T-110.5150 – Application and Services in Internet
Assignment 2 Report: Mobile Sensing

Group 20
Bhorkar Gaurav (545691)
Thapa Manish (534398)

1. LITERATURE REVIEW

Indoor Localization refers to the process of locating objects inside buildings. Usually in outdoor conditions we locate objects based on Global Positioning System (GPS) signals. Using GPS indoors is not very efficient since signal attenuation caused by construction material (concrete walls and roofs) is high and causes loss of signal power. Multiple reflections of GPS signal from surfaces also causes multi path propagation and introduces uncontrollable errors. Thus, receivers cannot get the proper data for positioning. Indoor Localization solutions especially make use of magnetic sensors, accelerometer, WI-FI or any other sensory information that mobile devices can collect and uses it for positioning. Indoor Localization solutions can be useful in many real world applications scenarios. For example: navigation inside huge building and malls, location detection of equipment in the warehouse, location detection of fire person in the building and many others. These solutions are designed based on different technologies. Radio frequency (RF) based technologies like using WIFI location fingerprinting, proximity based WI-FI positioning, Bluetooth, RFID, and non RF based solutions like using acoustic technologies, dead reckoning, and signage also exists. Some systems make use of hybrid methods as well. Several prototype solutions have been developed in this area, like Microsoft RADAR, SnapTrack, SmartLocus, Multiloc and others. There are few commercial applications as well. One such application is IndoorAtlas which makes use of magnetic positioning. IndoorAtlas can also integrate Wi-Fi and Bluetooth location information for optimized results.

Wi-Fi Fingerprinting

A Wi-Fi fingerprint is a measure of the signal strengths of all access points available at a location. In this technique the fingerprints of several locations (references) are stored in the database. When new location is required to be positioned it scans the current location fingerprint using mobile sensors and compares it with existing database to compute the relative distance from the available references. Distance can be measured by computing K Nearest Neighbor (Euclidean distance) or other methods. Majority of Wi-Fi based positioning system employ location fingerprint according to P Krishnamurthy in his book Indoor Wayfinding and Navigation, 2015. The advantage of this approach is most of the locations already have multiple Wi-Fi points and users also have mobile devices capable of capturing fingerprints which reduces cost of implementation of the solution. The weakness of this approach is it is labor intensive task to collect location fingerprints. And since accuracy is dependent on considerable dataset of measurements, collection is crucial for higher reliability.

Acoustic Positioning

Acoustic Positioning is non RF based approach where time of arrival of ultrasonic signals is used to determine the range of objects. This approach is more accurate than Wi-Fi fingerprinting and has an accuracy of centimeters as compared to meters in Wi-Fi fingerprinting. The disadvantage with this approach is that ultrasound cannot pass over walls and needs a dedicated line of sight. Another major disadvantage compared with Wi-Fi fingerprinting is that most of smart phones do not support ultrasound technology.

Bluetooth based positioning

Bluetooth based positioning is suitable for applications for workspaces which need low cost solutions and where room level accuracy is sufficient. Bluetooth is a specification for low power and short range wireless data. Most of mobile phones support Bluetooth technology which makes this approach feasible. This approach consumes less power than Wi-Fi fingerprinting. Unfortunately it provides less accuracy which confines its usage for limited applications.

