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

Toshiyuki Yamamoto, Tomoaki Usui, Norimasa Nakamura and Takayuki Morikawa

Nagoya University

# 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)

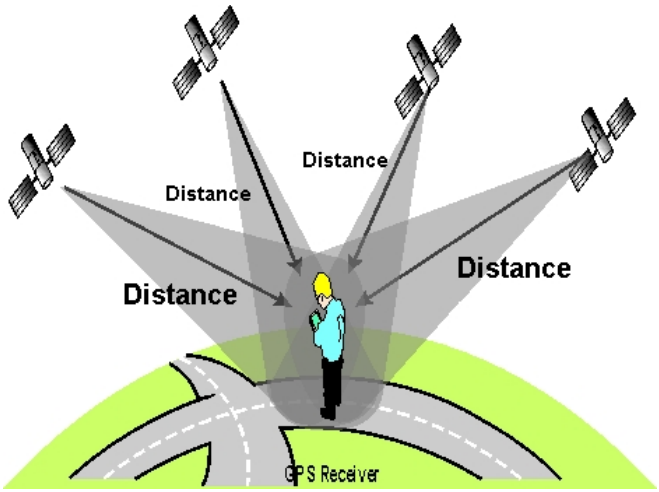
- Needs for survey cost reduction while keeping accuracy
  - Human resource for manual tracking
  - Battery power and signal-lost inside buildings for GPS tracking

# 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)




Source: Global Positioning System (GPS) 2nd edition


Source: www.libelium.com

| | GPS | BLE |
|---|---|---|
| Type of observation | **Lagrange**: observation along mobile object | **Euler**: observation at the stationary points |
| Location precision | **High** | Low |
| Battery consumption | High | **Low** |

# 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

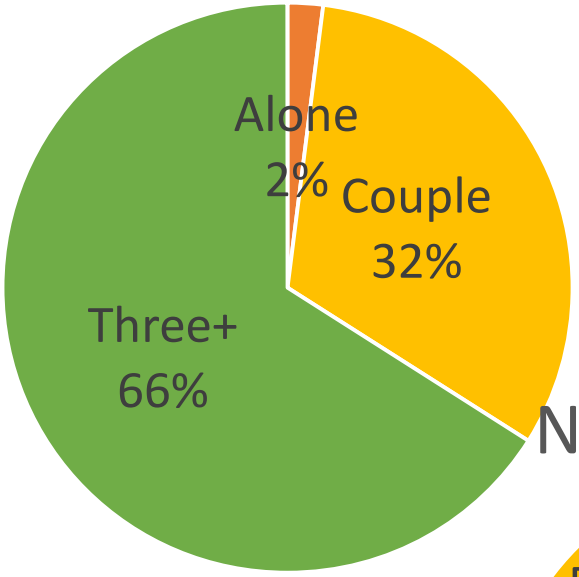
Grass slide field

# Survey

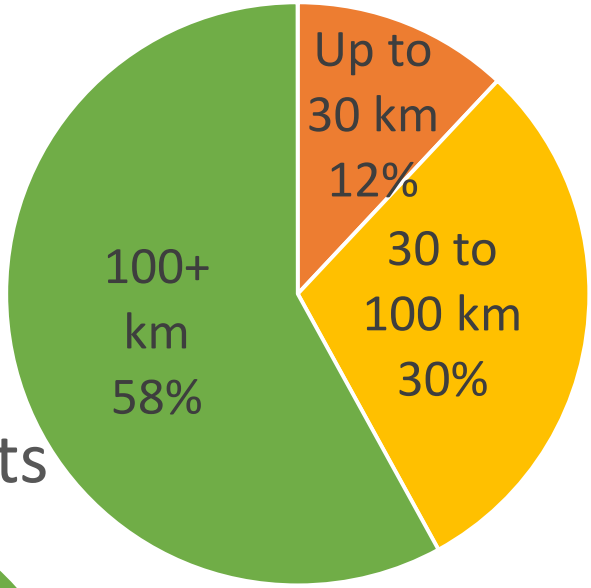
- Date: 2015/08/22(sat), 23(sun)
- Respondents: 280 groups of visitors
- Carrying both BLE device and GPS logger
- Questionnaire survey sheet: purpose of visit, frequency, etc.

