Exercise 1: WiFi-based Trilateration

Due date: 11:59pm, Oct 2nd, 2015

1 Introduction

In this homework, you will implement trilateration localization techniques discussed in the class using WiFi signals from campus WLANs. We strongly encourage you to go through the lecture slides before starting this exercise. To ease your work, you are provided with RSS measurements collected from multiple locations in the Information Technology Building (ITB) in the McMaster University.

Your implementation should be based on Matlab/Octave. For instructions on downloading and installing Octave, check out Download GNU Octave. Further documentation for Octave functions can be found at the Octave documentation pages. MATLAB documentation can be found at the MATLAB documentation pages.

2 WiFi-based Trilateration

The basic idea behind WiFi-based trilateration is to use a path loss model to infer distances to access points (APs) at known locations, and then determine the target location from the intersection of the circles with respective distances centred at the APs. In practice, implementation of WiFi-based trilateration faces many challenges due to the uncertainty and variability of radio propagation in indoor environments. More often than not, even with a good path loss model, the circles do not intersect at a unique location. In this exercise, you are given the path loss model and the main task is to implement a procedure to estimate the location.

2.1 Path loss model

The large-scale path loss model characterizes the attenuation of radio signal averaged over multiple wavelengths. In particular, let the P_r and P_t be the received and transmitted signals in dB (or dBm), and d_0 be a reference distance. Then, the path loss at distance d can be approximated by,

$$P_t[dBm] - P_r[dBm] = PL(d)[dBm] = PL(d_0)[dBm] + 10n\log_{10}\frac{d}{d_0}, \quad (1)$$

where n is called the path loss exponent.

Though field experiments, we have obtained the following parameters for ITB, namely, $d_0 = 1$m, $P_t - PL(d_0) \approx -25.57dBm$, and $n \approx 3.187$.

From the above relation, we can approximate the distance from a target location to an AP as,

$$d \approx 10^{-\frac{P_r[dBm]+25.57[dBm]}{31.87}} \quad (2)$$

Note the unit of dBm in the above equation.

2.2 RSS measurements

In the zip file, you can find the following files:

- itbap.csv contains the MAC addresses and the closest room and the estimated locations of each AP.
- X,Y.txt contains the RSS measurements from multiple scans of a subset of APs, where X, Y are the true x-, y-coordinates.

Figure 1 visualizes the AP locations and the RSS measurement locations.

In processing the RSS measurements, it is recommended to take an average of multiple scans from the same AP to reduce RSS variations. Since the RSS measurements are collected from APs on different floors, you may assume the z-coordinate of the data collection device to be 1.4m and the ceiling height to be 3m. The APs are typically installed in the ceiling.

2.3 Implementation

You need to implement a pre-processing procedure to read the RSS measurements from the data files as well as the Trilateration procedure. In evaluating the performance of your method, vary the number of scans to take average from and compute the resulting location errors (using the ground truth locations). In your report, in addition to detailing the trilateration

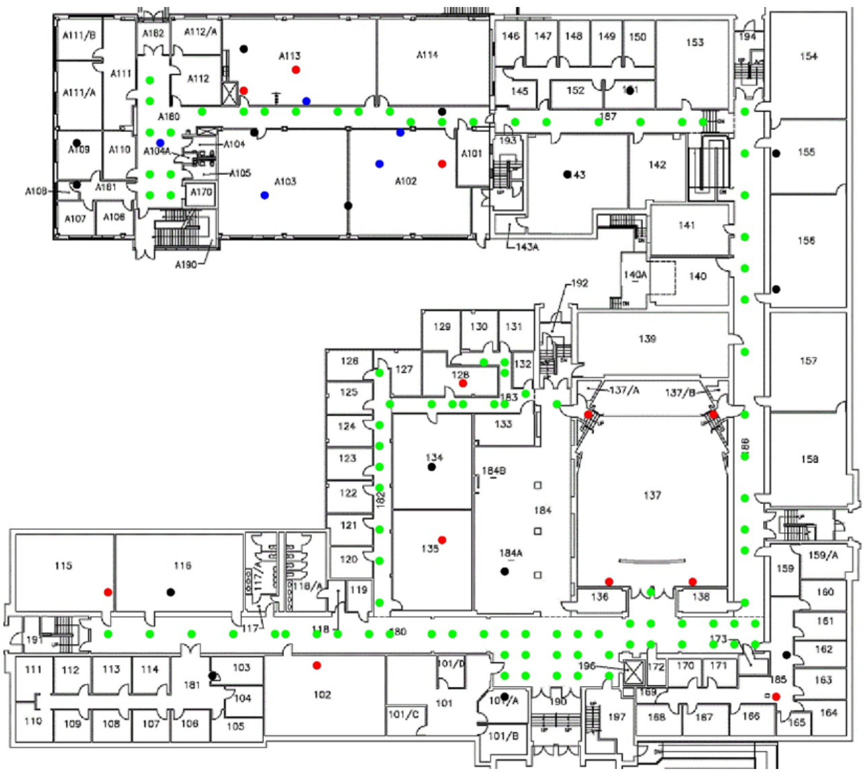

Figure 1: The locations of access points on the upper floor are in black. The locations of access points on the same floor are in red. The locations of access points on the lower floor are in blue. The data collection points are green. The training process collected RSSI data from 26 access points.

procedure your implemented, provide the mean[1] and the cumulative distribution function (CDF) of the location errors. Analyze the impact of the number of scans on location error distribution.

3 Submission

Your code should be able to handle different numbers of input RSS measurement files (.txt), compute and plot the mean and CDF of location errors automatically. Submit your report (in pdf) and codes (in .m) through SVN.

Acknowledgement

Many thanks to Chenhe Li for data collection and the path loss model.

[1] The mean errors with the trilateration method is around a few meters.