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Research on RFID Indoor Localization Algorithm

Yunhua Gu[1,2], Junyong Zhang[1,2], Jin Wang[1,2], Bao Gao[1,2], Jie Du[1,2]

1)Jiangsu Engineering Center of Network Monitoring, Nanjing University of Information Science & Technology, Nanjing, China, 210044;
2)School of Computer & Software, Nanjing University of Information Science & Technology, Nanjing, China, 210044.

Abstract. With the rapid development of wireless communication and embedded system, wireless positioning systems are paid more and more attention to. Radio Frequency Identification (RFID) localization system is getting more important, due to its own advantages, such as no contact, non-line-of-sight nature, promising transmission range and cost-effectiveness. To improve the accuracy of active RFID indoor location system, some traditional RFID indoor localization systems were studied, such as LANDMARC. On this basis, an adaptive self-correction location algorithm was presented, which uses a positioning correction value to correct the positioning result. Experimental results show that compared with adaptive *K*-nearest neighbor algorithm and error self-correction algorithm, the proposed method provides a higher accuracy and stability.

Keywords: RFID; indoor localization; adaptive *K*-nearest neighbor algorithm; LANDMARC.

1 Introduction

Indoor positioning technology has a wide range of applications at present, it can be used for positioning the object and personnel. Indoor localization systems can effectively improve the management level work efficiency. There are some effective methods[1], including RFID(Radio Frequency Identification), Wi-Fi positioning. RFID technology using RF non-contact form of two-way communication, automatic identification tag, access to relevant data, has the advantages of high precision, non line of sight, strong anti-interference, high security, can identify the high-speed movement of label and also identify multiple tags, is becoming the preferred technique for indoor positioning system.

At present, there have been some typical indoor localization algorithms based on RFID , such as RADAR [2], SpotON [3], LANDMARC [4] . These algorithms have laid a good foundation to study the indoor positioning technology. RADAR using fingerprint method to record the training data in the location space, will be divided into off-line training and real-time matching two stages, when the environment of off-line training phase and the environment of real-time matching phase are not the same, the positioning effect becomes worse. SpotON uses iterative method to approach the true value gradually, finally get a minimum error result. The positioning accuracy is

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influenced by starting point and step size, and has large computation. LANDMARC is based on the Received Signal Strength Indicator (RSSI), using the method of active reference tags aided positioning, not only reduce the number of reader and costs at the same time, but also further enhance the positioning accuracy.

2 LANDMARC and Error Self-correction

Suppose we have n RF readers along with m tags as reference tags and u tracking tags as objects being tracked. System layout is shown in Figure 1.

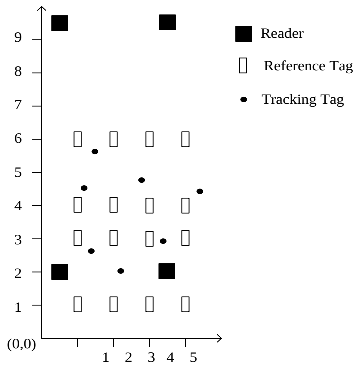

Fig. 1. LANDMARC System

The signal strength vector for a tracking tag is defined as $\vec{S} = (S_1, S_2, \cdots, S_n)$. S_i denotes the signal strength of the tracking tag perceived on reader i, $i \in (1,n)$. The signal strength vector for the reference tag is defined as $\vec{\theta} = (\theta_1, \theta_2, \cdots, \theta_n)$. Where θ_i denotes the signal strength of the reference tag perceived on reader i, $i \in (1,n)$. The Euclidian distance in signal strength between a tracking tag and a reference tag r_j can be defined as (1).

$$E_j = \sqrt{\sum_{i=1}^{n} (\theta_i - S_i)^2}, \ j \in (1, m) \tag{1}$$

When there are m reference tags, E vector of a tracking tag is $\vec{E} = (E_1, E_2, \cdots, E_m)$. K smallest values from the E vector are selected out and the unknown tracking tag will be located in a cell surrounded by these k reference tags. The unknown tracking tag coordinate is obtained by (2).

$$(x, y) = \sum_{i=1}^{k} w_i (x_i, y_i) \tag{2}$$

Where w_i is the weighting factor of k selected nearest neighbors, it defined as (3).