# Demographics of visitors (N=280)

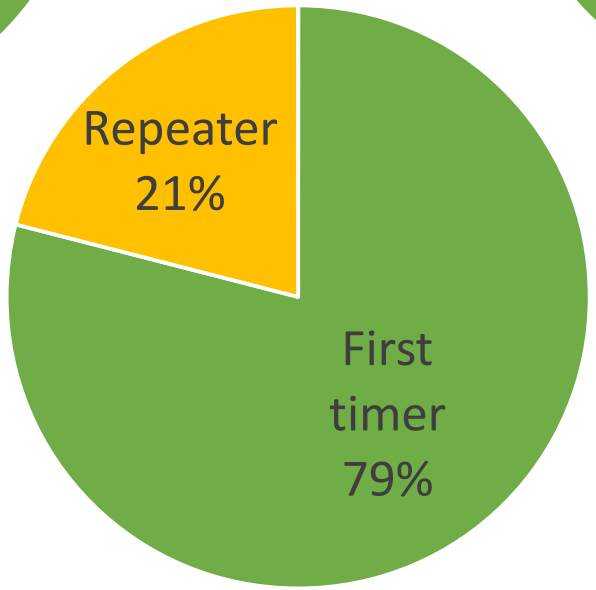
## Group size



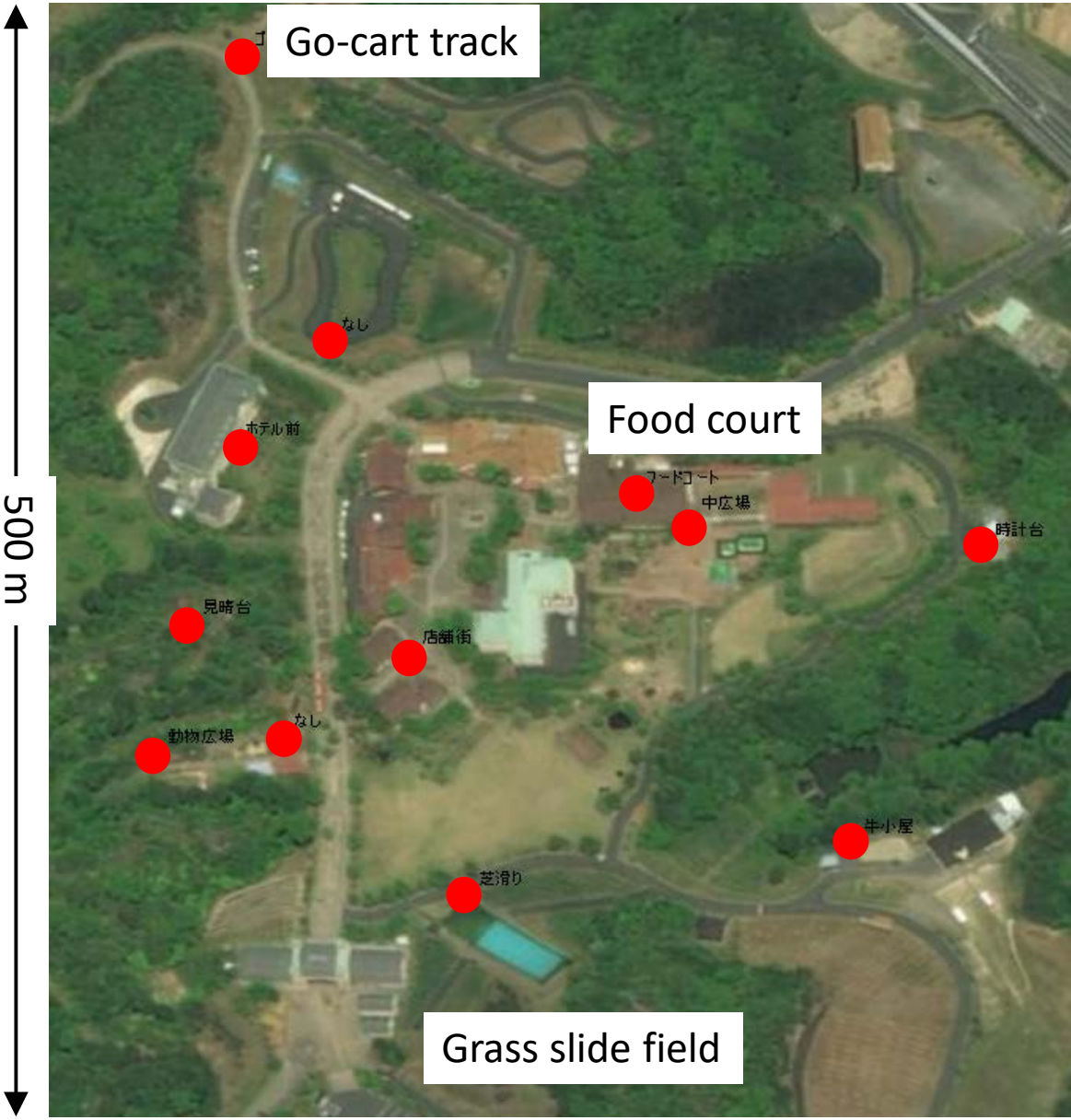

## Distance from home




## Number of visits

