SoccerBeacons: tracking player movements in a soccer game using iBeacons
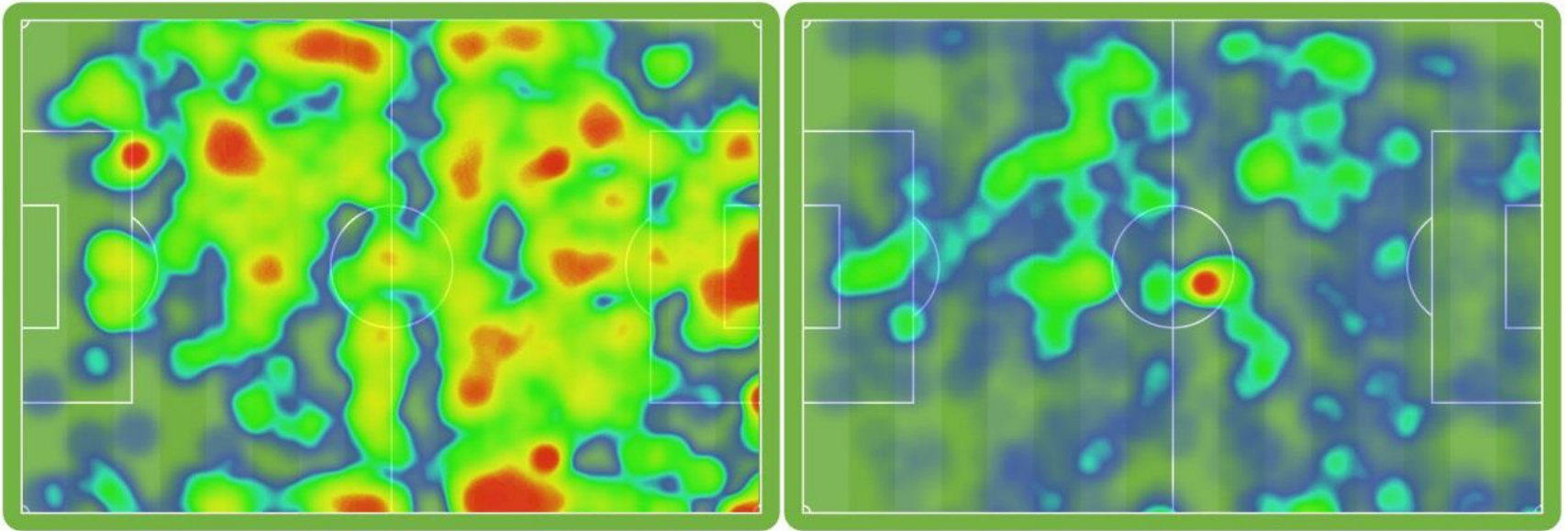
CS 6235 Project

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Motivation

- My friends and I gather together to play soccer together every week.

- Players love to compare their performances in a game with each other afterwards.

- # of goals scored often not fair enough.

- Is there any other metric that can represent the performance in a soccer game more fairly?

Movement Heatmap

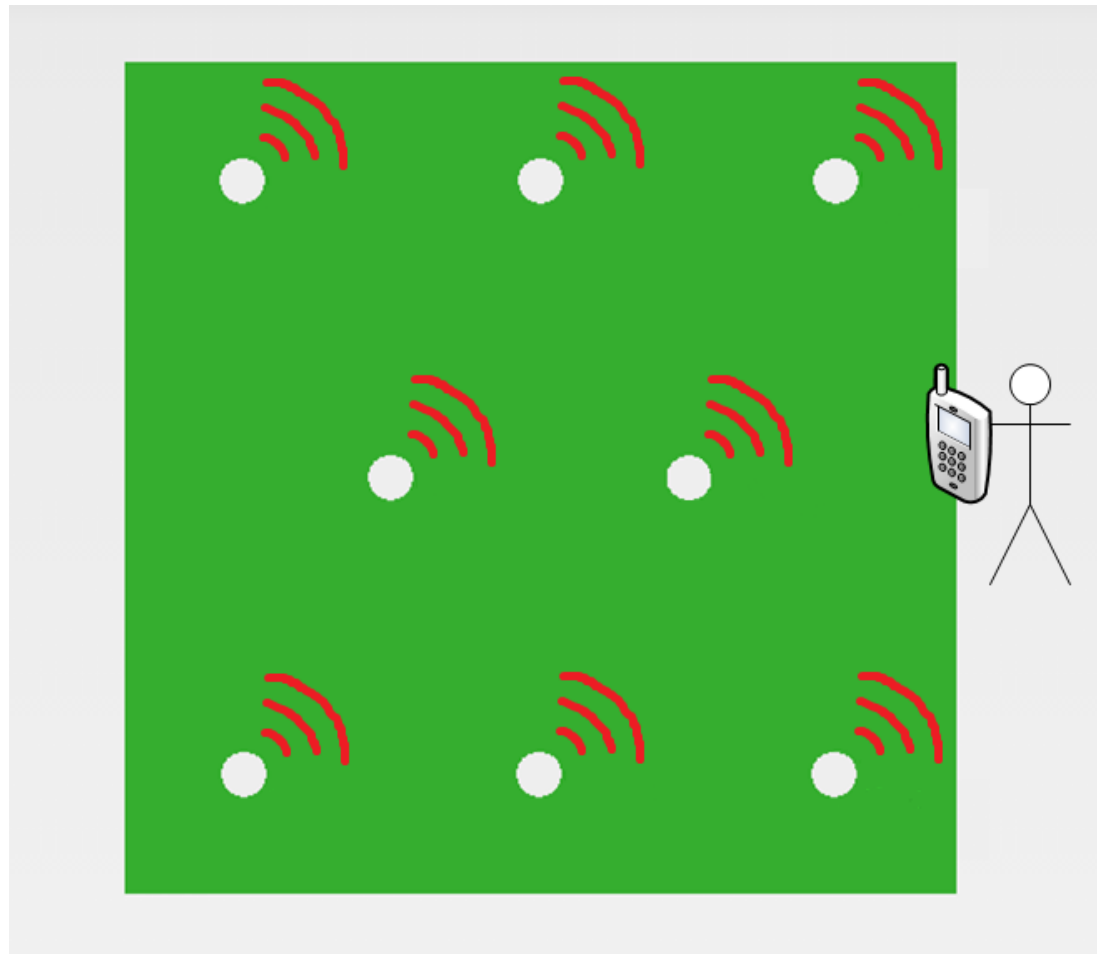Which side seems to have performed better in this game?

Tracking movements in outdoors

- GPS not suitable for tracking movements in a soccer game because of its coarse granularity.

- iBeacons are currently being used for tracking indoor movements.

- Why not apply it to outdoors? More specifically, to a soccer field!

