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Influence of number of access points for fingerprinting indoor positioning accuracy

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Abstract
The indoor positioning services based on fingerprinting mostly depend on the available access points in vicinity area. This paper explores the impact of number access points (APs) in indoor positioning accuracy based fingerprinting. The analysis is based on deterministic approach. The measurable analysis of test results demonstrates that, the positioning accuracy is highly affected by the number of access points. If the number of APs increased with well distribution positioning error is minimal. Hence, considering the adequate number of APs is guaranteeing an accuracy of an indoor positioning. The analysis could empower indoor positioning designer to enhance positioning performance and to model location fingerprinting based indoor positioning systems.

Keywords: APs; Fingerprinting; Indoor Positioning; Deterministic

1. Introduction

Location-based services (LBS) depend on the accessibility of sufficient number of APs to provide RSSI around the localization area. The Global Positioning System (GPS) can provide adequate positioning services in most cases; it suffers in indoor situations due to excessive multipath and wall attenuation [1]. As an option or corresponding answer for indoor situations, [2] suggested a localization approach based on the received signal strength indication (RSSI) in wireless local area networks (WLAN). Nowadays, the WLAN localization has ends up being additionally appealing for indoor situating as the effects of the growing availability of open and private APs [1].

Localization system that fit for the indoor positioning should be realistic to a changed number APs with comparative localization accuracy. The fundamental issue that impacts the accuracy of the RSSI based positioning is the number of APs utilized to set up the fingerprint database [1]. The positioning accuracy of mobile devices such as smart phone and iPod or laptop depends much on the APs used during the offline and the online phase. If the number of APs used in offline and online adjusted, the position accuracy contrasts too, this implies that the positioning system is affected by number of APs. At present, there are contradictory about the effect of APs which can be used for RSSI fingerprint database [4]. Subsequently, there are many algorithms with enormous various considerations and there will be more algorithms established consistently. Thus, it is important to understand how number of APs affects the indoor positioning accuracy.

The knowledge of accuracy based on number of AP is important for location determination algorithms such as the deterministic [5]. The variation number of APs is currently used to determine the location. However, the substantial scale measurements in [1] revealed that, the adjustment of APs may change localization system accuracy. On the other side, most existing data were collected and analyzed by considering same number of AP between online and offline stage. Contrasted and diverse number of APs in both stage, different number of APs used in offline and online phase can be used and accuracy may vary as the number of APs increased or decreased, thus the positioning using diverse number of APs would influence the indoor positioning application. The analysis results are clearly supported in section 3. This has motivated the current study in impact APs for WLAN based indoor positioning accuracy and the same number of APs used in both phase.

The paper consists four sections. Following after this brief presentation, Section 2 presents the measurement setup and positioning algorithm. Section 3 investigates the impact of different number of APs on indoor positioning accuracy. Section 4 concluded the paper.

2. Experimental setup and positioning algorithm

2.1 Experimental setup

The examination was conveyed basing on precise measurements of the WLAN RSSI using Android smart phones and Wi-Fi detection software. One Android smart phones namely; HUAWEI Y330-U11 equipped with one RSSI collecting application software was utilized to gather samples of RSSI data from APs at the Postgraduate research room in the College of Information and Communication Technologies, University of Dar es Salaam. The dimension of the room is nearly 8 m × 5 m. Three and four wireless APs located at height of 2.0m above the floor was deployed as shown in Fig. 1 and Fig 2. The three and four APs have the same merchant and models. As shown in Fig. 1 and Fig 2, a small area is defined as a grid of 6 points (the solid red dots in Fig. 1 and Fig 2). The minimum distance between two successive reference points known as grid spacing was estimated at a distance of 0.5 to 1 meter. Firstly, the estimation was made when three APs deployed in the study area and data gathered at different points. Six estimation places as appeared in Fig. 1 and Fig 2 meant as 1, 2, 3, 4, 5, and 6 were gathered the RSSI data. The 1, 2, 3 up to 6 represent point 1, point 2 up to point 6.

Fig 1: Location of three APs and the measurement points on the Postgraduate research room

Fig 2: Location of four APs and the measurement points on the Postgraduate research room

2.2 Positioning algorithm

In the deterministic algorithms, the position x is thought to be a non- irregular vector. Primary assignment is to compute the approximately value x, which is a permutation of offline and online value, where all weights value are nonnegative [6]. The deterministic algorithm, which keeps the K biggest weights and sets the others to zero is known as WKNN (Weighted K-Nearest Neighbour Method) [7]. WKNN with all weights i = 1 is known as KNN (K-Nearest Neighbour) approach [1]. The simplest method, where K = 1, is called the NN (Nearest Neighbour) technique [Li]. KNN and the WKNN can perform better than the NN method, especially with parameter values K = 3 and K = 4 [8].