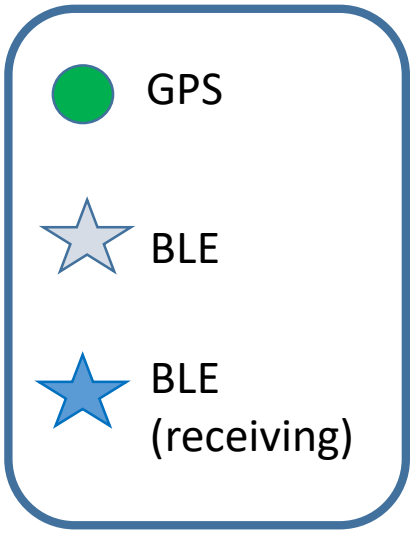


# BLE receivers

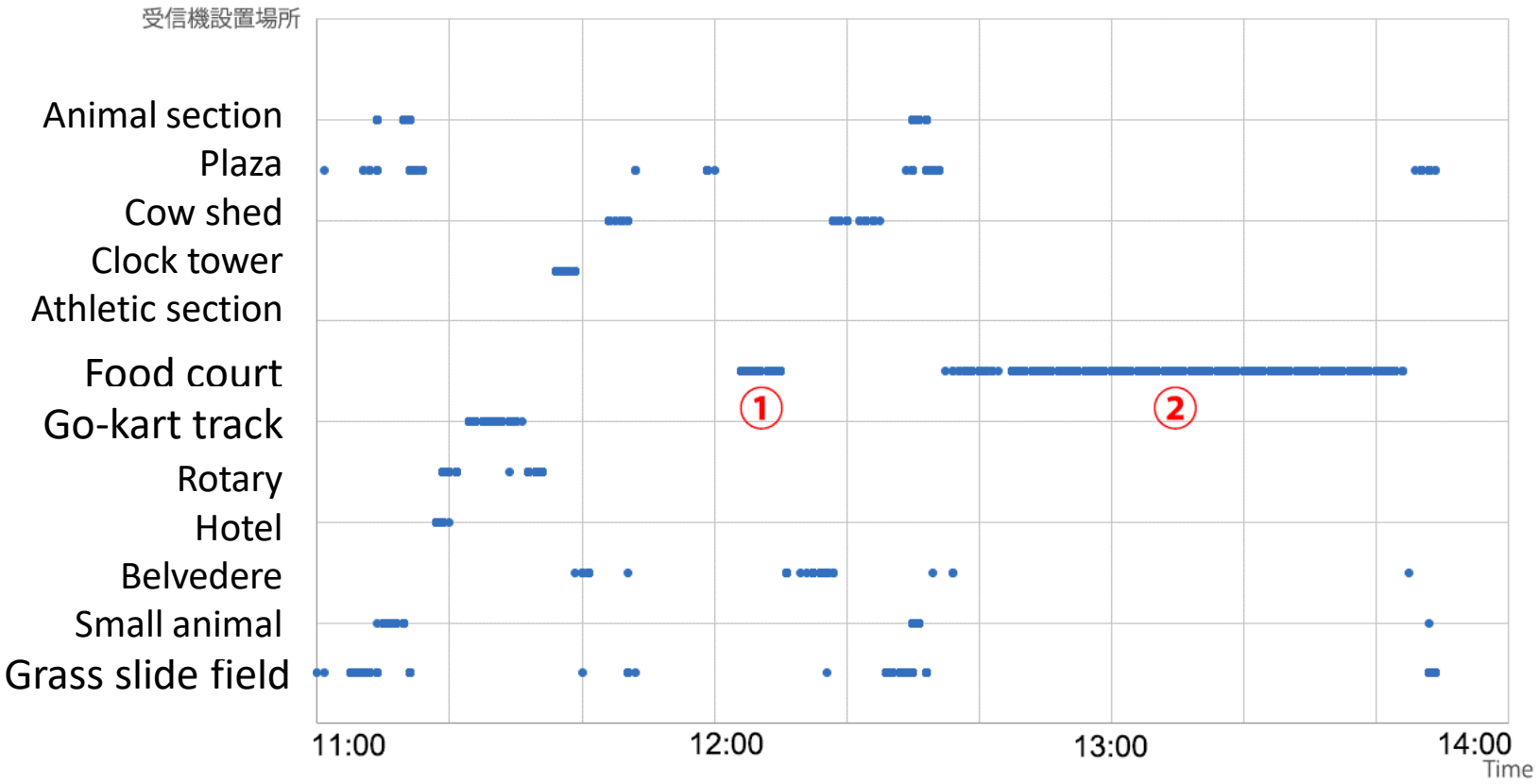

● 12 BLE receivers

# Group A




# GPS trajectory of Group A

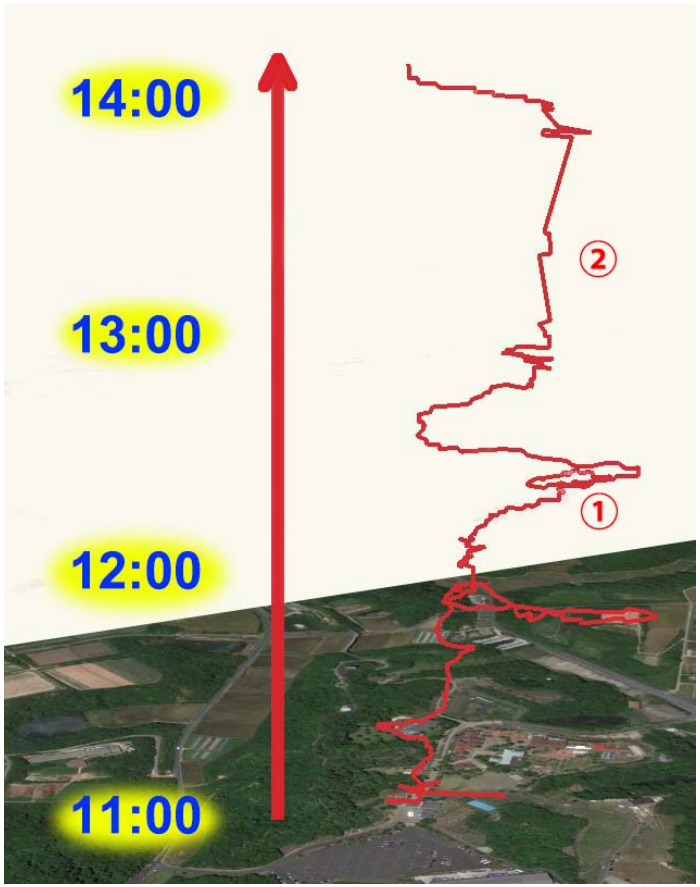
