An Indoor Location-Aware System Based on Rotation Sampling in Positioning

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Abstract. With the rapid development in hardware and software of wireless communications, applications of real-time positioning systems have been widely used; among them the Global Positioning System is the most popular [1]. However, the satellite signal is obstructed by the sheltering effect of the building and becomes too weak to be applicable for indoor positioning. Instead, the wireless sensor networks techniques are suitable for indoor positioning, for which many related researches and applications have been proposed. Based on the ZigBee wireless technology operating on the IEEE 802.15.4 physical radio specification, we use the Received Signal Strength Indicator together with the Signal Patent Matching method for positioning. Furthermore, to enhance accuracy of positioning, we adopt a sampling method to compare on-line samples as well as the rotation sampling positioning method.

Keywords: Wireless sensor networks, Indoor positioning, Rotation sampling, Received Signal Strength Indicator, Signal Patent Matching.

1 Introduction

In recent years, due to rapid development of wireless communication techniques and increasing popularity of mobile devices, measurement systems tend to be wireless, miniaturized, modular, web-based, economy-oriented, and power-saving; and so the real-time locating services technique based on wireless networks becomes one of the most active research topics. On the other hand, because the wireless network has advantages such as power-saving, large network nodes, and low cost, the wireless sensing techniques have been widely used in the home life, environmental monitoring, commercial, and military applications. This paper studies indoor positioning. With the aim to enhance accuracy of positioning, the Received Signal Strength Indicator (RSSI) as well as the Signal Patent Matching method is used to calculate the possible position of targets.

The rest of this paper is organized as follows. Section 2 briefly describes related works of indoor positioning techniques. Section 3 introduces the experimental environment, provides experimental results, and performs analysis. Finally, Section 4 concludes the paper.

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2 Related Works

In recent years, extensive research has been conducted on the Wireless Sensor Network (WSN), in which positioning of sensors is a very important issue. Currently, positioning algorithms used in WSN can be divided into two categories: Range-base and Range-free. The former required some information to measure the distance, such as the distance, angle and time difference of the location node and location tag. It is more accurate but need to pay additional cost of equipments. The related methods include Time of Arrival (TOA) [2][3], Time Difference of Arrival (TDOA) [4][5][6], Angle of Arrival (AOA) [7][8][9], and Received Signal Strength (RSS) [10][11]. The latter can locate the position without information of the distance, and the angle of location node and location tag. Its accuracy is less than that of Range-base, but it does not need to pay extra costs for equipments to obtain the distance and angle data. Thus, it is more suitable for low-cost and low-power WSN applications. Its related methods include DV-Hop Localization Algorithm [12], and Signal Patent Matching [13].

TOA, AOA, and TDOA positioning methods require more complex calculations and additional hardware to perform the time synchronization mechanism; whereas the RSS positioning method has advantages of low-cost, simple operation, and without the need to modify hardware. So we adopt RSSI for indoor positioning.

3 Experimental Methods and Results

In the experiment, a laboratory with a rectangular space of 10 x 4.5 square meters is used, in which a space of 6 x 3 square meters is planned into 11 x 6 = 66 reference points with an adjacent distance of 60 cm, as shown in Fig. 1.

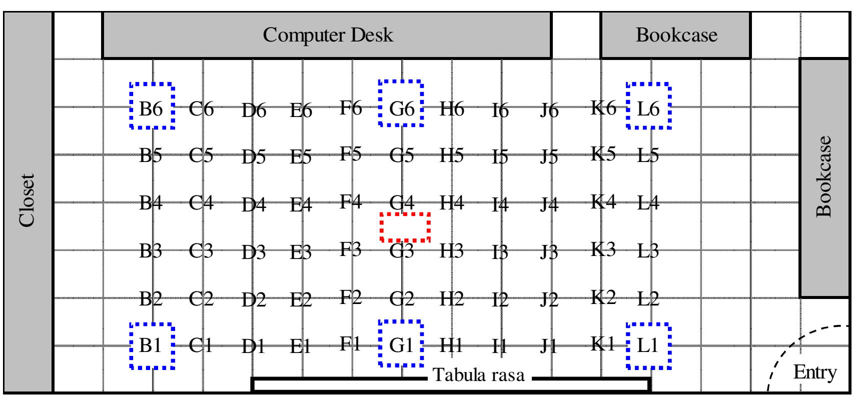

Fig. 1. Experimental environment

As listed in Table 1, four sets of experiments are performed using different location tag sampling methods with different rotation angle, in which the control group uses the fixed location tag sampling method. For Case 4, the object interference comes from a person or moving object.

