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Analysis of Selected Indoor Location APs in Wi-Fi Environments

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Abstract. Real-time indoor positioning systems based on Wi-Fi signal strength are studied. This study is about how to decide specific three target APs based on Wi-Fi RSSI signals from several APs(access point), and calculate the distance from a mobile object to the selected reference APs by ChipconCO formula. Calculated three distances are used to position the mobile object by using the triangulation method. To overcome the positioning errors, a topology which has five Aps in a square area is proposed and analyzed.

Keywords: Wi-Fi, RSSI, Indoor position, Triangulation

1 Introduction

The needs for indoor location tracking of mobile objects are increasing. So various studies for location tracking are ongoing. Major methods of indoor location tracking methods are Cell-ID, Triangulation, and Fingerprint [1]. In this study, the triangulation method for indoor location tracking based on Wi-Fi signal strength is used by selecting at least three APs based on RSSI values which show nearer distance to the mobile objects compare to other APs within all reference APs spread in the indoor area. Selected three APs could be used by the mobile object for deciding indoor position by using triangulation. For calculating the distance from the mobile object to each selected three APs using RSSI values, the ChipconCO formula [3] is used.

2 Previous and Related Studies

Three location tracking methods are proposed using Wi-Fi for calculating the current location of the mobile object. The Cell-ID method which determines whether the mobile terminals located in a designated area called cell [1]. Triangulation method which calculate location of the mobile terminals through the distance from three known reference points. By comparing the mobile terminals' signal pattern of tracked

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signal pattern database to determine the mobile terminal's location is called fingerprinting method [1].

2.1. A method for distance prediction by radio signal strength

Friis formula [2] and ChipconCO formula are used for calculating the distance between two objects (http://www.ti.com). Although prediction and calculation of the distance based on radio signal strength are very complex depend on environments. Calculation errors on distance decision are a major problem which has to be solved. In this study, the ChipconCO formula (1) is used for simplicity for distance calculation.

$$RSSI = -(10n\log_{10}d+A). \quad (\mathbf{1})$$

RSSI is signal strength, n is the propagation loss, d is the distance, A is signal strength from 1m distance in function (1). The distance between the receiver object and AP can be calculated using ChipconCO formula using the parameters.

Signal strengths affected by the surrounding environment may be varied by time changed. [11].

2.2 The characteristics of RSSI signal strength

When the distance from the AP to the mobile object measured at 1m to 3m, the calculated distance using RSSI signal strength is similar to the actual distance as showed at Table 1[5].

Table 1. RSSI values corresponding to the distance

Distances	RSSI values
1m	-16.5 dBm
2m	-19.2 dBm
3m	-24.0 dBm
4m	-28.8 dBm
5m	-31.5 dBm
6m	-31.9 dBm
7m	-31.7 dBm

Table 1 shows the signal strength from 1m to 7m with 1m interval. In 1m to 4m range, the difference of signal strength can be recognized. Signal strength from 4m to 5m shows insignificant changes. In case of more than 6m, it shows almost no change in the signal strength [8]. Therefore we decide the meaningful distance is within 5m for calculating distance from RSSI signal strength.

3.2 Sampling error

Difference of signal strength of sampled data farther than 5m is almost not recognized. There is no meaning in the distance further than the 5m between AP and mobile objects based on the experimental RSSI values. Therefore the distance of each AP and the mobile object must be set within 5m. A 6 x 6m square topology is considered as an experimented area for tracking. For triangulation at least three meaningful AP signals are needed. [6][7].

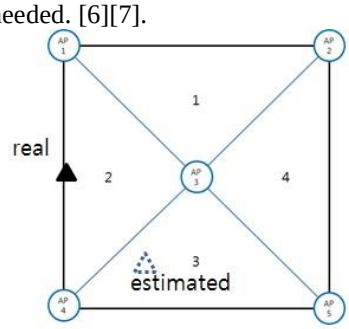

Figure 1. AP arrangement in 6 x 6m Square

The measured signals of the black triangle in Figure 1 are shown in Table 4. The chose three closer APs based on the signals are AP1, AP3, and AP4 [10].

Dotted triangle in Figure 1 shows that estimated position of the mobile object which is different with the real position. The quadrant of Figure 1 is provided for increasing position correctness. If the estimated quadrant area (area3) is revised to real area (area2), then the performance of positioning will increase [4] .

Table 4. Signal strength calculation for each AP

AP1	AP2	AP3	AP4	AP5
4.68m	6.62m	2.45m	1.61m	4.43m

Table 4 shows a result of calculation distances using the formula (1) using RSSI signals in Table 4. Errors of signals give wrong results. In Figure 1, closer APs from the mobile object which is shown as a black triangle is AP1, AP3, AP4, but the calculation result shows that the chosen closer APs are AP3, AP4, AP5. It may lead a mistake that the position of the mobile object is placed at the dotted line square.

4 Experiments for location decision

An experiment is carried out based on Figure 1 topology. The used 5 APs are the Iptime's dual band Wi-Fi AP Multi and as the receiver of the mobile object is Iptime's A2000UA. Signal reflectance by the floor is expected at the experiment. Therefore, it is measured from the height of 2m from the floor [13].

R5	3	(3,4,5)	(3,4,5)
R6	4	(2,3,4)	(2,3,4)
R7	3,4	(2,3,5)	(3,4,5)
R8	1,2	(1,3,4)	(1,3,4)
R9	2	(1,3,4)	(1,3,4)
R10	1,4	(2,3,5)	(2,3,4)

Case A and B in Table 7 shows measured quadrant and real quadrant.

Shaded cells in Table 7 are three APs which show wrong quadrants based on calculations by detected signal strengths. In these cases, the triangulation may lead to a large of location error. In the case of R4, the real position is in the quadrant 1 but the calculated position is in the quadrant 3.

Table 8. AP distance error for each position

(measure : m)

CASE A			
Location	Error distance	Location	Error distance
R1	1.22	R6	1.16
R2	1.81	R7	1.09
R3	0.84	R8	1.27
R4	0.79	R9	1.20
R5	0.76	R10	1.49
CASE B			
location	error distance	location	error distance
R1	1.28	R6	1.26
R2	1.56	R7	1.00
R3	0.88	R8	1.35
R4	0.87	R9	1.23
R5	0.80	R10	1.33

Table 8 shows the distance errors compared to positions. There is no apparent between two cases

5 Conclusions

Wi-Fi RSSI signal strengths are studied for indoor location tracking.

In order to increase the accuracy of the location estimation, triangle quadrants of the rectangle is introduced to predict precisely where the mobile object is located. In order to reduce the position error, to avoid selection of wrong quadrants, some additional methods are needed. Some of candidate additional techniques are considered to improve distance measurement.

Study about effects of sampling frequency in an arbitrary position is additionally studied. To increase correctness for deciding the correct quadrant, some epochal methods for deciding location of mobile object must be studied.

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