Another deterministic technique is depends on neural network [1]. Neural networks are given to be viably developing the non-linear input-output mapping. Favorable of this technique is high robustness and multifaceted nature, yet it doesn't accomplish accuracy of different strategies [9].

Localization approach utilized as part of experiment depends on NN technique. It is mobile supported solution, which implies that versatile station gives measured information to the server, which processes its position. Equation 1 is the Euclidean distance mathematical formulae utilized for this study. The location of the mobile user is estimated by averaging the coordinates of the minimum Euclidean distance as it can be shown in equation 1.

$$EuDis = \sqrt{\sum_{i=1}^{n}(RSS_i - RSS_{i'})^2} \quad (1)$$

n= Number of APs

RSS_i = is the ith APs signal strength in dBm received in the online phase

$\overline{RSSi}$ = is the average RSS in dBm value in the training database

$EuDis$ = Euclidean distance

3. Related work

Existing works of [10, 11] on their experiment used different number of APs to investigate the impact of number of APs in indoor positioning depends on fingerprinting. Though their investigation has shown that, the different number of APs has significance impact in localization, [10, 11] failed to explain if used the same or different number of APs between offline and online phase. [10, 11] also used the deterministic based on NN with parameters (μ) where μ is the mean of RSSI samples to determine the accuracy. However, [10, 11] the facts of the evaluation criterion were not reported. On the contrary, the test results in [12] demonstrated that the number AP has an impact in localization but analysis result is not shown.

The aim of experiment is to explore an effect of the number of APs utilized in localization process. It is necessary to note that the number of APs utilized in offline and online phase were the same in both test. This influence is observed histogramically and statically. In the initial experiment, radio map was created with use of 3 APs offline phase. The same numbers of APs were utilized in online phase. In the second experiment, radio map was created with use of 4 APs offline phase. The same numbers of APs were utilized in online phase. Results of this experiment are shown in Figure 1 and Table 1.

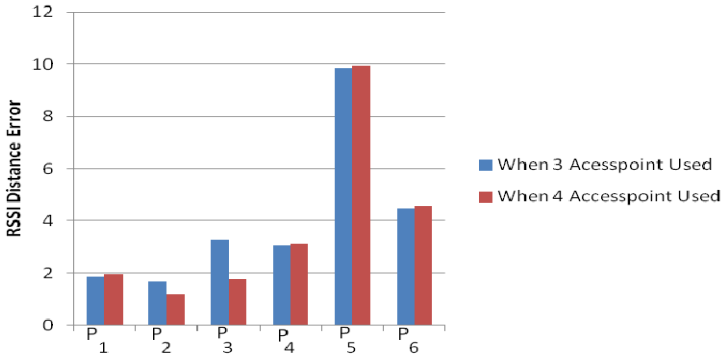

Fig 3: Mean RSSI distance accuracy error of three and four APs calculated based on deterministic algorithm at 6 places observed using histogram

From Figure 3 it can be seen that, the lower number of APs used in offline and online phase, the higher localization error. It is clear that localization error is decreased when the number of APs increased since APs increases the desired distribution. In

the experiment, the investigation has shown that, some of the reference points not much affected with the change number of APs because the additional of AP was not be able to affect the distribution in some of the reference point. Achieved results are shown in Tab. 1.

Table 1: Impact of the number of AP used in experiment

	Number of Access Point	
RP	3	4
1	1.854724	1.949359
2	1.702939	1.174734
3	3.269557	1.746425
4	3.072458	3.130495
5	9.852918	9.951884
6	4.463183	4.573839

As indicated by accomplished results, it can be seen that positioning error does not only depend on the number of AP used for radio map creation. Localization error depends also, on the distribution of AP used for localization. If the additional of AP does not affect the reference point distribution, the AP should be placed in such a way that it increases the distribution of the reference point as well as the entire radio map.

4. Conclusion

This paper examines the effect of number of APs in fingerprinting based localization. It is apparent that positioning error is significantly depends on number of AP utilized in online and offline phase of fingerprint positioning algorithm based on NN. The number of utilized APs was the same in both phases and shown minimal error when APs increased. Therefore the numbers of APs utilized in offline and online phase have serious impact on positioning accuracy.

To future, it is important find the algorithm for accuracy improvement. Such algorithm will help to minimize positioning error, particularly when number of AP in offline and online stage is not the same. Other objective is to propose dissemination of radio guide points, which can help to minimize localization error.

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