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Improvement of Position Estimation Accuracy Using Multiple Access Points in Terminal Position Estimation based on Position Fingerprint

Mayu Ohtani, Hisato Iwai, Hideichi Sasaoka
Graduate School of Science and Engineering, Doshisha University
1-3 Tatara Miyakodani, Kyotanabe, Kyoto, 610-0321 Japan
E-mail: {dun0348@mail4, iwai@mail, hsasaoka@mail}.doshisha.ac.jp

***Abstract* –In this paper, we consider a position estimation method based on position fingerprint of radio propagation characteristics. We propose a new method where multiple Access Points (APs) are used to improve the estimation performance. We experimentally evaluate the accuracy of the proposed method.**

***Index Terms* — Position estimation, Position fingerprint, Multiple access points, Indoor environment.**

I. Introduction

Recently, much attention has been paid to ubiquitous networks as wireless communications have widely spread. Services using the position information are expected to be among the major ones in the ubiquitous networks. For the subject, position estimation methods using wireless communications have been proposed. Most of them are based on Received Signal Strength Indicator (RSSI) and Angle Of Arrival (AOA) [1]. In this paper, we adopt a position estimation technique based on position fingerprint of radio propagation characteristic [2, 3]. We previously presented the measurement result of the position estimation based on the method and we showed position estimation is fundamentally possible [4]. However the estimation accuracy was not sufficient considering practical use. Therefore in this paper we consider the improvement of the estimation accuracy of the method. We propose a new method using multiple Access Points (APs). The position fingerprint is obtained from the received signals of multiple APs located at different positions and we estimate the position of a wireless terminal utilizing the multiple fingerprint data. We experimentally evaluate the accuracy of the position estimation by the proposed method.

II. Position Estimation Method based on Position Fingerprint Technique

The position fingerprint technique is a method to estimate the position of a wireless terminal by pattern matching between the pre-measured information at known positions and newly-measured information at the position to be estimated. Hereinafter the premeasured data is called as position fingerprint. Generally speaking, the radio information such as RSSI and AOA is used for the pattern matching. In this paper, we use artificially generated RSSI variation produced by changing antenna pattern of array antennas used in transmitter and receiver. We call a sequence of RSSI signal levels as an RSSI profile.

III. Experimental Setup

Figure 1 shows the experimental environment. It is a laboratory room of 6.2m×8.6m×3.0m. As shown in the figure, the room is surrounded by concrete walls, a metal door and glass windows. Desks and furniture are placed in the room. During the measurement, no one including an operator is in the room. In the figure, AP positions are shown. User Terminal (UT) is moved with 0.01m interval in the measurement area of 1.0 m×1.0 m. The distance between each AP and the center of the UT area is 4.03m, 4.72m, 1.12m, and 2.69m, respectively. The length of the measured RSSI profiles is 128.

IV. Terminal Position Estimation Method and Metrics of Estimation Accuracy

In the pattern matching between fingerprint and measured RSSI profiles, similarity of them is quantitatively evaluated. In our method, we use cross correlation coefficient. The correlations between all fingerprint RSSI profiles and the measured profile are evaluated and the position of the fingerprint profile giving the maximum correlation is selected as the estimated position. In this paper, we call the maximum correlation value as Maximum Correlation Coefficient (MCC). When multiple APs are used in the estimation, the position of the fingerprint profile which has the highest MCC among multiple APs is selected as the estimated position.

The distance between the correct and estimated positions is defined as estimation error. The average value of the error over the multiple position estimation attempts is calculated and expressed as the average estimation error.

V. Improvement of Position Estimation Accuracy using Multiple APs

Figure 2 shows the distribution of MCC. The measurement interval of the position fingerprint is changed from 0.02m to

0.2m and the number of APs is varied. It can be seen from the figure that MCC increases as the interval decreases. When multiple APs more than 3 are used for the 0.02m interval case, we can see MCC is more than 0.9 for 100%. We expect the higher MCC brings the higher estimation accuracy. However, the smaller interval results in the larger number of position fingerprint. Also by using multiple APs, MCC increases. From the result, we can expect the improvement of the estimation accuracy by using multiple APs.