- I developed an Android application that can track movements of a person for any rectangular-shaped field.
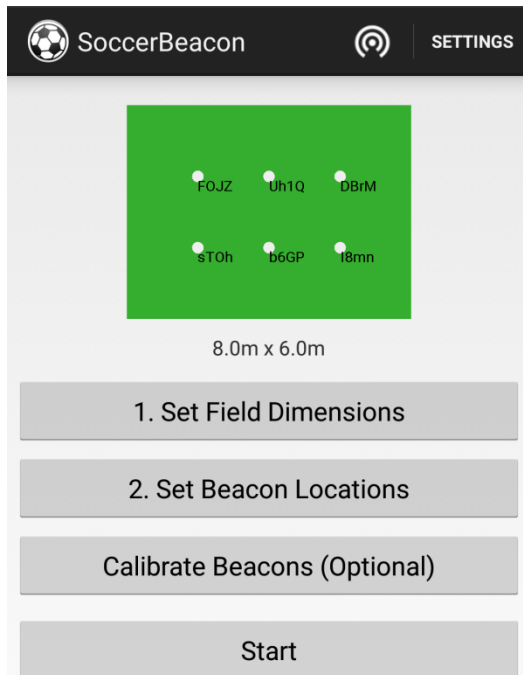
Application Workflow

1. Beacons will be placed in a rectangular-shaped field at certain positions.

2. After placing all beacons, users manually specify the dimensions of the field and coordinates of each beacon in my Android application.

3. Users have an option to calibrate beacons before starting to track positions.

4. Users also have an option to adjust certain parameters to make tracking result more accurate.

5. When a user ready, he/she can start the tracking process. The user carries the phone (with my Android application running) and moves around the field.

6. My Android application will track current position and show a live tracking result on the screen.

Example Setup

User Interface

Main Screen
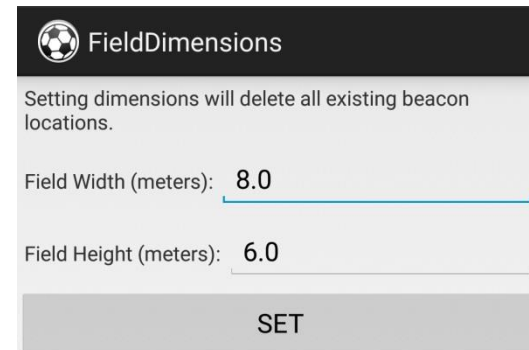
Enter Dimensions

User Interface

View/Add Beacon Locations

Beacons List

User Interface

Select a beacon for calibration

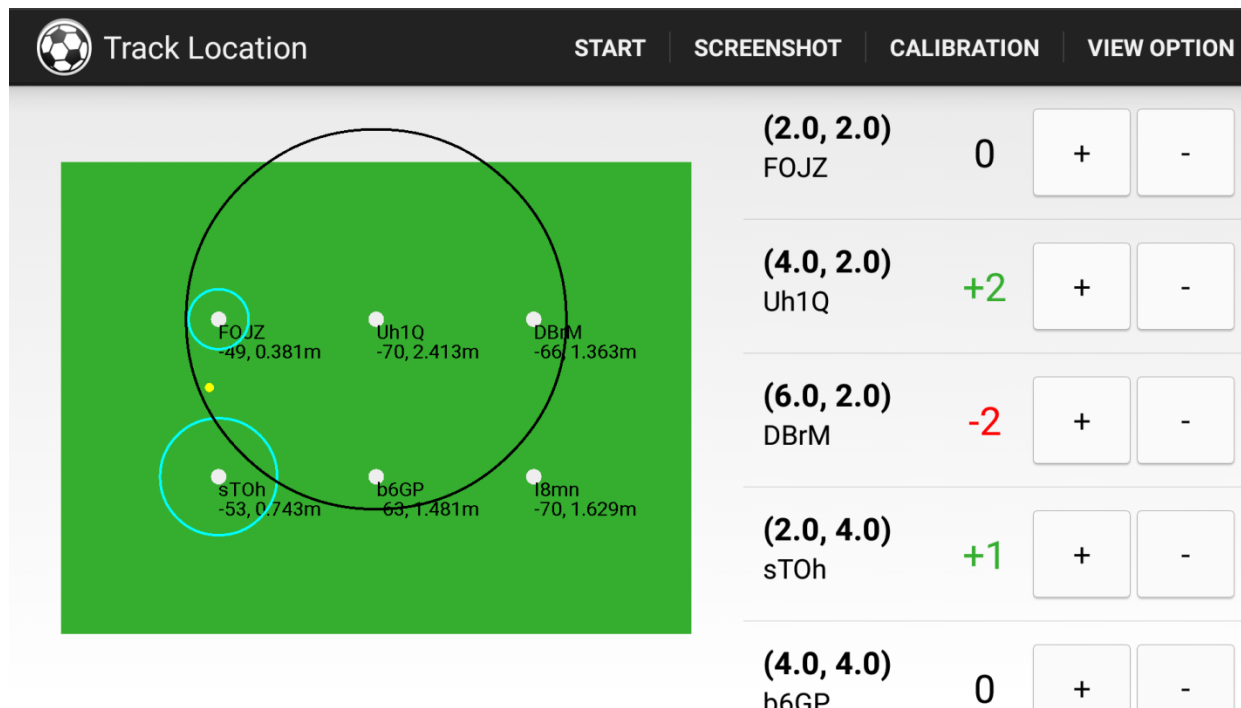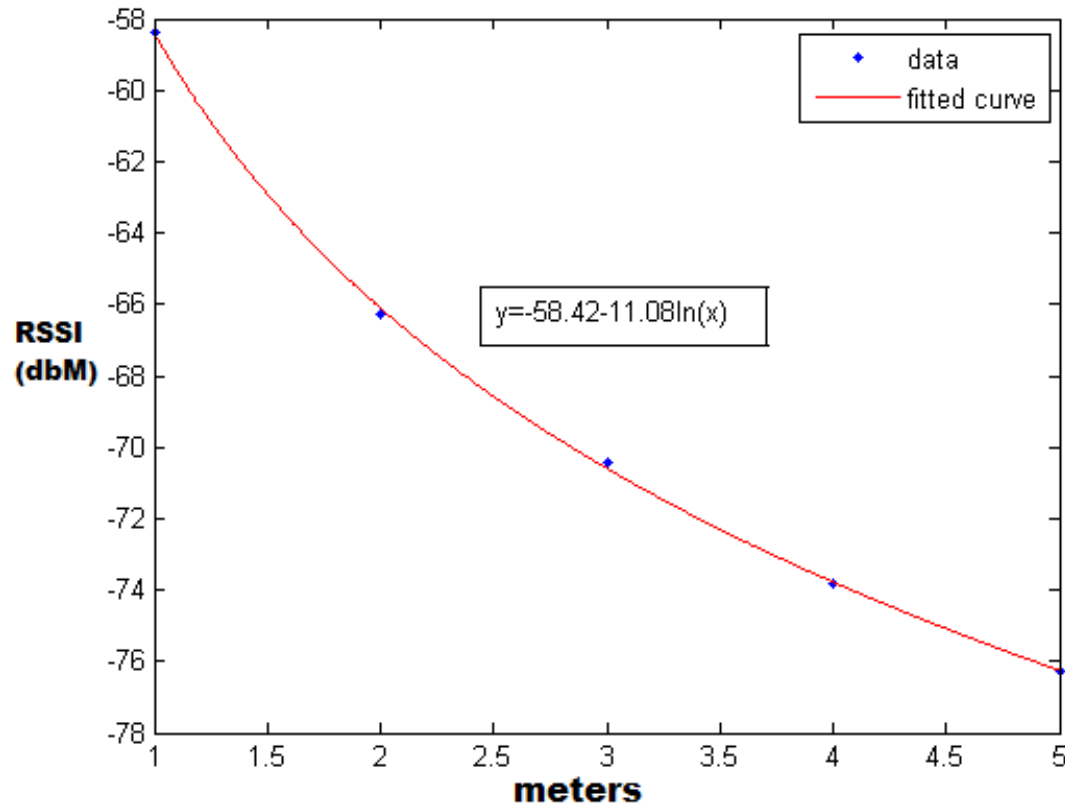Manual Calibration