Table 1. Experimental sets

	Case 1	Case 2	Case 3	Case 4
Sampling Methods	Fixed without rotation	180°	360°	360° with object interference

Figure 2 shows the experimental results. In view of accuracy of positioning, Case 3 is the best with an average location error about 65 cm, while Case 1 and Case 2 have close average location errors of 84 cm and 88 cm, respectively. Case 4 is the worst case with an average location error of 94 cm due to interference of moving objects.

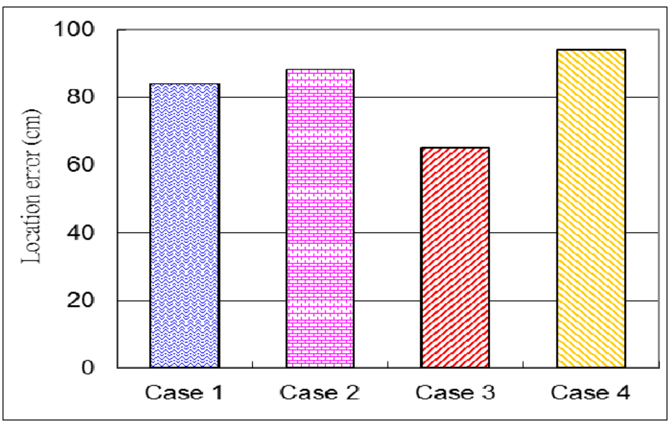

Fig. 2. Average location errors with different positioning sampling methods

Figure 3 shows distribution of location errors for the best three sampling methods in positioning. For Case 3, about 52% localization errors are under 60 cm, 41% localization errors between 61 cm and 120 cm; and especially, no location errors greater than 180 cm are measured, whereas in Case 1 and Case 2, about 9% location errors exceeding 180 cm.

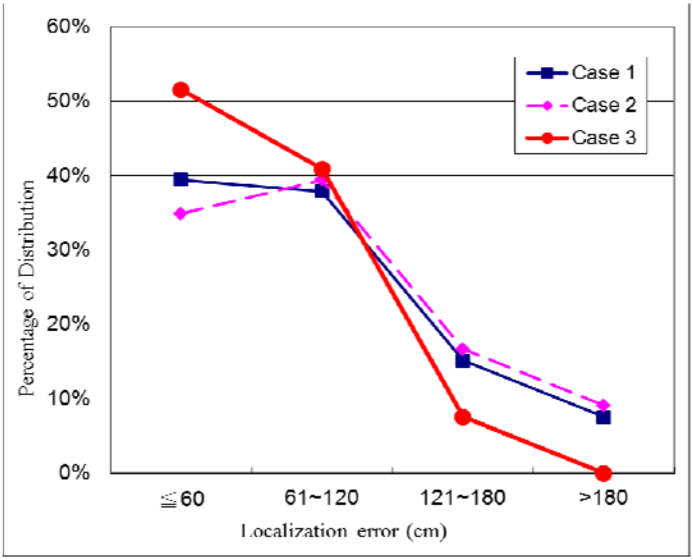

Fig. 3. Distribution of location errors with different sampling methods

4 Conclusion

The experiment results show that Case 3 measurement setting with a rotation angle of 360° performs best, in which about 22% enhancement of average location accuracy is achieved compared to Case 1 with the fixed and non-rotating sampling method; and particularly, more than half, that is, 52%, of localization errors can be controlled under 60 cm, so we infer that the Case 3 setting is best for indoor positioning in a small space. Moreover, based on average location errors for Case 3 and Case 4 settings, we observe that in wireless environments if the location tag is suffered from interference of moving objects, the average accuracy of positioning can be reduced by as much as 44% and the location error is much aggravated.

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