EAGER: An Indoor Positioning System (IPS) for Informal Learning Experiences

Award #1346664

PI: Joshua Gutwill
Co-PI: Joyce Ma, Bill Meyer
Technology Partner: Qualcomm, Inc.

Goal

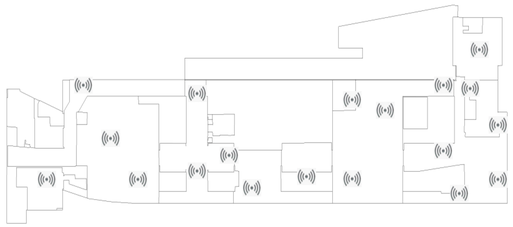
To generate early knowledge for the museum field about the capabilities and limitations of an indoor positioning system (IPS) to

- Automate the collection of timing and tracking data for visitor research
- Enable location-aware applications that enhance visitor learning

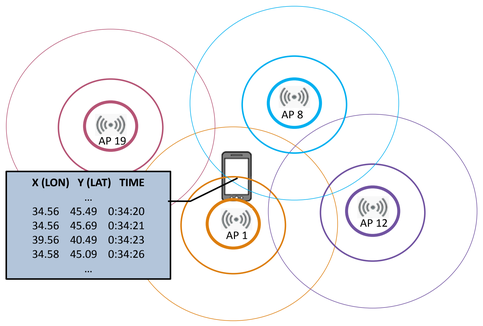
at three levels of resolution: (1) gallery, (2) cluster, and (3) exhibit.

The Prototype IPS

The Qualcomm prototype triangulates the location of mobile test devices based on the known position of wireless Access Points (APs ((•))) that are part of the Exploratorium's Wireless Local Area Network (WLAN).



Each test device monitors the Wi-Fi signals being broadcast from the different APs in the Exploratorium's WLAN. Based on the characteristics of those signals, the test device determines its position relative to the known position of the APs. Position and time data are logged by the test device and can be downloaded later for analysis.



Lessons Learned

- Configuring, installing, and maintaining Wi-Fi APs require time and expertise.
- IPS configuration (and therefore performance) is particular to the building geometry.

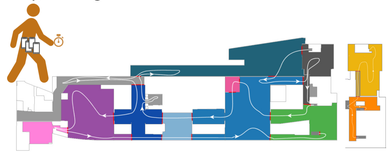
Ground Truthing the IPS

The process of gathering data in the field to validate/dispute data collected by the technological system under investigation.

Gallery Level

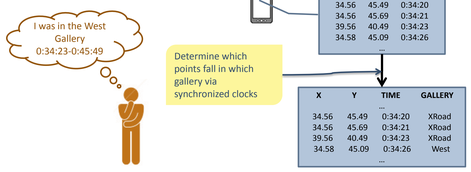
Method

A human tracker wore 8 tracking devices and walked a prescribed path that crossed every gallery or cluster boundary, noting when an area was entered.

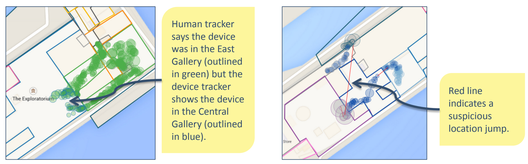


Data Analysis

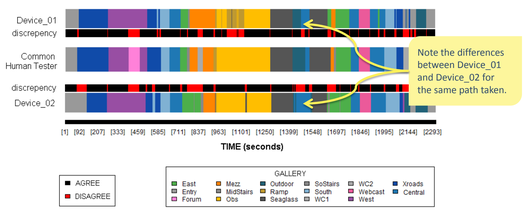
- The location data were downloaded from the devices. By synchronizing the device and human trackers' clocks, we determined when the devices were in which gallery.



- We cleaned the data (e.g., interpolating data gaps, removing impossible location jumps).
- Using a visualization tool we created, we plotted the data on a map to look for problem areas.



- We visualized and calculated the differences between human and device trackers.



Lessons Learned

- How a person wears/holds a device can affect the location data.
- It can be difficult to distinguish between floors without complementary technologies (e.g., a barometer).
- Gallery-level resolution depends on better than gallery-level resolution at gallery boundaries.

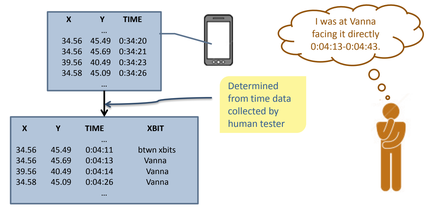
Exhibit Level

Method

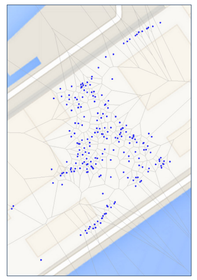
A human tracker wore 8 tracking devices and stopped at each exhibit in an area. At each exhibit she stood or sat for 30 seconds at each position from which the exhibit could be used, noting when she was at each position.

Data Analysis

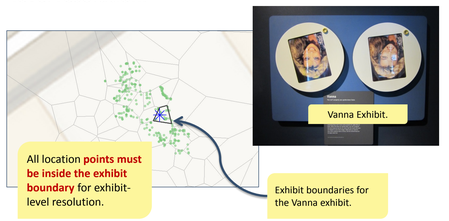
- The location data were downloaded from the devices. By synchronizing the device and human trackers' clocks, we determined when the devices were at an exhibit.



- To determine the boundaries of each exhibit , we created a Dirichlet tessellation pattern using the centroid of the location data, collected by the devices, corresponding to each exhibit stop.



- By plotting the device data on the tessellation pattern, we could see if the IPS gave us exhibit-level resolution.



Lesson Learned

- Exhibit-level resolution may require a complementary systems (e.g., proximity detection with Bluetooth technology).

Use Scenario: Whole Visit Timing and Tracking

Data of interest

- Which galleries did study participants visit?
- How long did they stay in each gallery?

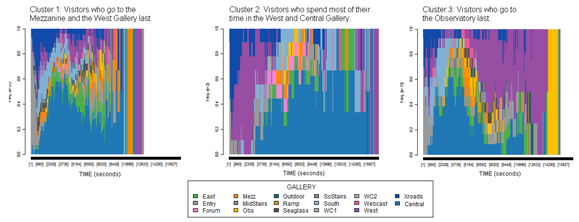
Method

Participants (adults) were recruited at the museum entrance and asked to wear a tracking device for the duration of their visit. A human tracker randomly selected participants to assess inter-rater reliability.

Data Analysis

- Cohen's Kappa was calculated assuming perfect human tracking of gallery visited.
- We calculated the dwell time per gallery and also generated heat maps for where a participant spent their time.

- We conducted a cluster analysis on the sequence of galleries visited to look for patterns.



Lessons Learned

- Validation with actual visitors can reveal additional challenges.
- A WiFi-based IPS may be susceptible to intermittent problems from high voltage exhibits and unshielded electronics.
- Inferring exhibit use (or other behavior) from position is challenging.

Challenges Ahead

- The prototype IPS as installed was unable to provide exhibit-level resolution.
  - ➢ We plan to experiment with a complementary system that uses Bluetooth Low Energy (BLE) beacons for proximity detection.
- We have encountered technical problems integrating the IPS with our location-aware, content-delivery and recording platform.
  - ➢ We are continuing to identify and debug these issues.