of path has a time stamp later than another, then this part of path occurred second after the first path. There can be 2 or 3 parts of a path for any pedestrian using the intersection

Output: Path
Possible Paths: AB, BC, BCD
Future Work

• Optimization of $\Delta$RSSI threshold value
• Incorporating multiple devices being tracked at once
• Splitting the intersection into more zones, creating more path options
• Adding this technique to multiple intersections in a road network to obtain pedestrian path throughout city network
Thank you