Figure 3 shows the average error when the measurement interval of position fingerprint is varied. The minimum average estimation error in the figure shows the average error when the closest fingerprint position is ideally selected as the estimated position, which is the lowest boundary of the error in this configuration. From the figure, when single AP is used, in order to realize the average estimation error less than 0.2m for instance, 0.08m or less is required as the interval of the position fingerprint measurement. In the case, the number of the pre-measurement becomes huge and it is difficult to realize. When 4 APs are used, the average estimation error decreases. To realize the error less than 0.2m, the required interval of the fingerprint is around 0.13m. But the large difference compared with the minimum average estimation error still exists. As above mentioned, utilization of multiple APs contributes to increase MCC, but, from the result, we assume the high MCC does not always provide high accuracy in the multiple AP case.

VI. Summary

In this paper, we experimentally evaluated the improvement of the position estimation accuracy of the terminal position estimation using multiple APs. As the number of the utilized APs increases, the correlation coefficient becomes higher, and the average estimation error decreases. However we cannot achieve sufficiently small error by the method. It is necessary to develop a new method to utilize the information of multiple APs more effectively to realize the higher estimation accuracy.

References

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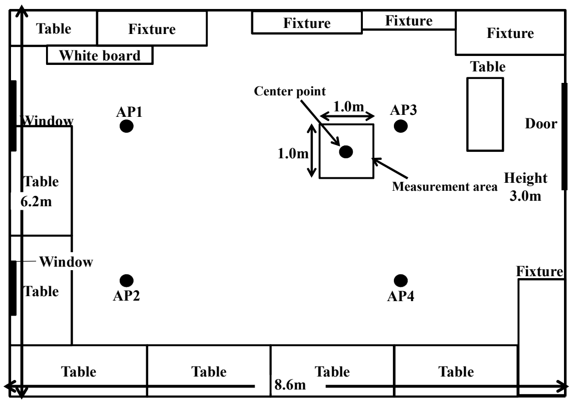
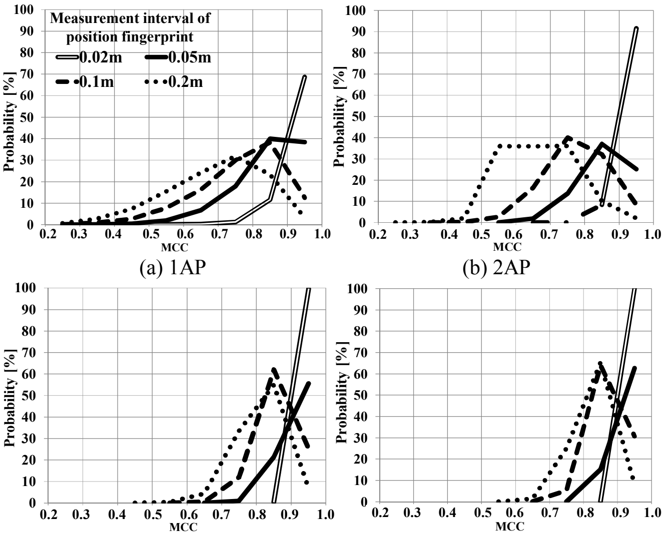


Fig. 1 Experimental environment.



(a) 1AP (b) 2AP

(c) 3AP (d) 4AP

Fig. 2 Distribution of MCC.

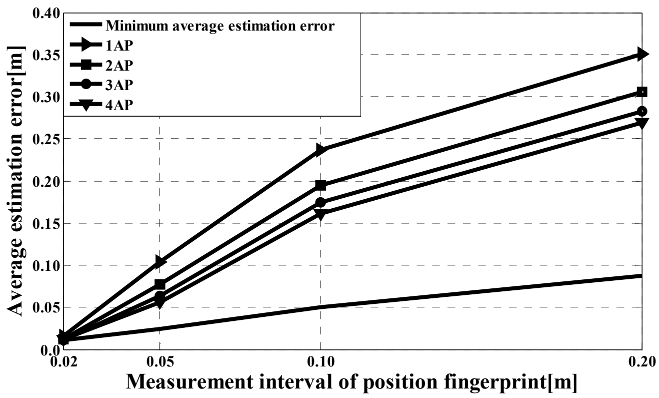


Fig. 3 Average estimation error.