CLIENT/SERVER - BASED INDOOR POSITIONING WITH WLAN

The rise of indoor location based systems in recent years shouldn't come as a surprise given the technological improvements in hand held technologies in the last decade. The fact that these devices are assessed more in indoor environments make a even stronger case for investing time and money in bringing location based services to an indoor environment. Common use cases of indoor location services include proximity advertisement in malls with many retail shops, gate and platform location in train stations and airport, just in time narration in museums just to mention a few.

Given the physical limitation of GPS, with poor signal reception indoors, has made it imperative to seek other means to solve the problem posed by indoor positioning. The system specifications of smartphones is another factor to be considered when providing a solution to the indoor location problem. Their low processing powers often dictate the computational complexity of the solutions to be installed on them. This cause serious limitations since only a few algorithms could be used; needless to say that it hampers scalability of such system. A way around this is to lift the burden of performing complex computation off the smartphones and place it on a more worthy counterpart. Thus, the use of a client/server system in the problem of indoor positioning. In such system, the client was used in extracting the features from the test site and presenting user's location as dots on the map to the user. While the server stores the fingerprinting data collected by the client and uses them for computations during location estimation.

Many new generation Smartphones are equipped with in built WLAN adapters which makes them suitable for use in indoor positioning systems based on location fingerprinting. Unlike the GPS, location fingerprinting techniques do not rely on geometry and angle measurement to derive an object's position. Instead, they extract location specific features and uses these features to predict the location of an object in the same environment where the features were extracted. Most prominently used of such features is the access point received signal strength. This technique is a very simple one and requires almost no additional cost in setting it up since existing WLAN system could be used. Its advantage however, quickly turns to a disadvantage because of its dependence on the arrangement of the access points in the test area, the amount of time for location fingerprinting and inflexibility of the test environment.
The location fingerprinting technique estimates the position of a mobile client using the map-based technique which requires the generation of an intensity map of the test area. The intensity map essentially contains signal strengths (SS) from all available access points to be used in the location determination. This works in two phases; namely: the offline or training phase and the online or location determination phase.

In the offline phase, Access point (AP) received signal strengths (RSS) are measured for a period of time at known locations (reference points) in the test area and are saved in a database (as the intensity map) for reference during the location determination phase. During the online phase, RSS from available AP are then matched with values stored in the intensity map to obtain an estimation of the user’s location. This technique requires a lot of man hour (which may take several hours or days depending on the number of reference points and the size of the test area) to generate the intensity map.

An experiment was performed on the 4th floor of the Institute of Photogrammetry (Ifp) to determine object’s location on the corridor using location fingerprinting technique. This was aimed at obtaining parameters such as the minimum amount of offline time required to generate the intensity map, the grid spacing (distance between two closest RP), the number of access point required for the test area and improving the accuracy of the location estimation results obtained from applying the derived parameters.

Received signal strengths (RSS) of access points were extracted using a mobile client during the offline phase and the obtained data stored on a server for reference during location estimation. The RSS are measured in four orientations (0°, 90°, 180° and 270°) for each RP. To obtain the aforementioned parameters, a new set of points (39 of them, referred to as the test points, also with known coordinates) are introduced to the test bed. During the online phase, the location of these points are determined and compared with the known coordinates and the difference between the two is measured in terms of the distance away from the original point.

The representation of the arrangement of the reference point, test points and access point could be seen in figure 1. The reference points are the red dots while the green dots are the test points.

![Figure 1: Floor plan of the Ifp corridor.](image)

The nearest neighbour (KNN) estimation method is used to obtain the required parameter and they are shown in the table 1.
Using these parameters, the Baye's classifier method and a derived method referred to as the modified nearest neighbour (M-KNN) are used in location estimation and the results compared with those obtained with the conventional KNN method. The accuracy and precision of all three methods are as shown in table 2. The Baye's classifier method used the same parameters as the other methods except for its fingerprinting time which is 2 minutes for each orientation. This is because it's a probabilistic method and requires more samples to obtain a reasonable degree of accuracy. The performance evaluation of all three methods using their accuracy and precision was obtained from the results and are as shown in table 2.

For most indoor applications, it is sufficient to have a system that could give a 10m accuracy at least 90% of the time. This signifies that any of the above listed techniques can easily pass for most indoor applications. Choosing a technique for use then depends on the requirement of the system to be developed. Such requirements may include the number of man hour required for intensity map generation, accuracy and precision expected, computational requirements, deployment time, scalability and user interaction required to set up such system.