# BLE observation of Group A



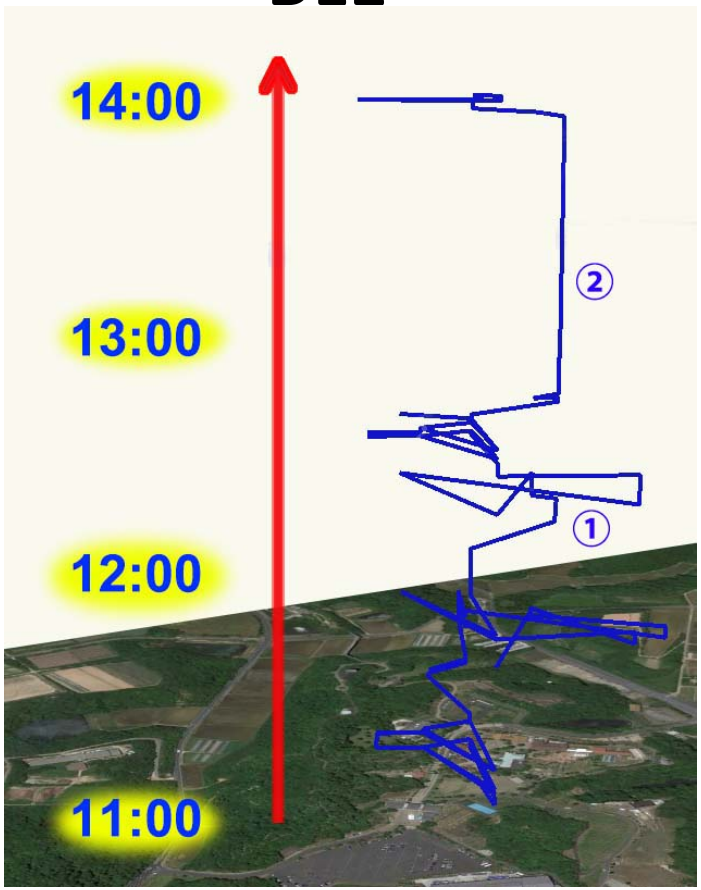

Very short stay seem false-positive because of receiving signal from long distance