User Interface

Settings

User Interface

Track Locations

Estimating Distances



- Sampled and averaged beacon signals at 1m,2m,3m,4m,5m from beacons
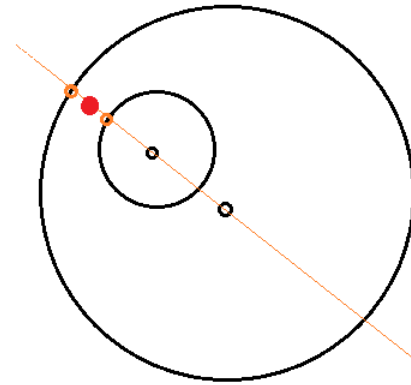- Fitted a logarithmic curve to find a distance function

Algorithm

- 1. Find two beacons that are giving the strongest signals. Given two "range circles" from each beacon, there are three cases:
  - two range circles intersect with each other: take the middle point
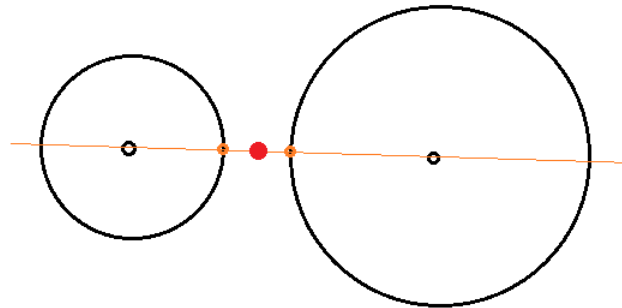 - one circle is contained in another
  - two circles are disjoint
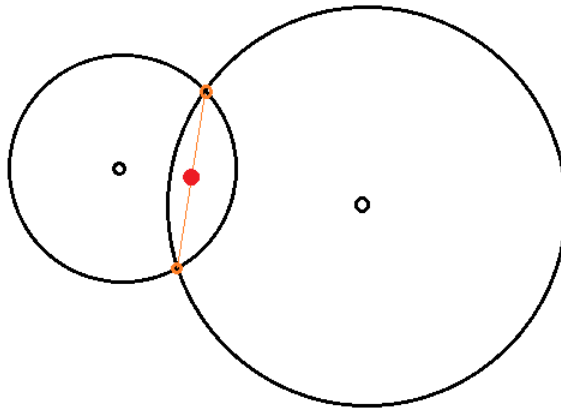
Algorithm

Two circles intersect

One circle is contained in another

Two circles are disjoint

Algorithm

- 2. Then using from this base point, I find a third beacon to use to determine the location. There are two possible choices here:
  - Use the closest beacon from the base point
  - Use the beacon that is giving the strongest signal
- There is a high probability that the closest beacon from base point is a correct choice even if it doesn't give the strongest signal.

# Algorithm
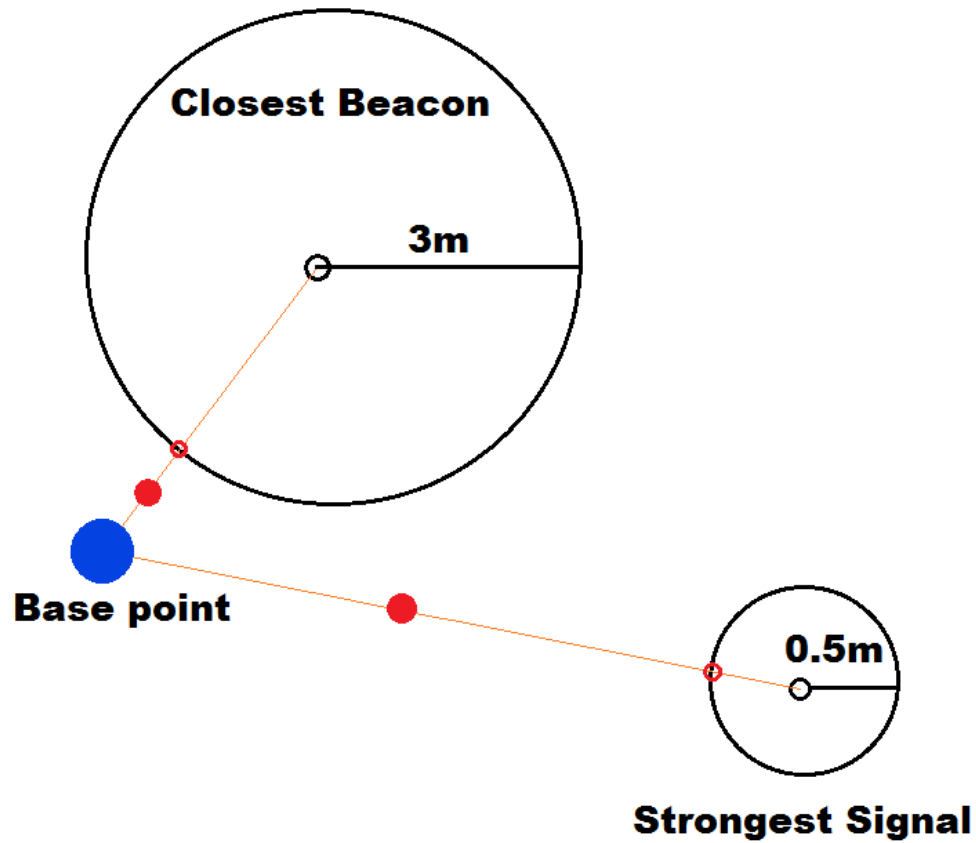
Configurable Parameters

1. **Field display margin**: display purpose
2. **Scan Interval**: interval between each scan
3. **Running Sum Count Limit**: affects running sum average
4. **Outlier Trim threshold**: determines outlier
5. **Outlier trim factor**: multiplied to outliers
6. **Third Beacon Choice**: Closest Beacon or Strongest Signal