$$wi = \frac{\frac{1}{E_i^2}}{\sum_{j=1}^{k} \frac{1}{E_j^2}} \quad (3)$$

3 Adaptive Self-correction

Through the analysis and Research on error self-correction algorithm, it has the following problems: (1) Select the same *k* neighboring reference tags, will get the same positioning results. Set *k*=4 in Figure 2. Obviously, two adjacent tracking tags are locate in the different positions, select the same reference tags connected by dotted lines to calculate their positions. The algorithm calculates the tracking tag position by using the mean position. Using the mean position of three reference tags as the estimated position of the remaining reference tag, it would lead to a fixed positioning correction value. Using the mean position of four reference tags plus the positioning correction value, it will lead to the same final positioning result. Therefore, as long as the same k neighboring reference tags are selected, we will have the same positioning results. (2) The positioning correction value is not accurate. When the tracking tag locates in the middle area (Figure 3), the distances of the tracking tag to four neighboring reference tags are similar. The errors of four neighboring reference tags are involved in calculating the positioning correction value.

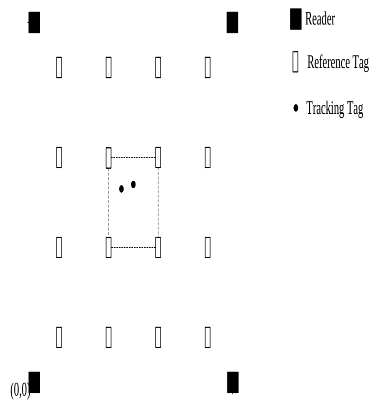

Fig. 2. Error Self-correction

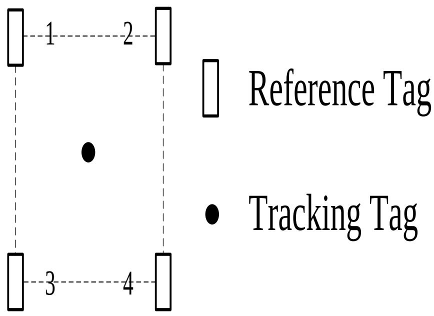

Fig. 3. Middle Area

The value is credible, which could improve the positioning accuracy. But when the tracking tag locates in the border area (Figure 4), the tracking tag is too far away from the 4th reference tag, the environmental impacts are different. Let the 4th reference tag involve in calculation will get a value that is not credible, even reduce the positioning accuracy.

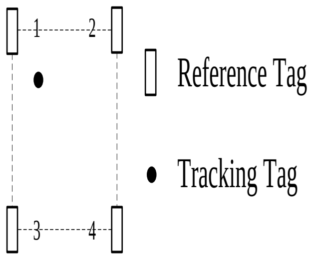

Fig. 4. Border Area

The former problem is caused by using the mean position way, do not use it can solve the problem. This paper focuses on the latter and puts forward a new positioning correction value calculation method.

Adaptive *K*-nearest neighbor algorithm supposes that the tracking tag and the nearest reference tag will have the same optimal *k* when they locate in the similar environment. If the tracking tag and the nearest reference tag locate in the similar environment, they will have the similar error when using the same k and positioning method. Therefore, we use only the error of the nearest reference tag to calculate the positioning correction value.

4 Experiment and Result

The experiment used to determine the optimal value of N by comparing the mean positioning error under different N, and analyze that whether the proposed method has a higher accuracy than adaptive K-nearest neighbor algorithm and error self-correction algorithm. Let the proposed method is compared with adaptive K-nearest neighbor algorithm and error self-correction algorithm.

Figure 5 shows the result. It is the cumulative percentile of error distance of three methods. About 70% of the mean errors are below 0.5 m in the proposed method, it means that the proposed method has a higher stability than adaptive K-nearest neighbor algorithm and error self-correction algorithm.

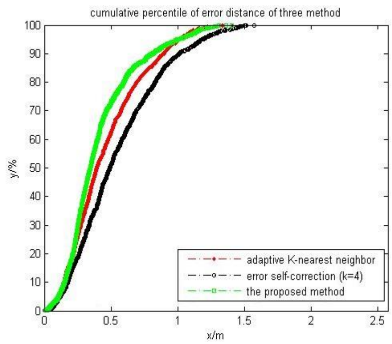

Fig. 5. Cumulative Percentile of Error Distance

5 Conclusions

To improve the accuracy of active RFID indoor location system, an adaptive self-correction location algorithm based on LANDMARC improvement was presented. Experimental results show that compared with adaptive K-nearest neighbor algorithm and error self-correction algorithm, the proposed method provides a higher accuracy.

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