A Survey on Android based Indoor Wi-Fi Positioning System using Tri-Lateration

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ABSTRACT
Indoor Positioning System (IPS) has been studying in many fields. Recently, the IPS market is growing rapidly and many companies are following the techniques like tracking and navigation technologies and services. There are many different schemes for indoor positioning such as Wi-Fi Positioning Systems (WPS), Bluetooth, Infrared, ultrasound, etc. Global Positioning System (GPS) is the best positioning system but it works accurately for outdoor localization and is also used for navigation and tracking for any devices or smartphones. However, unfortunately it is difficult to use for indoor applications i.e. inside the buildings the signal is not available, IPS solves this problem and for more accuracy IPS is done using Wi-Fi positioning which uses RSSI data from Wi-Fi access points to do localization in indoor environment.

Keywords
Access Points (AP's), Indoor Wi-Fi Positioning, Received Signal Strength Indication, Tri-lateration, Android, Smartphone.

1. INTRODUCTION
To locate people or objects inside buildings an Indoor Positioning System is used. Indoor Positioning System basically uses sensory information from acoustic signals, radio waves or magnetic fields collected by mobile devices. There are many systems on the market, but IPS systems have no particular standard. Different technologies like magnetic positioning, distance measurement to nearby anchor nodes (nodes with known positions, e.g. Wi-Fi access points). To find exact location at least three independent measurements are required by the system and this is known as tri-lateration. The methods using Wi-Fi are more preferable because Wi-Fi networks are prevalent in most public buildings, its use does not require additional infrastructure, and it allows determination of the location of each mobile device. The Wi-Fi signals provide a low precision for tracking the locations. Therefore, in order to acquire more accurate location of a target, Wi-Fi APs dedicated for localization should be installed in the respected location.

In this paper, a Wi-Fi based indoor positioning system is explained. In Wi-Fi, various methods are used for positioning purpose. One of the methods used in proposed system is Trilateration method for indoor localization, which makes use of the point of intersection of three circles of Wi-Fi APs, which gives the exact position of user. The rest of the paper is organized as follows. Section II describes Indoor localization,

III explains the literature review, section IV describes Survey of IPS, V explains the Results, VI explains the Conclusion, VII shows the references.

2. INDOOR LOCALIZATION
2.1 Wi-Fi Trilateration Approach
Signal strengths from all the existing Wi-Fi AP's is gathered in trilateration. Signal propagation models relate the received signal strengths from existing AP's and converts to distance from respective AP's. Afterwards to obtain the position of user in indoor environment trilateration algorithm is used. Trilateration is simple and easy to implement method for indoor localization. Further to improve the accuracy and to reduce the errors various methods are used in trilateration method. Trilateration is also called as dynamic method of positioning. Fingerprinting method is used for indoor positioning. It has got mainly two phases which are offline training phase and online training phase. The offline phase prepares a database which stores the co-ordinates of respected area. Accuracy of the system depends on this phase. In online phase, fingerprint database is queried for location of user. Various pattern matching algorithms are used to match the database entries with dynamic RSS. We have explained the indoor positioning system based on Wi-Fi technology which uses Trilateration method to estimate user position in indoor.

Trilateration algorithm is shown in the Fig 1 and calculates the exact location of user. Name of the algorithm suggests that it requires minimum of 3 Wi-Fi access points in indoor environment to calculate user location co-ordinates.

The three circles are shown below are AP's whose center co-ordinates are known. The point of intersection of these circles is the position of receiver. Now, knowing d1, d2, d3 i.e. distances from center of access points and center co-ordinates (x_i,y_i,z_i) of AP's the exact location of receiver (x,y,z) can be calculated by solving this set of equations.