Experiments

- 10m x 10m square field in Klaus Atrium
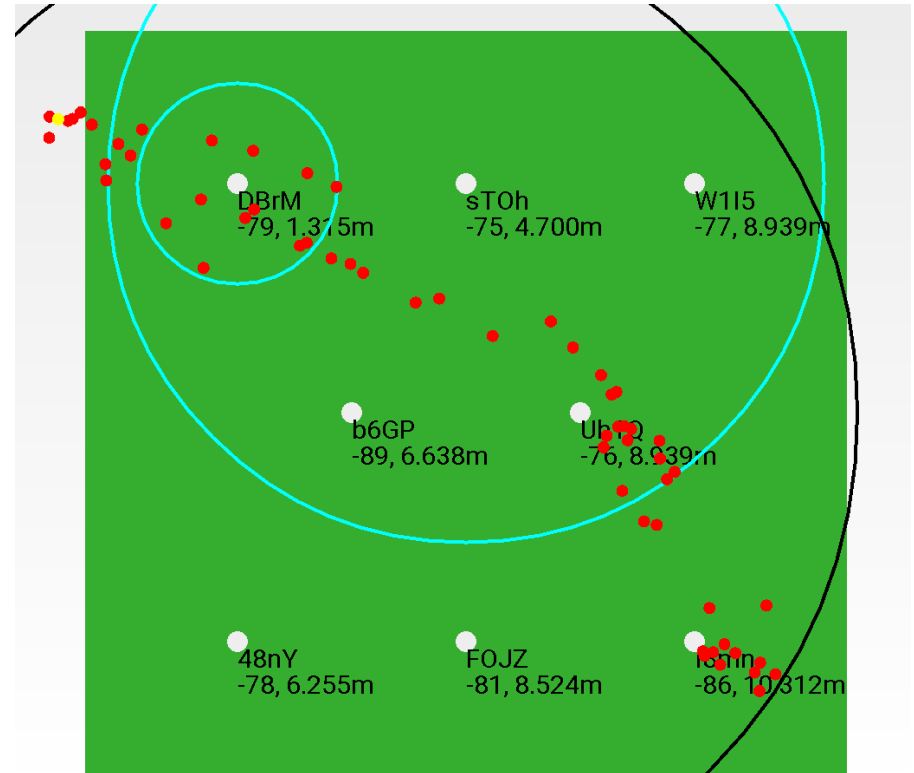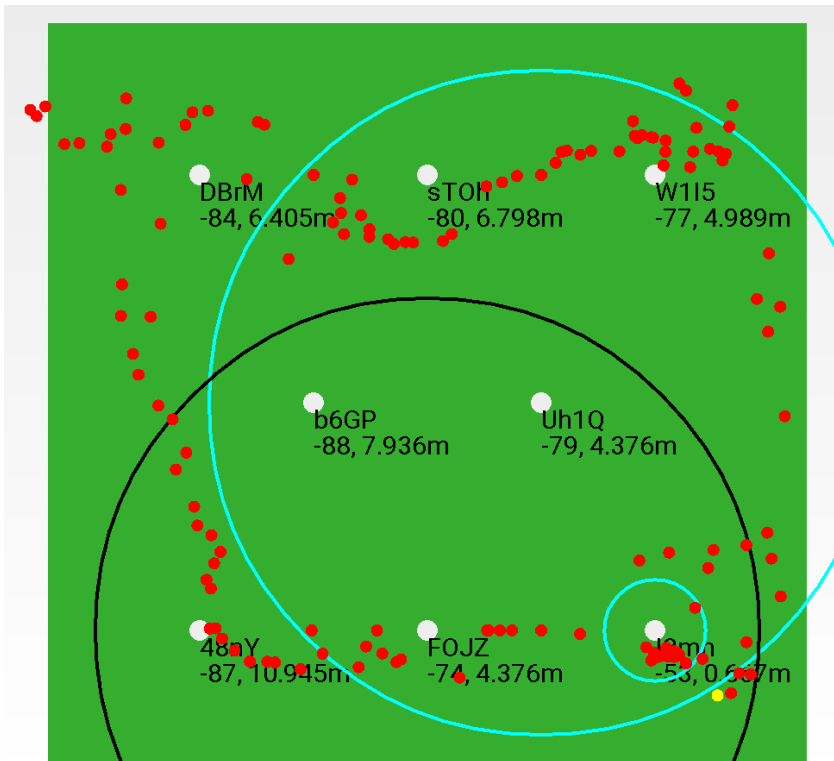- Two movement patterns: border and diagonal
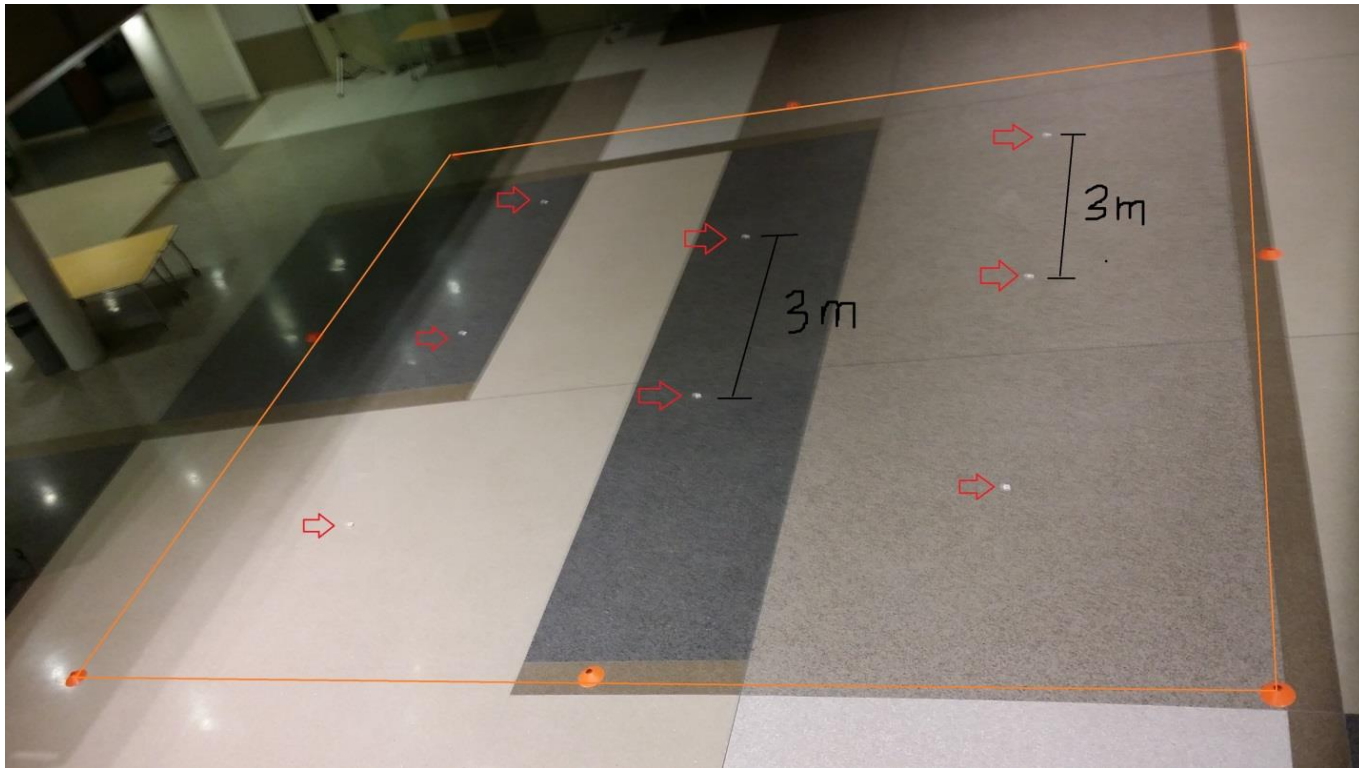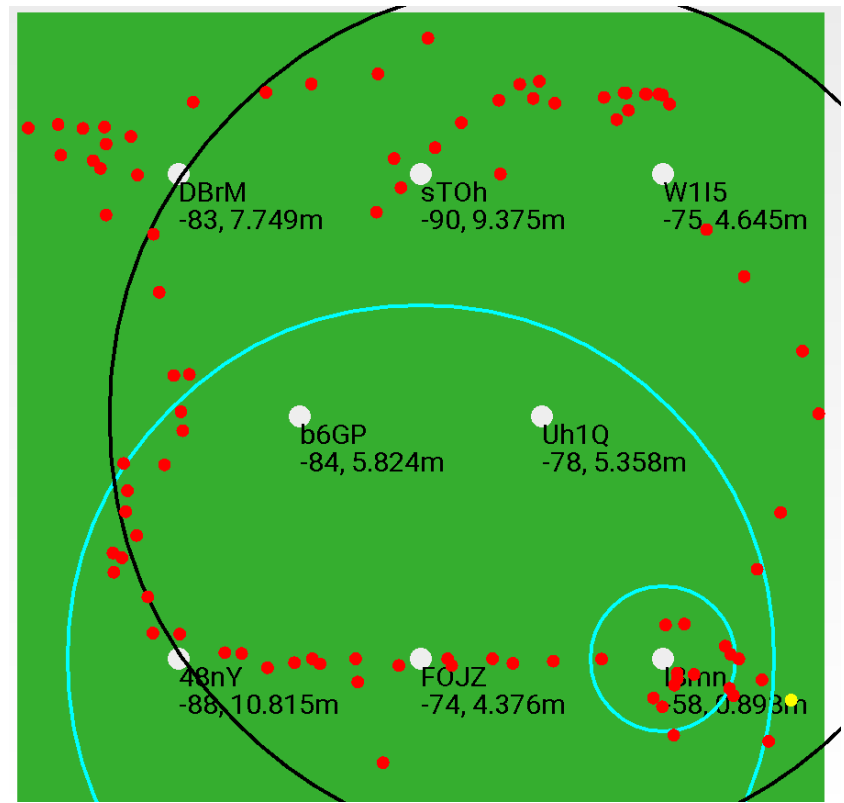