Indoor Localization With iBeacons

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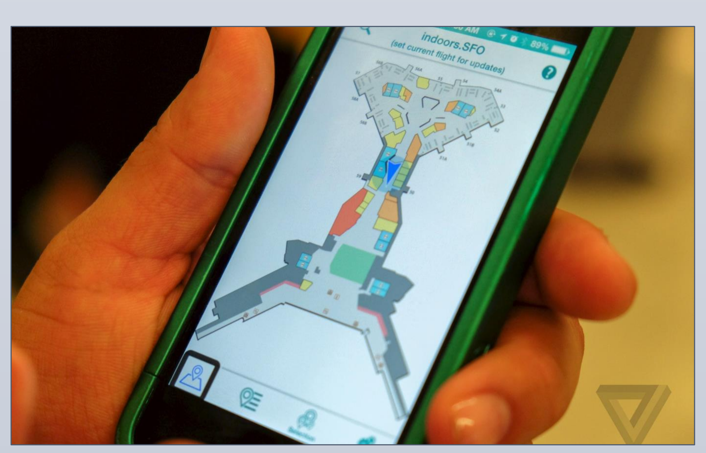
INTRODUCTION

- Apple recently introduced their iBeacon technology
- Allows for mobile applications that communicate with small, inexpensive beacons using Bluetooth Low Energy protocol
- Widespread applications in in-store product advertising and indoor localization
- Low cost and portability allows dense wireless networks to be setup with relative ease

A Gimbal Series 10 iBeacon

- The San Francisco Airport recently installed such an indoor localization system to aid the visually-impaired
- The SFO mobile application shows the user's position as well as points of interest
- Uses voice commands to aid in navigation
- One of the first publicly installed systems of its kind



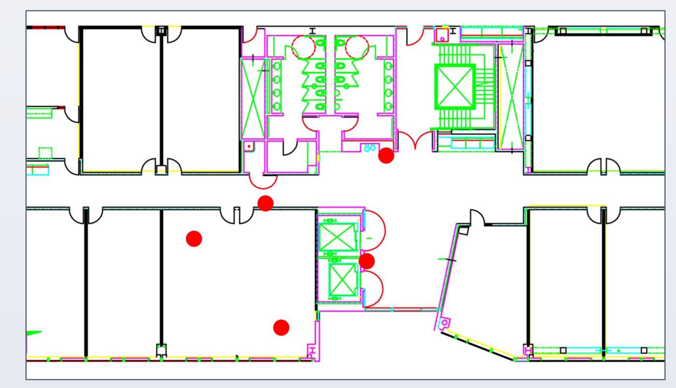
Indoor localization application recently developed for San Francisco Airport

GOALS OF PROJECT

- Develop iOS application to collect data that could form the basis of an indoor localization system
- Analyze Bluetooth signal strength (RSSI) data as a user moves through an indoor environment
- Reconstruct the walking path of a user using iPhone's inertial sensors

IMPLEMENTATION

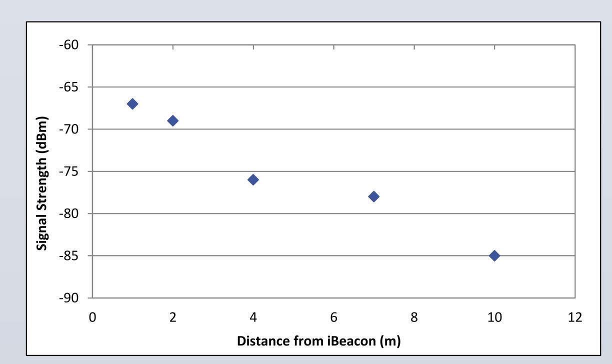
- Five Gimbal Series 10 iBeacons were placed throughout a lab and a corridor of the Engineering 2 building at UCSC