# Space-time path of Group A

GPS



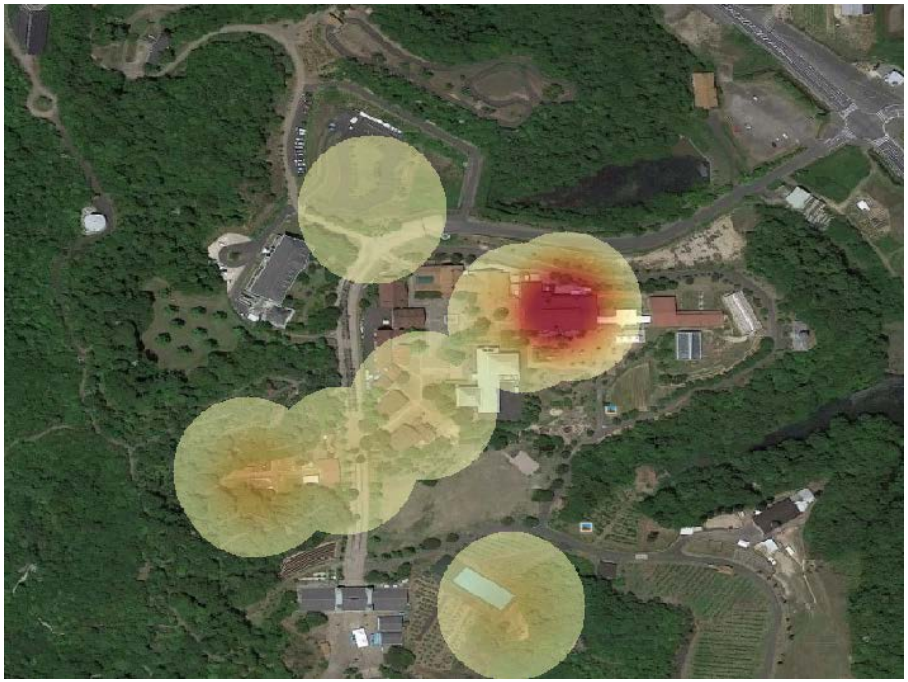

BLE



# Kernel density of Group A

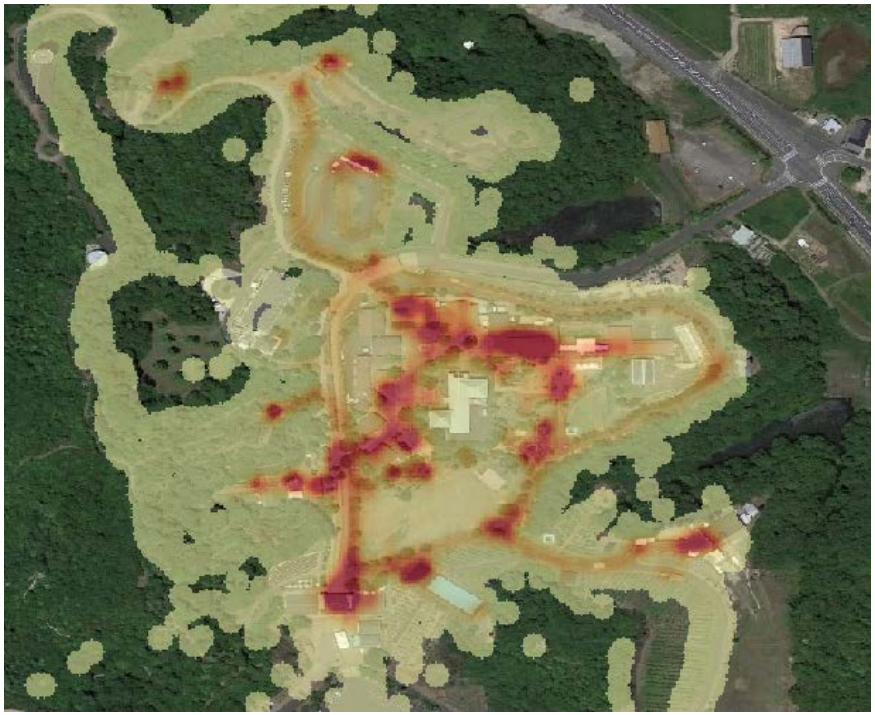
GPS (10 m)

BLE (50 m)



# Kernel density of all groups

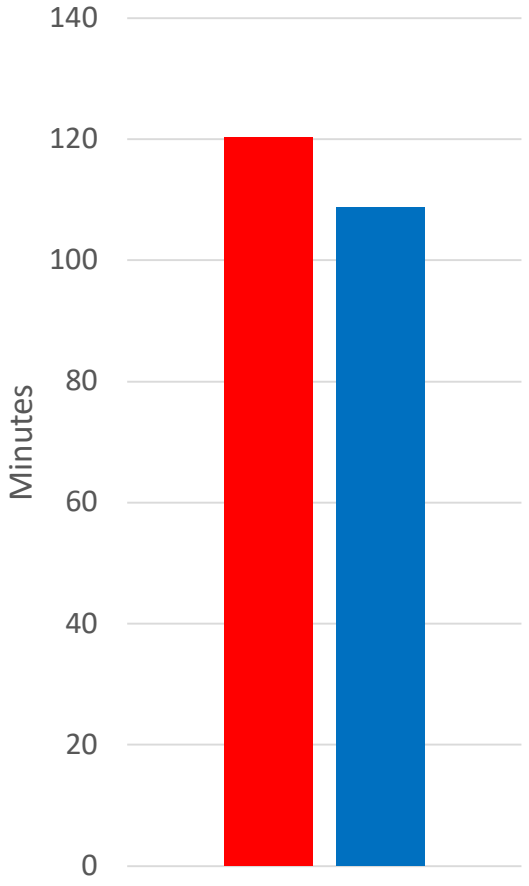
GPS (10 m)



