Accurate Indoor localization with Channel State Information

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ABSTRACT

Device-free localization(DFL) is an emerging technology to detect whether there exists any target(s) in the area of interests without carrying any device to them. It is an essential primitive for a large-scale range of application including intrusion localization of warehouse, elder care at home, and action about hostage rescue, etc. Most DFL relying on received signal strength (RSS) have proposed to be able to provide acceptable accuracy and distance error. Although RSS can be easily measured with commercial equipments, it is suspectable to measurement itself due to multipath effect in indoor environment. In this paper, we present the Ailot approach to overcome the preceding RSS-based limitation. Ailot explores properties of Channel State Information(CSI) from PHY layer and uses the novel feature extracted from CSI to leverages frequency and spatial diversity. The target localization of Ailot approach is conducted with maximum likelihood method. We implement Ailot approach and evaluate its performance in a real-world indoor environment. Experimental results show that Ailot can achieve high localization accuracy and distance error. Moreover, comparing to RSS-based scheme, our CSI-based approach enables better localization performance in accuracy and distance error.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Location

Keywords

device-free localization, CSI, RSS,maximum likelihood method

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1. INTRODUCTION

The location technology has become an important assistant technique to many currently location service systems. Recently, GPS technology has taken the domain on the outdoor location service. However, it is difficult to repeat its success indoor location. Navigation and location applications degrade severely in indoor environment, because modern architectures will cause gravely change of satelliteąŕ signal, such as refraction, scatter, reflection, diffraction, and so on.

To overcome previous active approaches faults, the DFL has proposed as an emerging indoor location technology and became hot research [3] [1].This paper introduces Ailot, a fine-grained CSI localization approach that works in the presence of rich multipath. In line with common practice in locating or detection with CSI [4], Ailot divides area of interest (AoI) into a number of cell , and generate CSI-based fingerprinting, which leverages CSIs to locate or detect target(s). However, the usage of MIMO for each transmitter-receiver antenna stream or aggregation over all streams is challenging.

2. PRELIMINARY AND METHODOLOGY

To consider the frequency diversity, we quantify the power of a package, denoted as total CSIs. Specifically,

$$H_e = \sum_{i=1}^{I} |H_i|^2, \quad i \in [1, 30] \tag{1}$$

Localization :Previous work in [2] show that the probability model can availably address the localization issue in indoor environments. Therefore, we also adopt maximum likelihood method, According to Bayes'law,

$$P(l_i|H_e) = \frac{P(l_i)P(\mathbb{H}_e|l_i)}{\sum_i P(l_i)P(\mathbb{H}_e|l_i)}) = \frac{P(l_i)P(\mathbb{H}_e|l_i)}{P(\mathbb{H}_e)} \tag{2}$$

Finally, we calculate the Eqn.2, and estimate the unknown location from the posterior using Eqn.3.

$$\hat{l} = max \sum_{i=1}^{L} P(l_i|H_{test}) \tag{3}$$

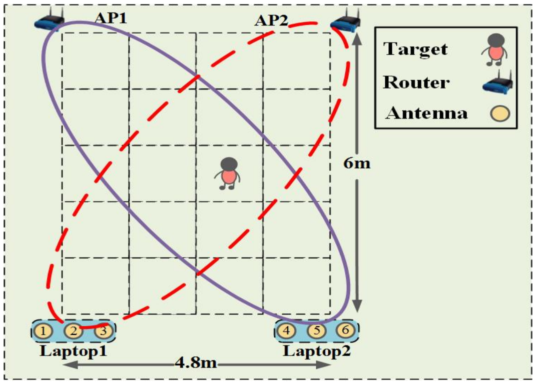

Figure 1: **Experimental set.**There are two pairs transceiver-receiver,and this area having 20 testing locations is a rectangle with 6m times 4.8m,which area of each cell is $1.44m^2$.

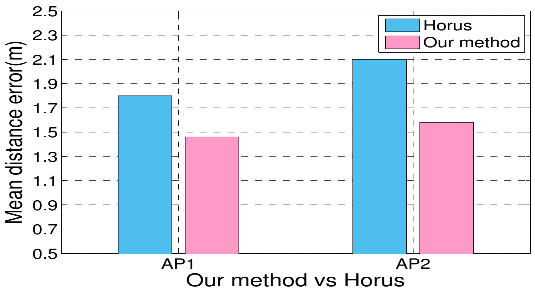

Figure 2: **Mean distance error with different APs.**

3. EXPERIMENT AND EVALUATION

3.1 Experimental

Experimental : We set up one typical indoor testbed of the lobby in Information Science and Technology of Northwest University. We deployed Ailot a testbed in a rectangle lobby, which spreads over approximately $28.8m^2$. In this experiment, we symmetrically place two pairs of APs and DPs such as Fig.1.

Data Collection and process : In our experiment, we use two TP-LINK TL-WR842N routers as wireless AP that transmit information over a radio-frequency link to two DPs.Both DPs are immobile computer equipped with commercial 802.11n 5300 NICs having three receving antennas. Ailot deployment composes of 2 pairs of APs and DPs.Each pairs AP$-$DP has two transmitting antennas and three receiving antennas. In current implementation, we utilize the over antennas to improve the accuracy of localization. Raw CSIs collected need to be smoothed with sliding-window in order to degrade the localization error.

3.2 Accuracy of Localization and Distance Error

We firstly compare mean distance error using our experiment devices for Horus and our method in terms of AP1 and AP2 respectively as shown Fig.2. As a whole, the mean distance error using AP1 exceeds the AP2's result, Whatever method including our method and Hours is used. Especially,Fig.2 shows that the maximum performance gain of our method over Horus is 18.9% and 24.8% for AP1 and AP2.

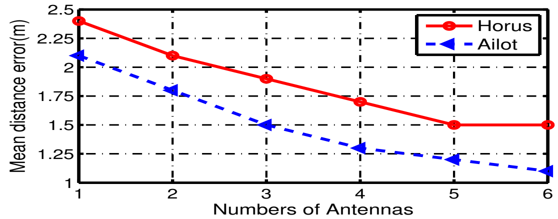

Figure 3: **Mean distance error with different numbers of antennas**

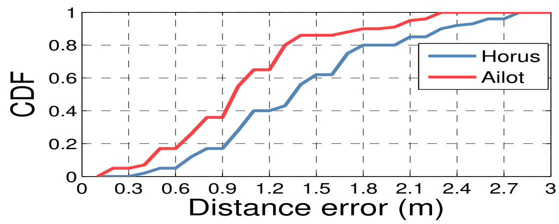

Figure 4: **CDF of localization error in lobby**

Fig.2 also hints our method performance over Horus in the lobby experiment.

We evaluate the effect of increasing numbers of antennas (from 1 to 6) on the performance of the approach proposed in Ailot and the RSS-based approach proposed in Horus. The mean distance error in lobby is shown in Fig.3. Ailot achieves mean distance (14%) lower than Horus approach. As changing the antennas from 2 to 6, mean distance of Ailot is improved between 16% and 26% than Horus approach, and best mean distance is 1.1 meters for 6 antennas.

Fig.4 illustrates the cumulative distribution function(CDF) of localization errors in the lobby. The data were collected over the 20 positions in the lobby. From Fig.4, we can observe that localization error of Ailot falls within 1.5 meters and the 50 percent accuracy is less than 1 meter. The Horus however can locate target within 2.3 meters of their actual position with 90 percent probability and 50 percent accuracy is less 1.35 meters.

4. ACKNOWLEDGMENTS

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