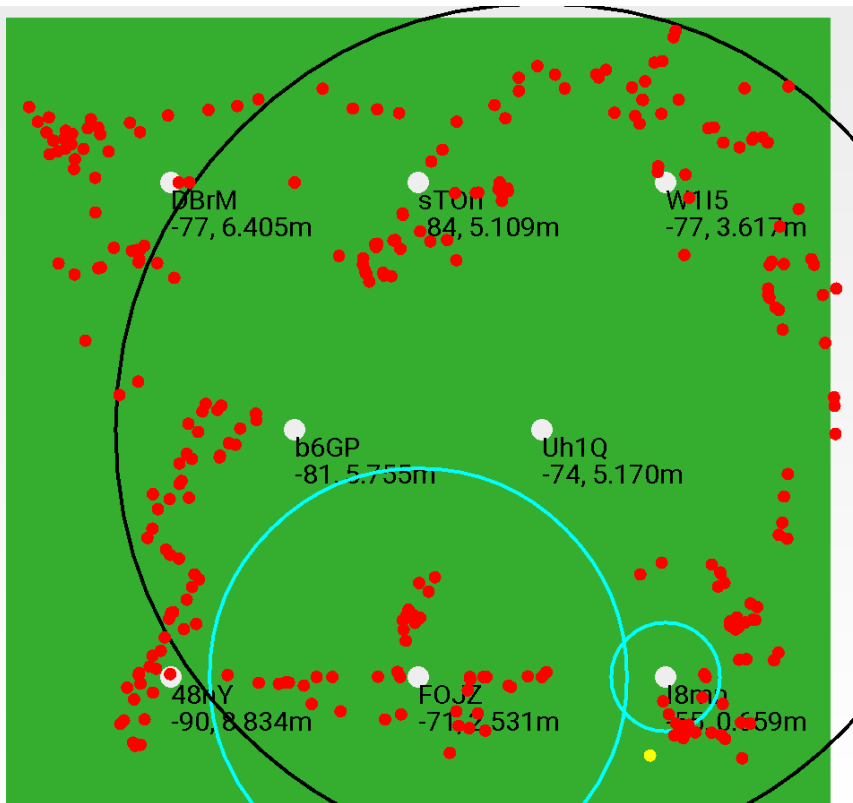
Third Beacon Choice
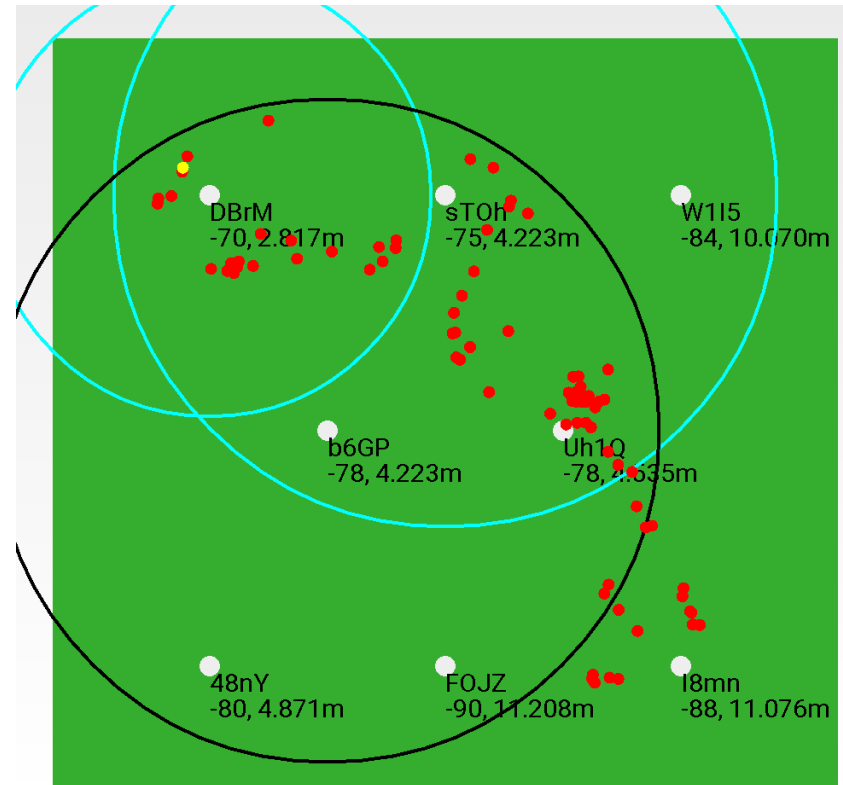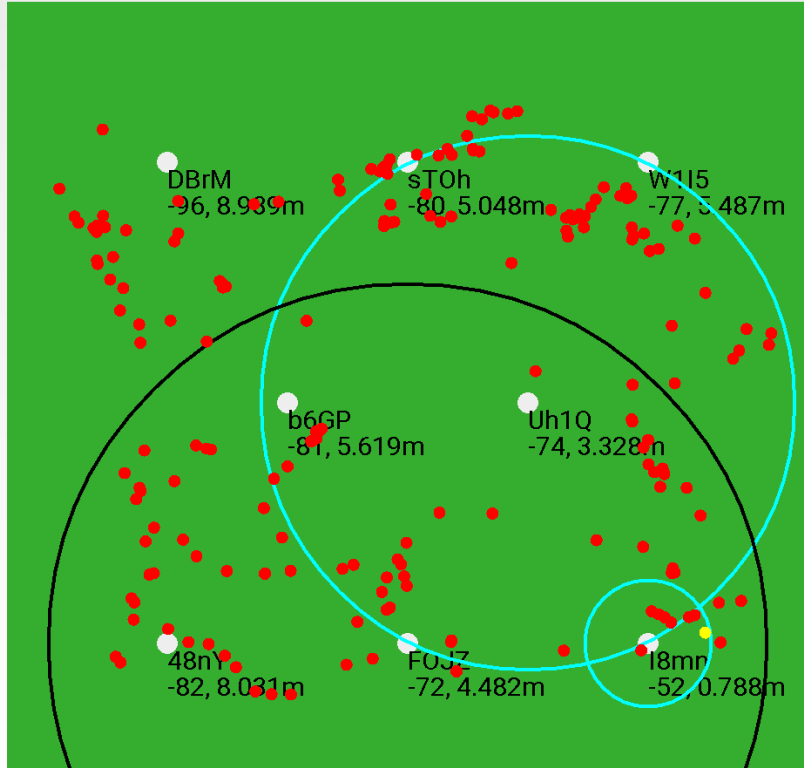
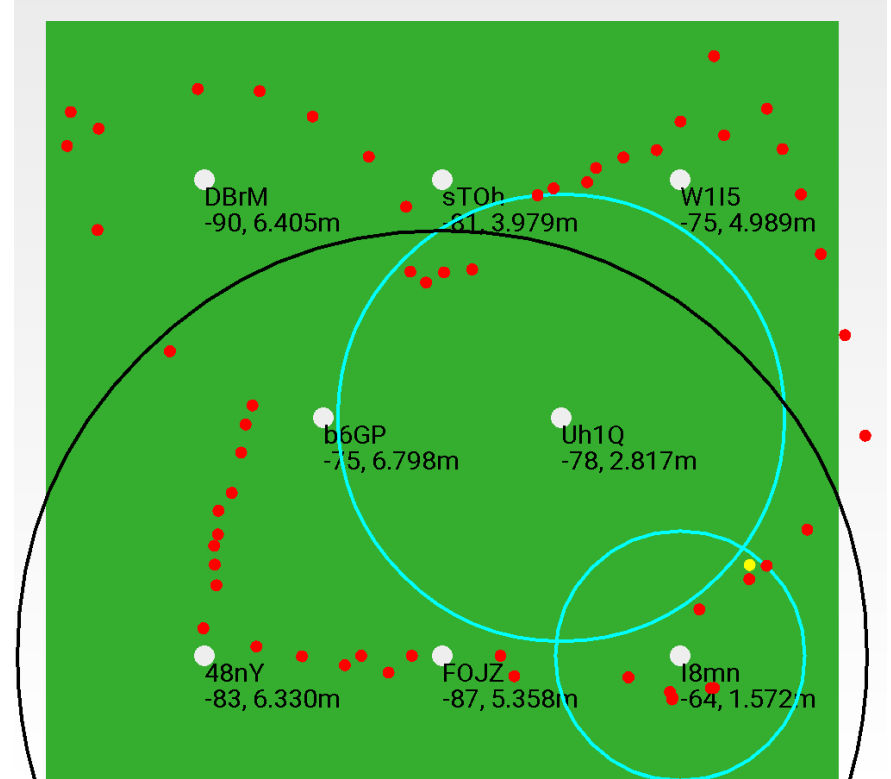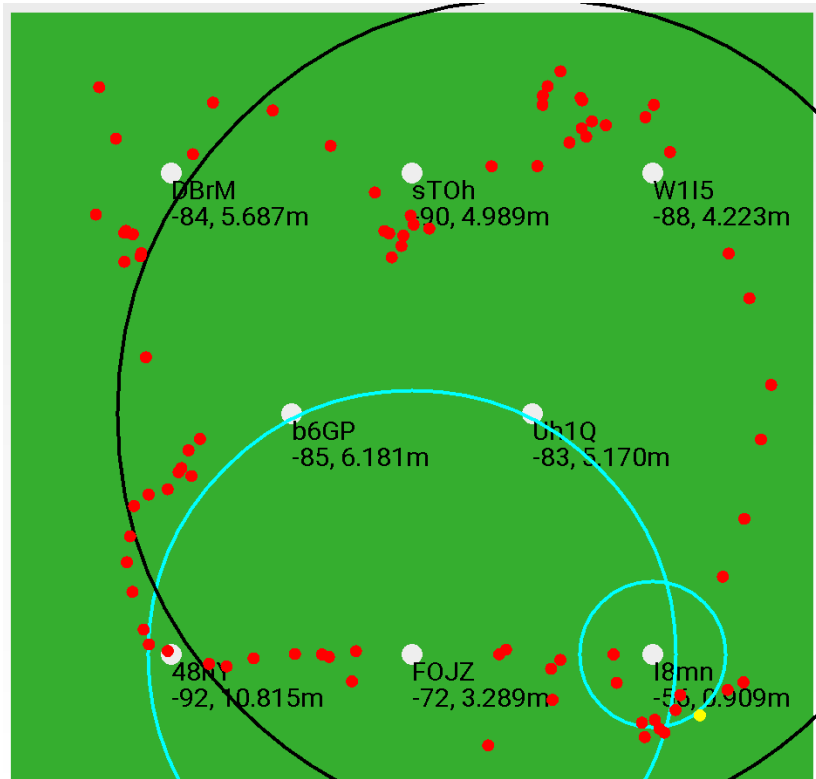Strongest Signal (border and diagonal)