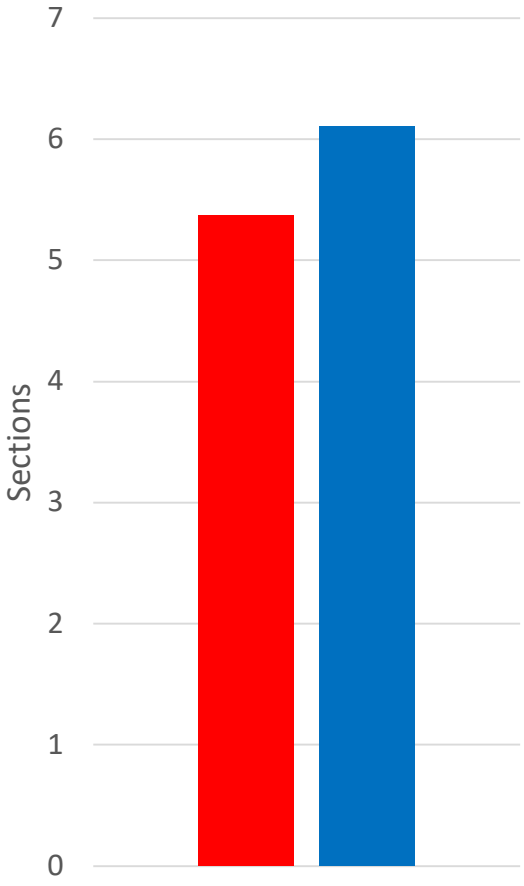
BLE (50 m)