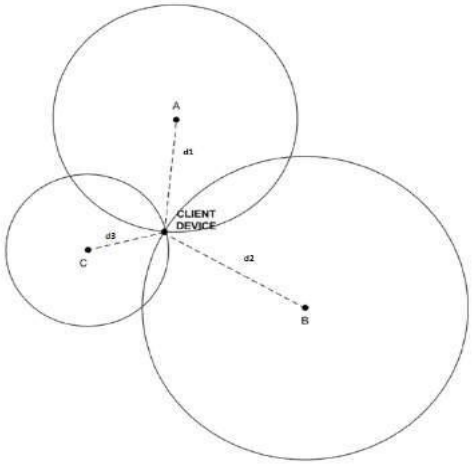

Fig 1: Trilateration algorithm

$(x_1-x)^2 + (y_1-y)^2 + (z_1-z)^2 = d1^2$

$(x_2-x)^2 + (y_2-y)^2 + (z_2-z)^2 = d2^2$

$(x_3-x)^2 + (y_3-y)^2 + (z_3-z)^2 = d3^2$

These equations reduce to linear set of simultaneous equations which can be solved using the matrices. The system gives accurate solution (x,y,z) which is the required position of user in indoor environment.

2.2 Wi-Fi Trilateration based on RSSI approach

Received Signal Strength Indicator (RSSI) is the power for measuring the received radio signal. RSSI is usually invisible to a user of a receiving device. Trilateration or multi-lateration. In triangulation, position of target is determined using a combination of range and angle information. In multi-lateration, position of target is determined using time difference of arrivals of the transmitted signal, at three different receivers. This is called as hyperbolic positioning. These techniques cannot overlook certain shortcomings. In triangulation, angle information is needed apart from distances between APs. Measurement of angles subtended is difficult and either AOA or TOA information is required. In multi lateration, a minimum of 4 APs are needed for localization in 3D space. These will increase the hardware complexity. To overcome these difficulties, trilateration technique is adopted.

3. LITERATURE REVIEW

3.1 RSSI based Indoor Localization for Smartphone using Fixed and Mobile Wireless Node [2]

Md Osman Gani, Casey O'brien, Sheikh I Ahamed, Roger O Smith in 2013 has presented that there are several methods for estimating positioning and the three types of measurements mainly used a) Angle of Arrival (AOA) b) Time of Arrival (TOA) and Time Difference of Arrival (TDOA) and c) Received Signal Strength Indicators (RSSI). Each of these parameters has some advantages and disadvantages. In contrast with AOA, TOA/TDOA, measuring the RSSI value is very simple and also available in all of the existing wireless systems. That is why RSSI based methods are preferable and easy to implement.

Mathematical Model: The result from a separate experiment (RSSI value and orientation of smartphone and wireless node) was used to build the mathematical model. From the experimental result, the RSSI value was found which varies with the orientation of mobile device and Wi-Fi node. To normalize the orientation, effect the system collected RSSI value with the rotation of smartphone by 360 degrees 5 on the horizontal plane. Then the system used mean value of the collected RSSI to compute the distance.

3.2 Efficient Wi-Fi Fingerprint Training Using Semi supervised Learning [1]

Y. Yuan, L. Pei, C. Xu, Q. Liu, T. Gu in 2014 has presented the concepts and algorithms of the Wi-Fi fingerprinting technique for indoor positioning- based systems as it is the approach being used for the system developed in this work. Wi-Fi fingerprinting, a scene analysis technique, has been shown to be a reliable way to localize people indoors since it uses infrastructure already deployed indoors. A novel approach to improve accuracy of an indoor positioning system based on Wi-Fi fingerprinting was presented. The results of this work also show improvement for an indoor positioning system. The approach takes advantage of the AP option in most smartphones to create dynamic access points and fingerprints. The accelerometer embedded in most smartphones was used to predict the movement patterns of the users as static or dynamic using machine learning algorithms.

3.3 Dynamic Wi-Fi Fingerprinting Indoor Positioning System [3]

Omar Costilla-Reyes, Kamesh Namuduri in 2014 has presented, an indoor positioning system (IPS) is a solution to locate objects or people inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices. Instead of using satellites, IPS solutions rely on different technologies, including distance measurement to nearby anchor nodes (nodes with known positions, e.g., Wi-Fi access points). An Android app on an ordinary smart phone, it comprises a calibration stage and a navigation stage. In the calibration stage, the system creates a Wi-Fi fingerprint for each room of a building, where the received signal power of multiple signals are collected over time and space and stored as multivariate Gaussian distributions. During the navigation stage, the system determines its position by matching Wi-Fi signal strengths to the fingerprints with maximum-likelihood classification.