Third Beacon Choice

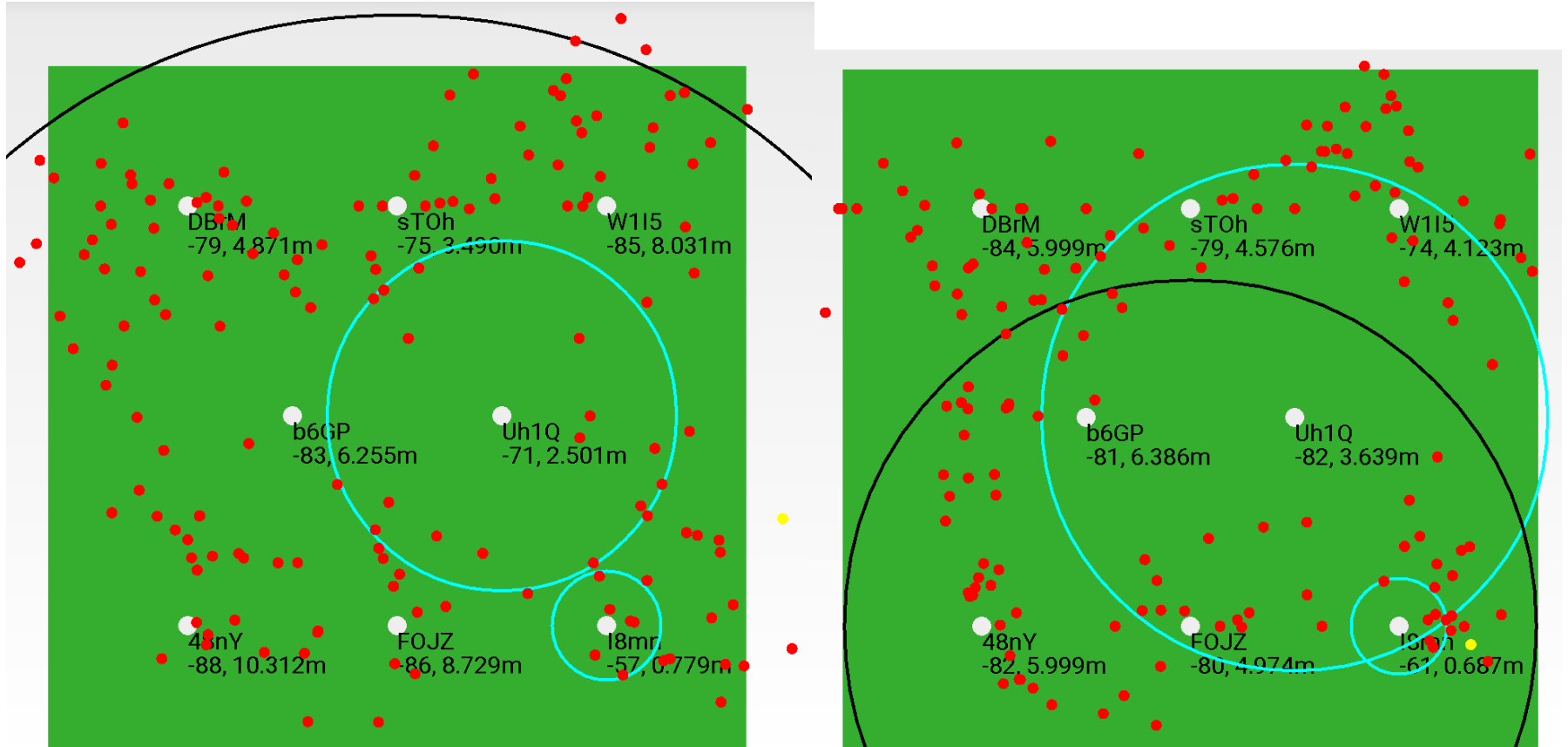Closest Beacon (border and diagonal)