# Comparison of sample average

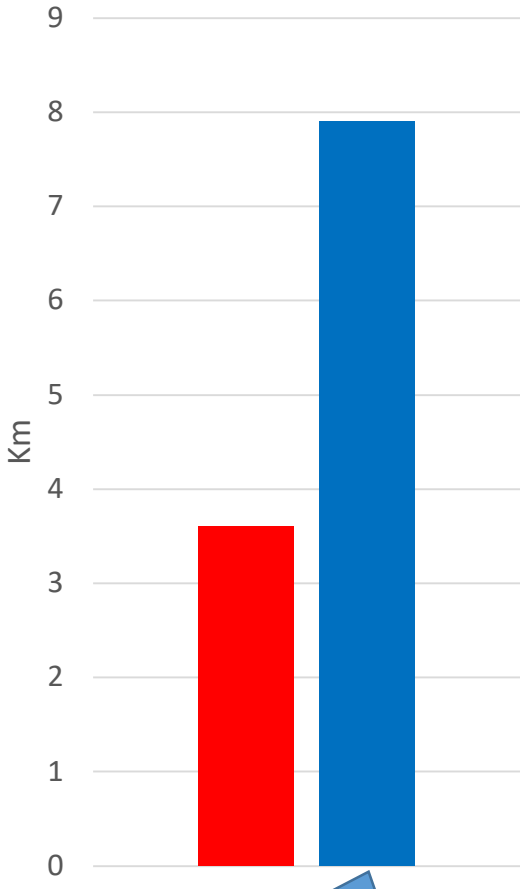
## Total duration at park




## Number of sections visited




## Total walking distance

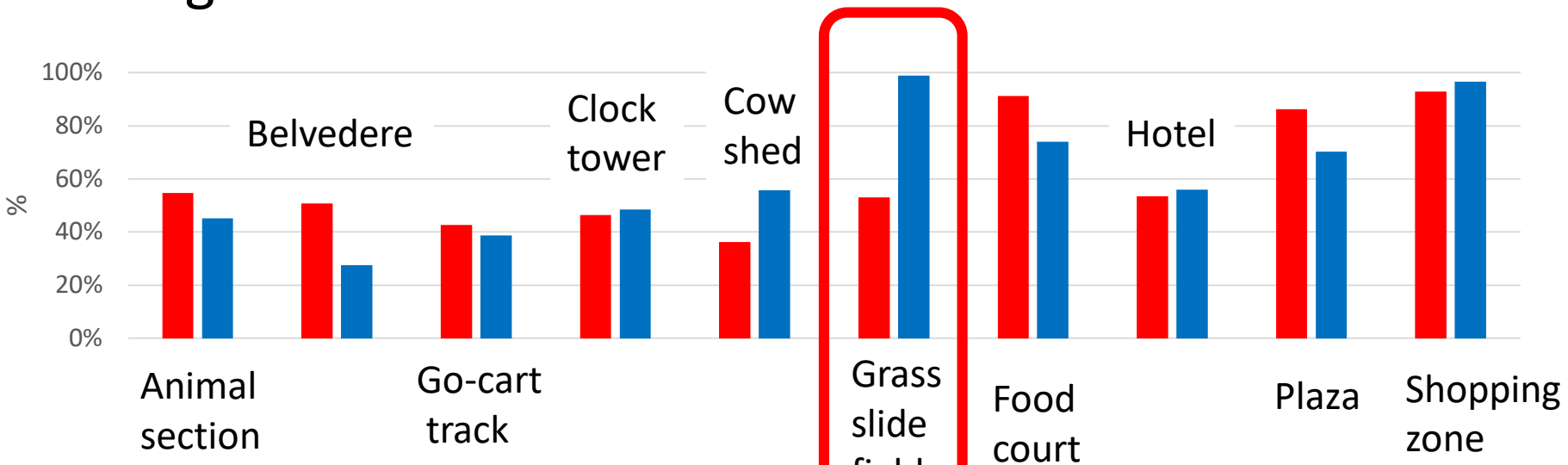



GPS BLE

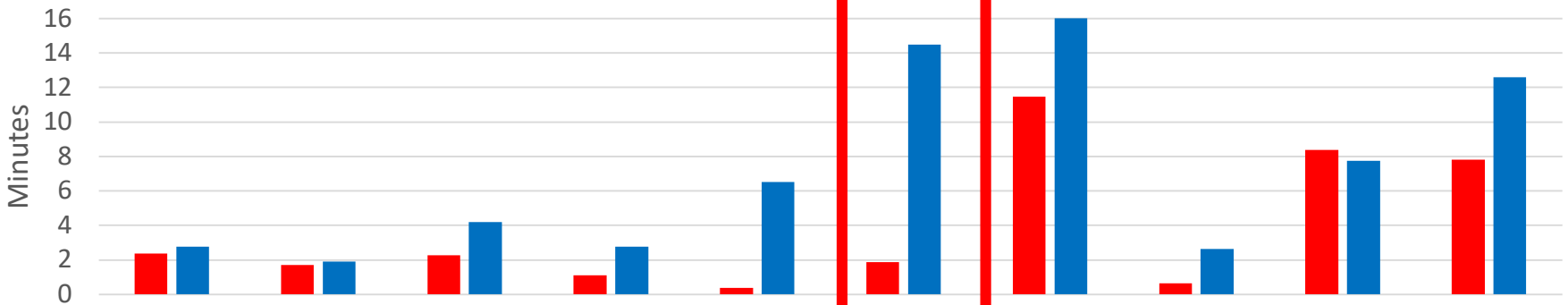
Effect of false-positive