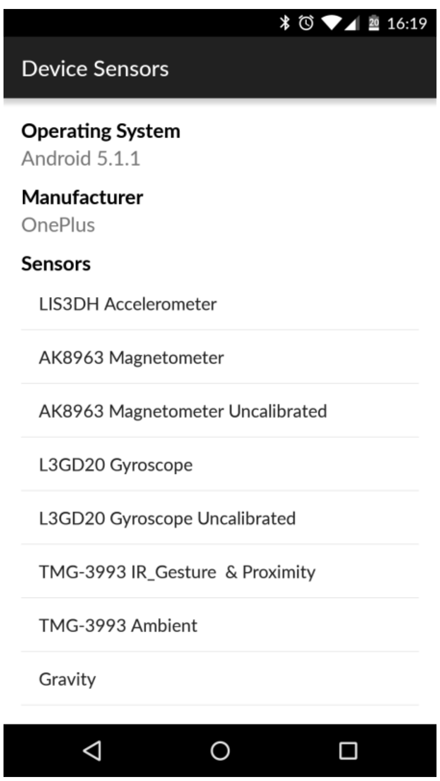
2. SIMPLE APPLICATION FOR INDOOR LOCALIZATION

We developed a simple indoor localization application based on Wi-Fi fingerprinting. The application acquires the Wi-Fi fingerprint of the current location and compares it with the Wi-Fi fingerprints of the reference locations in order to estimate the closest reference location.

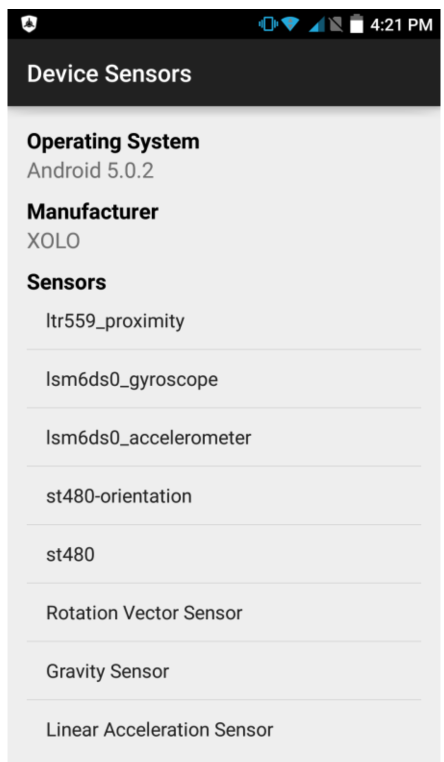
2.1. Device Information

Following are the devices used in the experiments and for testing the application

Operating System: Android 5.1.1
Manufacturer: OnePlus
Total Number of Sensors: 28



Operating System: Android 5.0.2
Manufacturer: XOLO
Number of Sensors: 10



2.2. Localization Algorithm

The algorithm relies on finding the distance of the current location from each reference. The lower the distance means that the location is closer to that reference. Following is the algorithm:

1. Find the Wi-Fi Fingerprint of the current location.
2. For all reference locations
3. Find Euclidean distance of current location from the reference (for all common BSSIDs) (based on the below given formula)

   $$D=\sqrt{\sum_{each\ BSSID}(SL_{measurement}-SL_{reference})^2}$$, where *SL* is the signal level.
4. Find reference with lowest Euclidean distance. The location is closest to this reference.

Since there are several measurements stored for the Wi-Fi fingerprints of reference locations, we compute the average of all measurements.

There are two measurements given in the assignment. Following are the calculations based on the above algorithm.

1. Measurement file: *result_20151104_170212.json*

Euclidean distance from A112: 62.75
Euclidean distance from A118: 56.18
Euclidean distance from **A124: 48.23 (nearest)**
Euclidean distance from A128: 105.69
Euclidean distance from A136: 108.63
Euclidean distance from A141: 113.64

2. Measurement file: *result_20151104_170414.json*

Euclidean distance from A112: 80.86
Euclidean distance from A118: 98.07
Euclidean distance from A124: 70.71
Euclidean distance from A128: 54.04
Euclidean distance from **A136: 42.47 (nearest)**
Euclidean distance from A141: 67.71

2.3. Localization with mobile application

The given measurement data near room A141 yielded positive results from our algorithm

(file: *result_20151104_170559.json* renamed to file: *result_near_a141.json*).