Scan Interval

150ms (Left) and 350ms (Right)
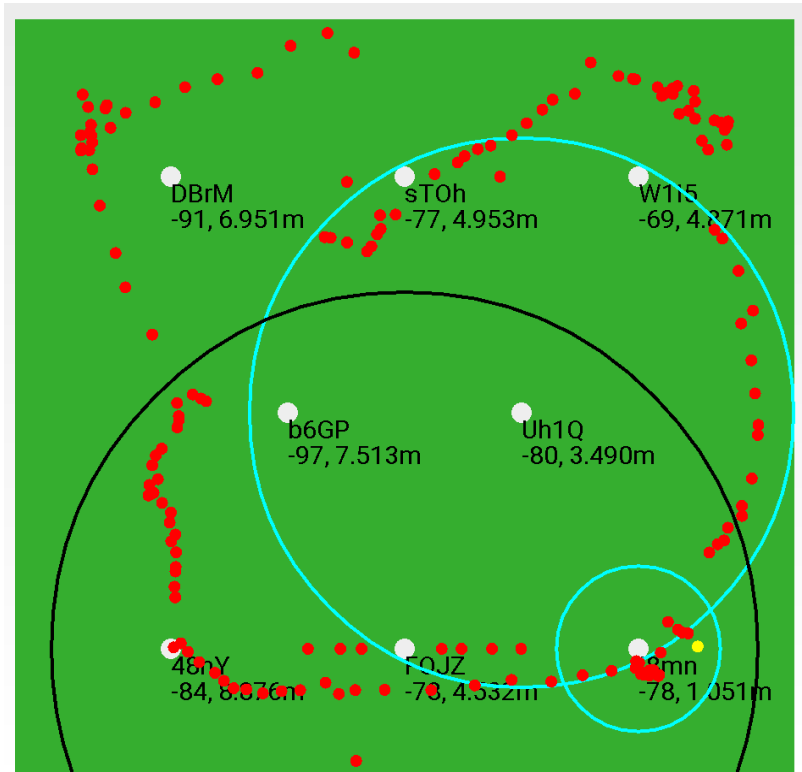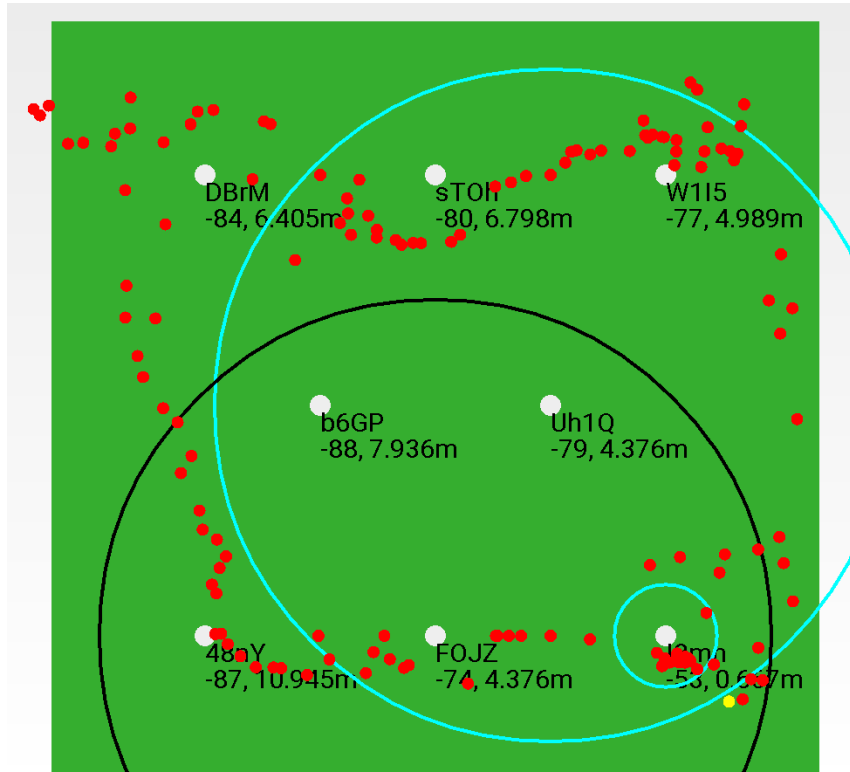
Scan Interval