# Comparison of sample average

## Visiting rate for each section




## Stay duration at each section

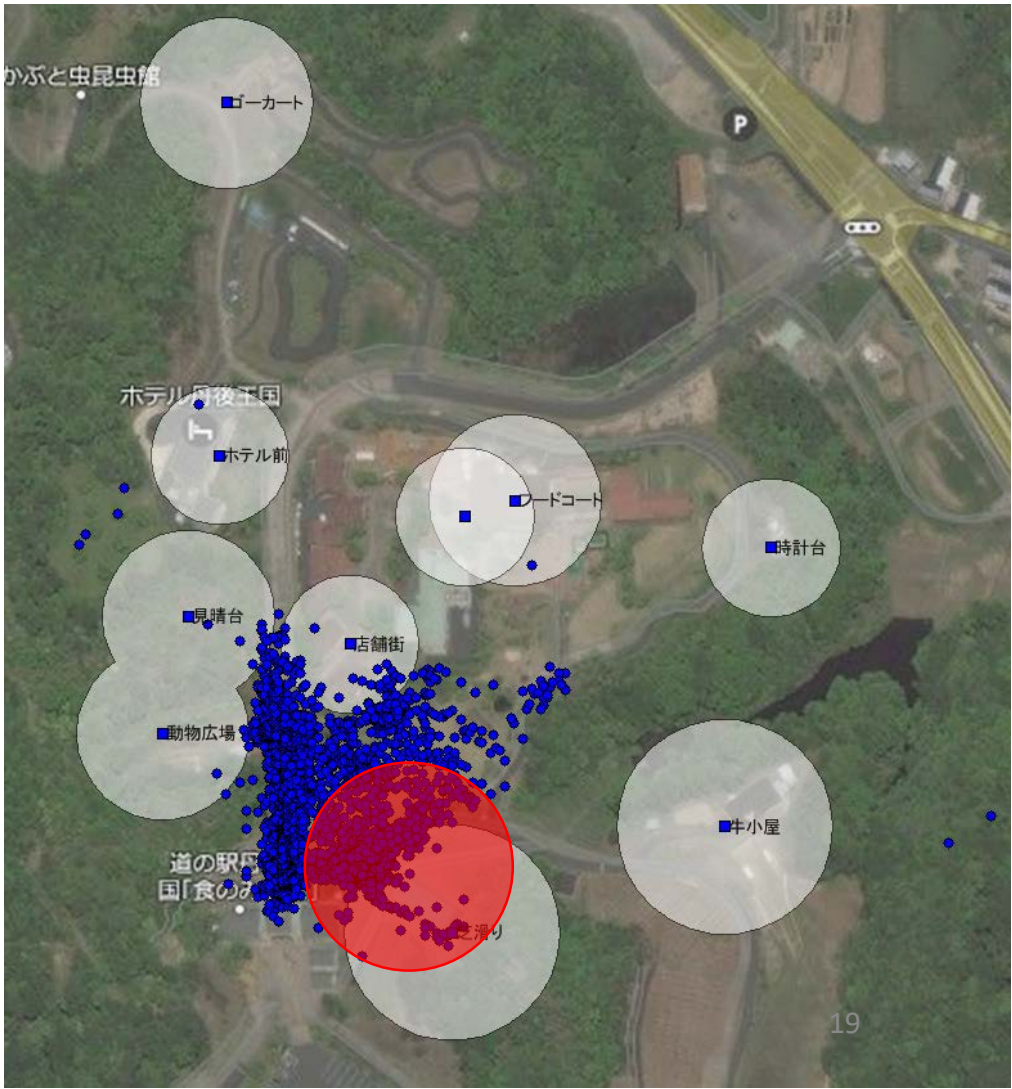



GPS BLE

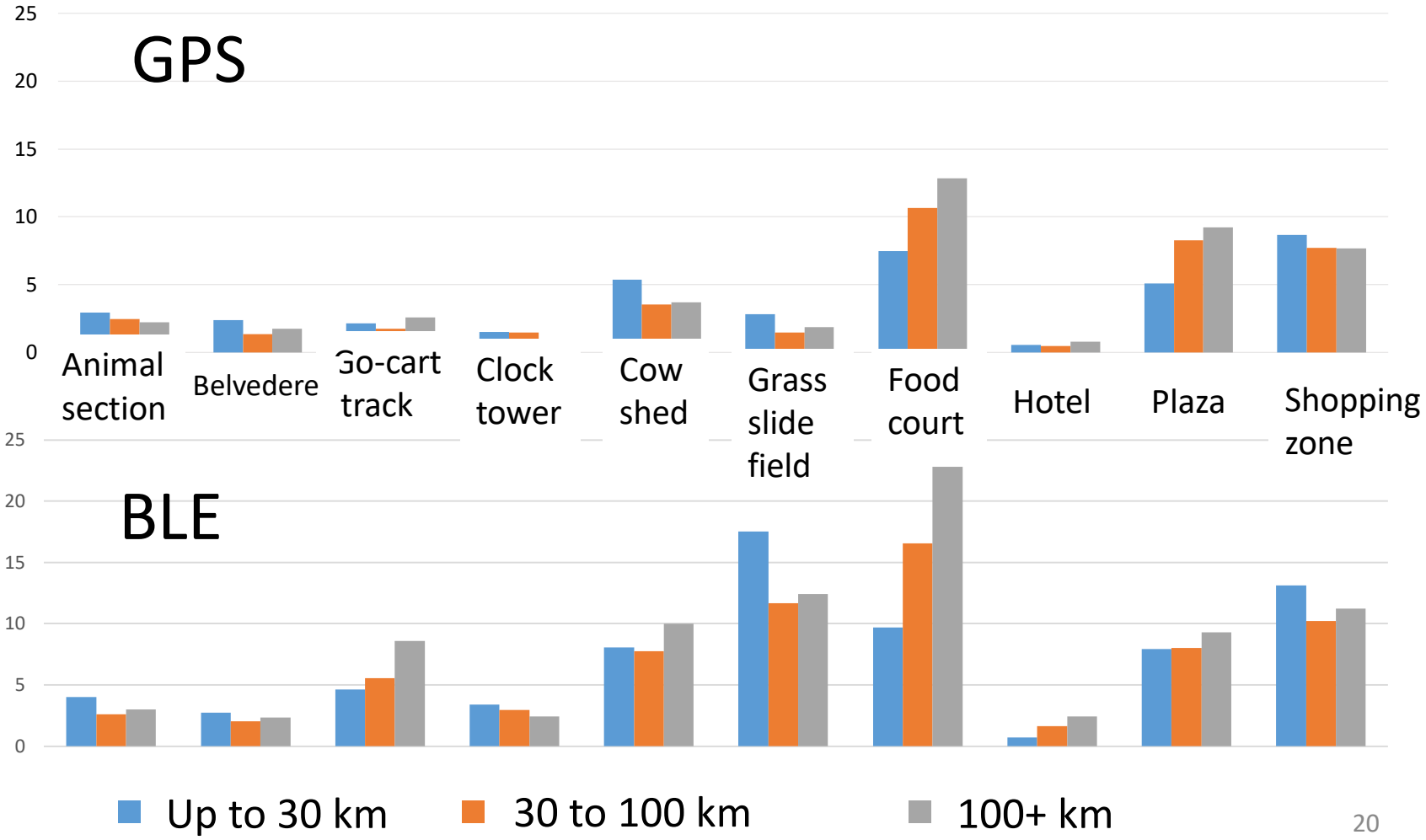
Effect of false-positive

# 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



# 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