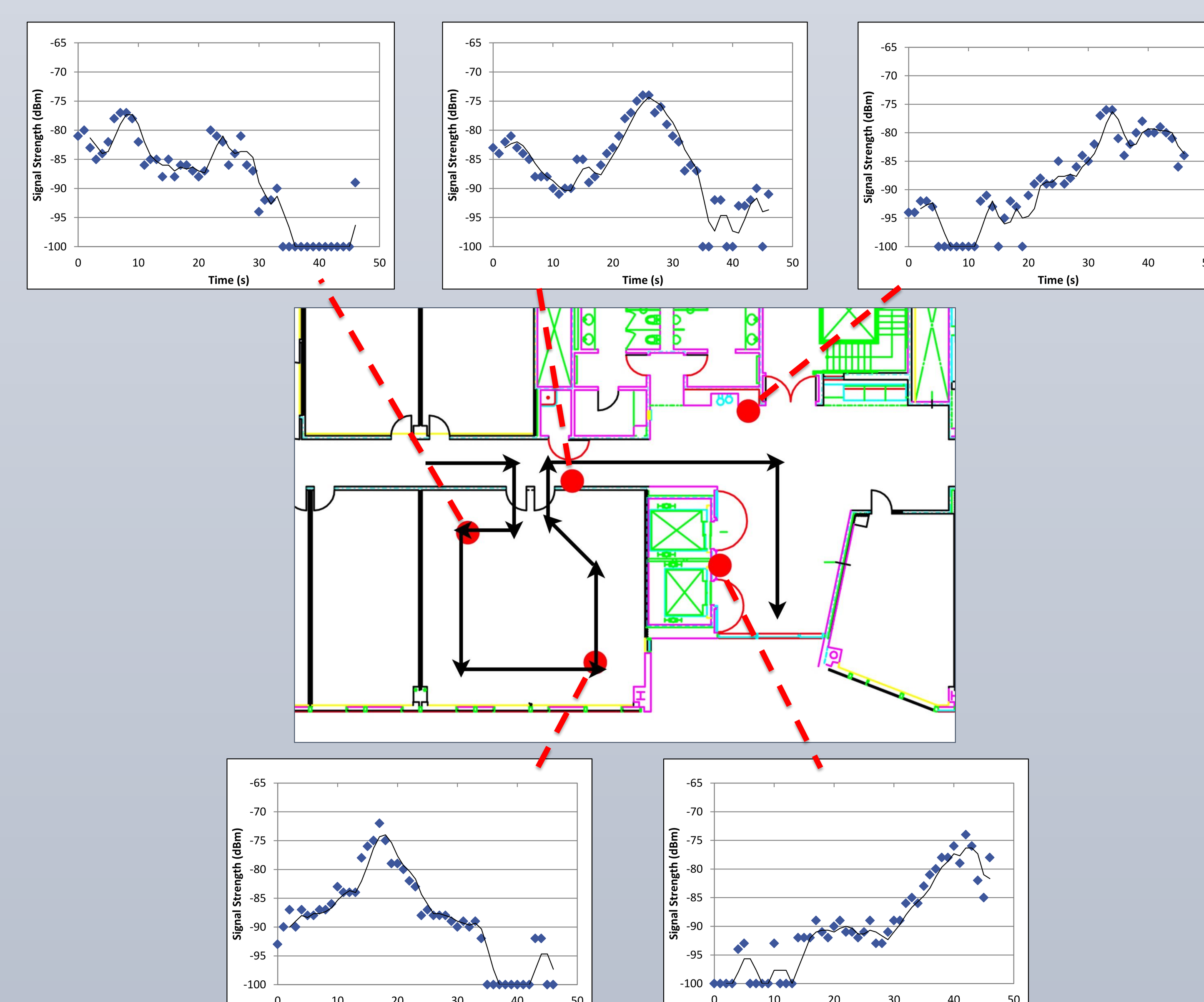
Floor plan of experimental setup, with beacon locations shown in red

- Our iOS application tracks the RSSI value of each iBeacon
- The iPhone's accelerometer and gyroscope records the user's heading and step count
- All data is logged once per second on a Google Docs spreadsheet

RESULTS



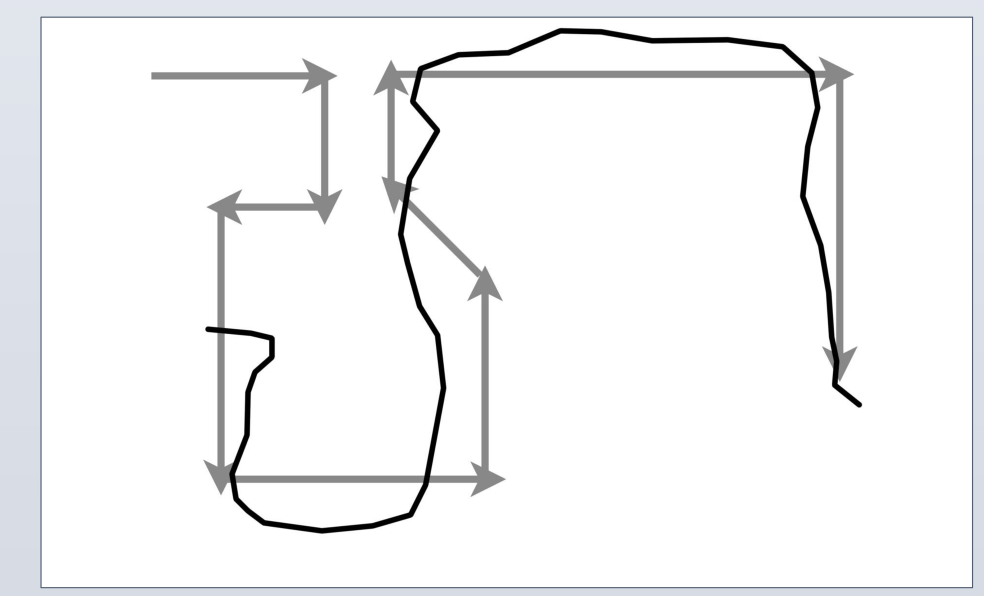
The measured signal strength of a beacon decreases as the distance from the beacon increases. While the relationship is almost linear, it is not perfect, as the signal strength readings are often inaccurate due to environmental factors



Exact walking path taken through experimental area (shown as black arrows), with corresponding graphs of signal strength vs. time for each of the five beacons placed throughout the lab and corridor. A three-period moving average trendline was added to each graph

RESULTS (CONTINUED)

- A direct correlation exists between the recorded signal strengths and the user's distance from the beacon
- Walking path reconstruction was intended to test whether relative changes in users' positions can be calculated
- Heading information was represented as degrees of rotation from the user's initial reference frame
- Due to software limitations, step count data was not updated for every reading
- Linear interpolation was used – this eliminated "jumps" in the step count data



Exact walking path of experimenter, shown in grey, compared with reconstructed path using iPhone's accelerometer and step counter, shown in black

- Using the step count data and heading information, the user's path could be reconstructed
- The reconstructed path mimics the general shape and direction of the actual path

CONCLUSION

- The beacons' experimentally recorded RSSI values demonstrated the relationship between distance and signal strength
- The iPhone's inertial sensors were able to successfully reconstruct users' walking paths
- Future work could use experimental data to construct fully-functioning indoor localization system

ACKNOWLEDGEMENTS

- Mobile application image found at http://www.theverge.com/2014/7/31/5956265/san-francisco-airport-testing-beacon-system-for-blind-travelers
- Floor plan found at https://facilities.soe.ucsc.edu/floor-plans