700ms (Left) and 1000ms (Right)
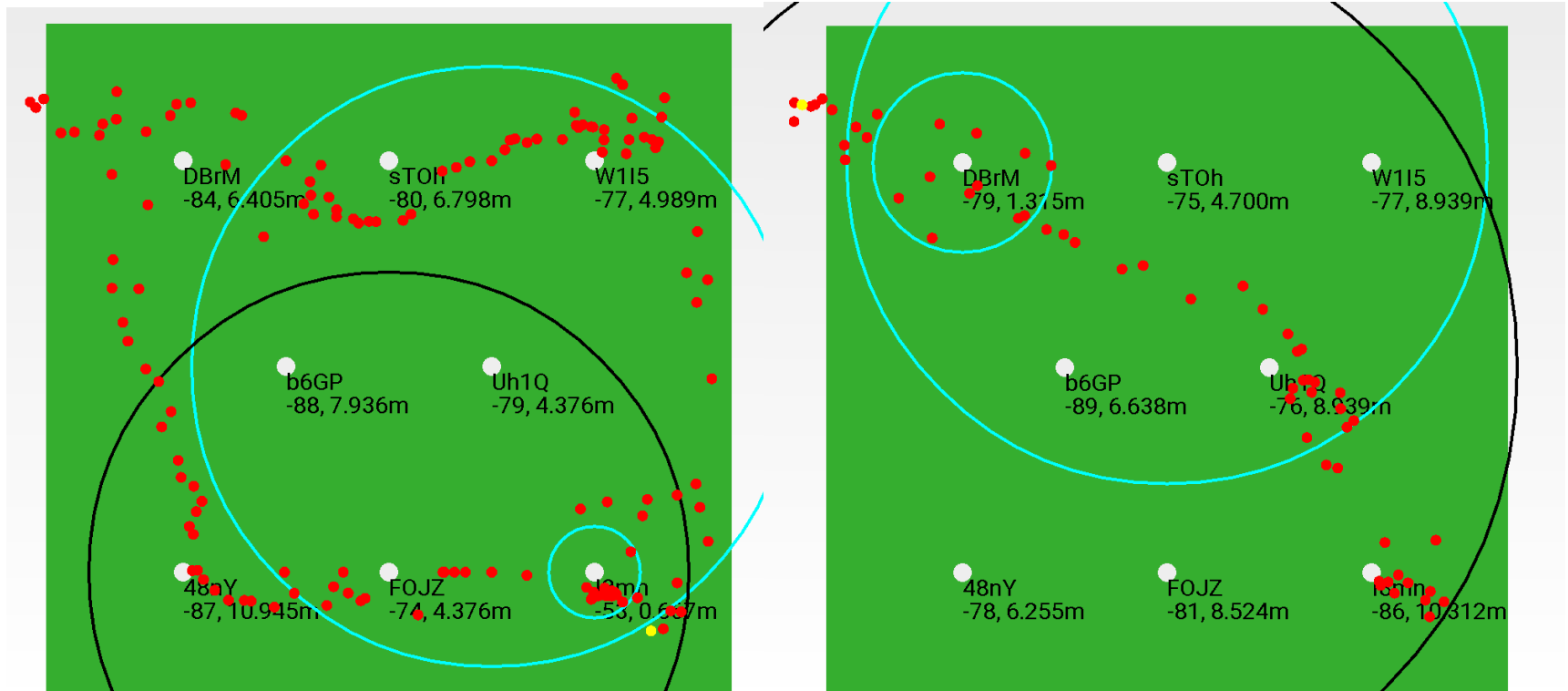
Running Sum Count Limit

1 Running Sum Count (Left) and 4 Running Sum Count (Right)
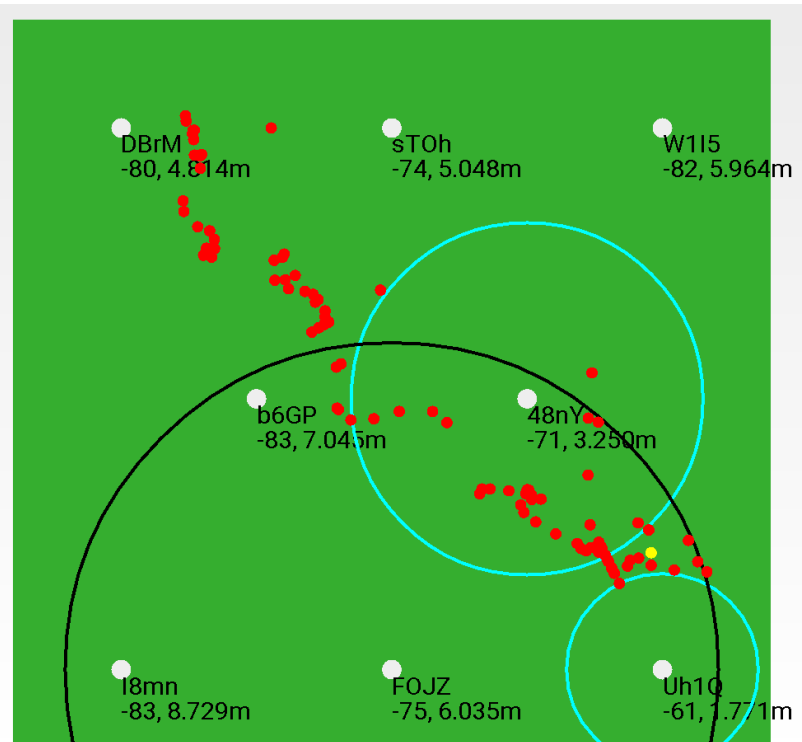
Running Sum Count Limit

Running Sum Count (Left) and 15 Running Sum Count (Right)

3m vs. 5m distance

3m horizontal distance between beacons

3m vs. 5m distance
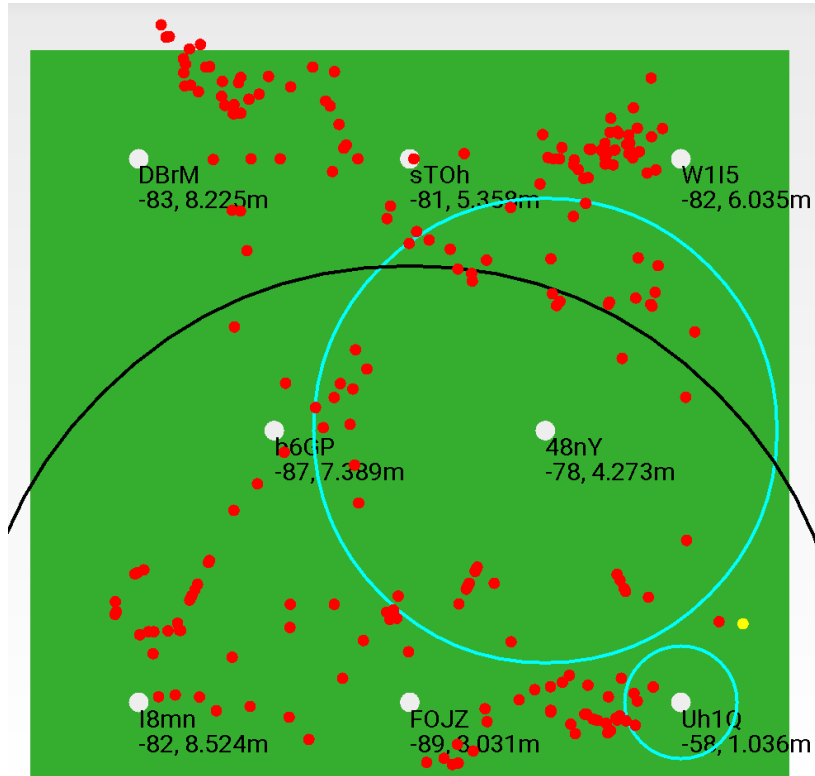
5m horizontal distance between beacons

Lessons Learned

- Signal strengths from iBeacons can vary widely from time to time.

- Below certain signal strength, it is impossible to get an accurate estimate of distances from a beacon.

- RELATIVE distances between the beacons are far more important than ABSOLUSTE distances from the beacons.

- I overestimated the capability of beacons before the project.

Applying it to a soccer field…?

- Typical soccer field's dimension is 100m x 60m.

- Let's say that we apply to a much smaller soccer field, say 70m x 40m.

- We need 91 beacons to cover this smaller soccer field.

- It will cost easily more than $1000 even with the cheapest beacons

- Very impractical costwise!

Applying it to a soccer field…?

- However, apart from the cost, this project clearly showed that the beacons can be used to track outdoor movements.

- Feasible…? **YES!**

- Practical…? **NO!**

- Hopefully, beacons technology improve in the future so that it also becomes "practical" to apply this project to a soccer field.