Fingerprinting involves two stages: 1) Offline stage: Creation of radio map(Database) by collecting Received signal strength integration readings from available surrounding Wi-Fi Access Points (APs) within the area of interest in particular known and selected positions (Reference points). 2) Online stage: Device position estimation by comparing the online RSSI readings of the device with the offline RPs observation, forming the database.

4. SURVEY OF WLAN IPS

There are many approaches of indoor positioning and localization techniques as GPS based, Cellular based, WLAN, Bluetooth, etc. We focus on the WLAN for indoor positioning. The overview of basic WLAN indoor positioning is described as follows:

4.1 Wi-Fi Based

This midrange wireless local area network (WLAN) [12] standard, operating in the 2.4-GHz Industrial, Scientific and Medical (ISM) band, has become very popular in public hotspots and enterprise locations during the last few years. With a typical gross bit rate of 11, 54, or 108 Mbps and a range of 50– 100 m, it is currently the dominant local wireless networking standard. It is, therefore, appealing to use an existing WLAN infrastructure for indoor location as well, by adding a location server. The accuracy of typical WLAN positioning systems using RSS is approximately 3 to 30 m, with an update rate in the range of few seconds.

4.2 HORUS

Horus system offered a joint clustering technique for location estimation, in this system each candidate location coordinate is regarded as a class or category. In order to minimize the distance error, location is chosen while its likelihood is the highest. The experiment results show that this technique can acquire an accuracy of more than 90% to within 2.1 m. Increasing the number of samples at each sampling location could improve its accuracy because increasing the number of samples would improve the estimation for means and standard deviations of Gaussian distribution.

4.3 RADAR

RADAR localization technique uses the nearest neighbor(s) in signal-space technique, which is the same as the KNN. The accuracy of RADAR system is about 2–3 m. RADAR was enhanced by a Viterbi-like algorithm. Its result is that the 50 percentile of the RADAR system is around 2.37–2.65 m and its 90 percentile is around 5.93–5.97 m.

4.4 CUPID

CUPID computes the distance of the client by combining the time-of-flight and energy of her direct path, called TFDP and EDP respectively. The average positioning error under high density (40 clients) and low overhead (1% airtime usage) is approximately 3:2m. The error will be lower if a higher overhead is acceptable (1:7m with 5% overhead) because CUPID2.0 can utilize the TFDP more frequently to deal with the errors in EDP-based location estimation.

5. RESULT

Table 1 briefly compares the current systems and solutions. The systems solutions shown in this table are mainly the ones whose specifications have been reported by their developers. Some of the results obtained of localization at different locations are shown in Table 1.

Table 1. Different Wireless Indoor Positioning Systems

System/ Solution	Positioning algorithm	Accuracy	Precision	Complexity	Scalability/Space dimension	Robustness	Cost
RADAR	KNN algorithm	3-5m	50% within 2.5m & 90% within 5.9m	Moderate	Good	Good	Low
Horus	Probabilistic method	2m	90% within 2.1m	Moderate	Good	Good	Low
RSS	Trilateration	2.5-3m	50% within 2.5m	Moderate	Good	Good	Low
Cupid	TFDP	3.2m	90% within 3.5m	Moderate	Good	Good	Medium
Robot Based	Bayesian Approach	1.5m	Over 50% within 1.5m	Moderate	Good	Good	Medium

6. CONCLUSION AND FUTURE SCOPE

The system surveyed achieves better positioning accuracy for mobile devices using the Wi-Fi signals which is easy to implement and requires lower cost than other localization systems and the method is used to implement is tri-lateration. The accuracy of positioning can be further improved by using more number of Aps i.e. access points in the system. We expect the indoor WPS for smart phones to be used at various places.

The performance can be improved and the system can further be improved in accuracy point of view. The number of Access Points can be reduced. The Indoor Wi-Fi Positioning system can be implemented as an application for smartphones for the localization can be developed.

7. REFERENCES

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