무선센서네트워크에서 RSSI를 이용한 협업 거리측정법과 삼각측량법의 효율성평가

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Performance Evaluation between Collaborative Ranging and Trilateration Positioning using RSSI in Wireless Sensor Network

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Abstract

Generally, distance between sensor nodes is measured using received signal strength indicator (RSSI) in wireless sensor network (WSN). Since RSSI is not absolutely accurate and stable in indoor environment, the performance of position estimation largely depends on estimation methods. In this paper, performance evaluation is presented to compare trilateration based positioning technique and collaborative ranging (CR) technique. From evaluation results, CR method is shown to be better than trilateration based method in terms of accuracy and precision.

I. Introduction

Based on the way of estimation, lateration based positioning techniques can be either trilateration or multilateration [1]. If initial position is unknown, trilateration is used instead of multilateration to find the first position. Because of using received signal strength indicator (RSSI) for indoor distance estimation, the estimated position is affected by fluctuation and error of RSSI. Thus, different estimation techniques provide different level of performance. This paper compares trilateration based estimation and the newly developed collaborative ranging (CR) estimation [2] based on accuracy and precision.

II. Position Estimation Methods

For locating indoor targets, ac hoc wireless sensor network (WSN) is not necessary. Instead, the allocation of reference nodes can be planned according to the shape of indoor space which is normally square or rectangular. Thus, the estimation of x and y positions can be separated with horizontally alined and vertically alined sensor nodes respectively. To simplify the problem, this paper only considers horizontal positioning for x.

2.1 Trilateration

For this approach, RSSI is first converted to distance using path loss model [3]:

$$P_d = P_{d0} - 10n\log\left(\frac{d}{d_0}\right) \qquad (1)$$

where P_d is the received power at distance d to the transmitter. P_{d0} is the received power at reference distance d_0. n is the attenuation exponent. With distances d_1 and d_2 (from target to the horizontally alined reference nodes), position x can be estimated:

$$x = \frac{u^2 + \left(d_1{}^2 - d_2{}^2\right)}{2u} \qquad (2)$$

where u is the distance between reference nodes.

2.2 Collaborative Ranging

Without converting RSSI to distance, horizontal position x can be estimated directly using RSSI:

$$x = \frac{u}{2}\left(\frac{P_{d2} - P_{d1}}{a \times (\mu \times y/u)^{\gamma}} + 1\right) \qquad (3)$$

where P_{d1} and P_{d2} are the received power from reference nodes. a is environmental parameter. y is the vertical displacement between reference nodes and target. μ and γ are defined in Table 1.

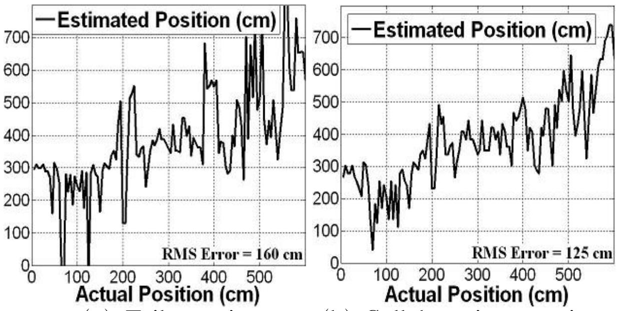
Table 1: Selection of μ and γ

Condition	μ	γ
$(y/u) < 0.5$	2.9	0.75
$0.5 \leq (y/u) < 1$	2.9	0.98
$(y/u) \geq 1$	2.0	1.70

Ⅲ. Performance Evaluation

In this evaluation, RSSI values are measured when target move from one end to another 600 cm apart. Positions are estimated using trilateration and collaborative ranging as shown in Fig. 1(a) and (b).

It is clear that the stability in Fig. 1(b) is much better than Fig. 1(a). This shows that CR is more reliable than trilateration approach. On the other hand, the root-mean-square (RMS) error in Fig. 1(b) is smaller than Fig. 1(a). This verifies that CR is more accurate than trilateration approach. Fig. 2 shows the estimation result after curve smoothing. This result shows that CR is able to contrast distance between the two ends, thus providing clear distance variation as target moves.



(a) Trilateration (b) Collaborative ranging

Fig. 1. Position Estimation (without smoothing)

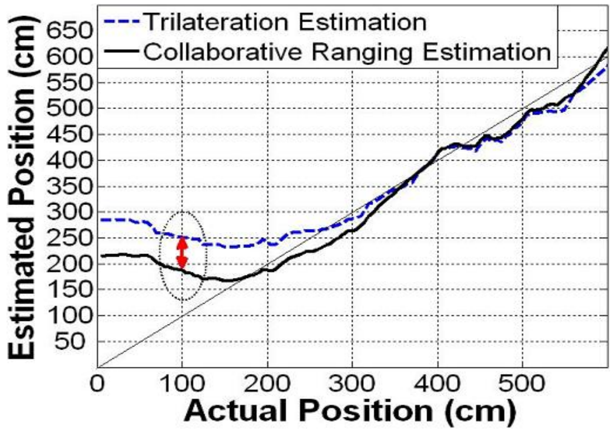


Fig. 2. Position Estimation after smoothing

Ⅳ. Conclusions

In this paper, both trilateration and CR approach are evaluated. The results show that CR is better than trilateration approach in term of reliability and accuracy.

References

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