Activity-travel behavior survey at tourist attraction by BLE in comparison with GPS

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Background

• Disaggregate activity-travel behavior data as important resource for tourism research
  • Traditional questionnaire survey: inaccurate respondent’s memory and burden to answer
  • Manual tracking by investigator (e.g., Sasaki and Matsui, 1968)
  • Mobile phone with GPS (e.g., Asakura and Hato, 2004)

• Needs for survey cost reduction while keeping accuracy
  • Human resource for manual tracking
  • Battery power and signal-lost inside buildings for GPS tracking
Potential of Bluetooth

• Several studies using Bluetooth technology (e.g., Malinovskiy et al, 2012)
  • Lower energy consumption than GPS
  • Capability inside buildings and urban canyons

• However, accuracy should be verified
  • Travel time was investigated in the literature (e.g., Aliari and Haghani, 2012)
  • How about other dimensions of activity-travel pattern?
GPS versus BLE (Bluetooth low energy)

<table>
<thead>
<tr>
<th></th>
<th>GPS</th>
<th>BLE</th>
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<tbody>
<tr>
<td>Type of observation</td>
<td><strong>Lagrange</strong>: observation along mobile object</td>
<td><strong>Euler</strong>: observation at the stationary points</td>
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<tr>
<td>Location precision</td>
<td>High</td>
<td>Low</td>
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<td>Battery consumption</td>
<td>High</td>
<td>Low</td>
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Objective

To verify accuracy of observed activity-travel patterns by BLE in comparison with GPS

- Activity-travel patterns within a park with several sections
  - Tango Kingdom in Kyoto, Japan

- Several dimensions of activity-travel patterns
  - Number of sections visited, duration of stay at each section, order of visits to each section, etc.
Tango Kingdom

• Located at Kyoto, Japan
• One of the largest roadside stations in western Japan
• Started operation at April, 2015
• 34 ha of the land filled with many sections
• Market area of fresh vegetables and seafood, restaurants featuring local ingredients, go-cart track, grass slide field, pony rides, etc.
Park map

Go-cart track

Grass slide field
Survey

• Date: 2015/08/22(sat), 23(sun)
• Respondents: 280 groups of visitors
• Carrying both BLE device and GPS logger
• Questionnaire survey sheet: purpose of visit, frequency, etc.
Demographics of visitors (N=280)

**Group size**
- Alone: 2%
- Couple: 32%
- Three+: 66%

**Distance from home**
- Up to 30 km: 12%
- 30 to 100 km: 30%
- 100+ km: 58%

**Number of visits**
- First timer: 79%
- Repeater: 21%
BLE receivers

Go-cart track

Food court

Grass slide field

12 BLE receivers
Group A

- GPS
- BLE
- BLE (receiving)
GPS trajectory of Group A
BLE observation of Group A

Very short stay seem false-positive because of receiving signal from long distance
Space-time path of Group A

GPS

14:00
13:00
12:00
11:00

BLE

14:00
13:00
12:00
11:00
Kernel density of Group A

GPS (10 m)  BLE (50 m)
Kernel density of all groups

GPS (10 m)  BLE (50 m)
Comparison of sample average

Total duration at park

Number of sections visited

Total walking distance

Effect of false-positive
Comparison of sample average

Visiting rate for each section

Stay duration at each section

Effect of false-positive
GPS locations when BLE at grass slide field receives signals

At some geographic conditions, BLE signal reaches far longer than assumed 50 m distance
Staying duration at each section by distance from home

**GPS**

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<th>Animal section</th>
<th>Belvedere</th>
<th>Go-cart track</th>
<th>Clock tower</th>
<th>Cow shed</th>
<th>Grass slide field</th>
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**BLE**

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Conclusions

• BLE can collect the information of visitor’s activity-travel behavior as accurately as GPS
  • Number of sections visited
  • Total duration at the attraction
  • Visiting rate for each section for most sections
  • Duration at each section for most sections

• At some conditions, BLE signal reaches far longer which results in false-positive and lower accuracy
  • Total walking distance
  • Need for error cleaning algorithms