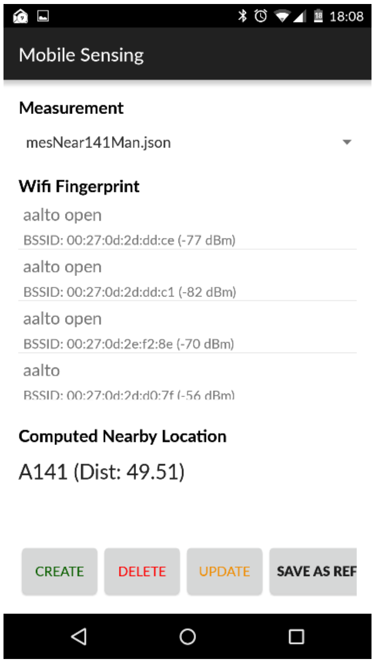
Following screenshot shows the computed location correctly as A141.

Euclidean distance from A112: 67.25
Euclidean distance from A118: 107.35
Euclidean distance from A124: 95.35
Euclidean distance from A128: 76.67
Euclidean distance from A136: 80.14
Euclidean distance from **A141: 49.42 (nearest)**

Localization with given measurement data (near A141)

We measured our own data near room A141 to test the correctness of our algorithm. The results with our own measurements were also correct.

Measurement file: *mesNearA141Man.json*



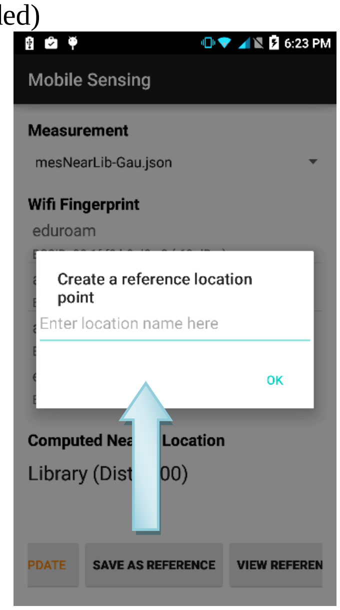
Localization with data gathered from device (near A141)

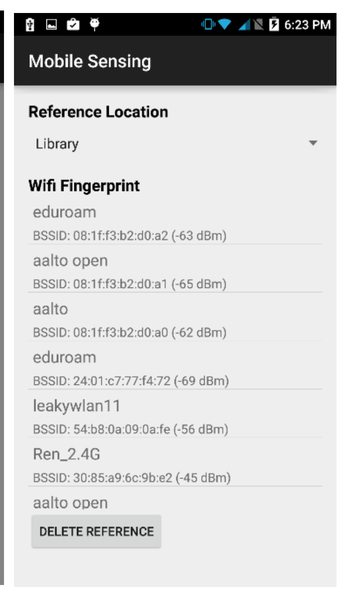
2.4. Building reference data

We can build our own reference data using the measurements taken. To create reference data following process should be followed:

1. Create measurement data using the application at the desired location. (The app will show approximate location which can be dis regarded)
2. Update the measurement data several times during the day by taking measurements at the same location.
3. Export the measurement as a reference.

Exporting new measurements to the same references will result in better results. Once a reference is added, it will be used to estimate the location of the measurements.





3. TIME ESTIMATE

Topic	**Approximate Time (2 students)**
Literature Review	12 hr
Algorithm design / discussion	12 hr
Coding/testing application (and revisions to algorithm)	30 hr
Measurements / Experiments	5 hr
Final testing and report	5 hr
Total	64 hr

We spent an approximate amount of 32 hours (per student) for this project.

4. FEEDBACK

The assignment was challenging and very interesting. This got us interested in the field of Indoor Localization and helped us understand how the process works.

5. CONCLUSION

The assignment helped us learn Android programming and the principles of indoor localization using Wi-Fi fingerprinting. We now understand that there is a huge scope of research in this area in the future. Furthermore, this assingment also gave us a first hand view of experimenting and data collection.