An Improved VIRE Approach for Indoor Positioning Based on RSSI

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Abstract. Nowadays, RFID positioning has become the preferred technology in indoor positioning because of its strong anti-interference ability, short recognition time, large amount of storage data and low cost. In this paper, based on RFID technology, a method of virtual tag is proposed to further optimize the adjacent area, the positioning accuracy is further improved without increasing extra cost and signal interference which has more superior performance and a higher practical value, so as to achieve the purpose of optimization.

Keywords: Radio frequency identification · Virtual tag · Adaptive threshold · Indoor positioning

1 Introduction

Over the years, many universities and research institutions have conducted research on indoor positioning technology [3]. Triangulation, scene analysis, and proximity are the three principal techniques for automatic localization technology. One of the most well-known location-based systems is the Global Positioning System (GPS), which is the most mature and the most widely used automatic localization technology at present. But for GPS is a system depending on satellite, it is difficult to localization in complex indoor environment [4]. In order to achieve the ability of locating objects in buildings, different methods are proposed by researchers. RFID has strong anti-interference ability and low maintenance cost. Because of its ability to calculate data quickly, the result is very effective. So it is feasible to use RFID technology in practical system. At present, many indoor localization algorithms are using RFID technology [5]. LANDMARC is a typical example of indoor localization system using RFID technology. It introduces the concept of reference tag. VIRE is based on reference tag and proximity maps to guarantee the accuracy of localization without adding other real reference tags [6].

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In this paper, the existing VIRE system was analysed, and the proportion of the two weight factors in VIRE was modified. The proportion of weight factors with small interfering factors is higher.

2 VIRE System

The location of the target tag is obtained by comparing the RSSI value between the reference tag and the target tag [1–4]. A large number of reference tags are required to ensure accuracy. This increases interference and the cost of the system. VIRE uses grid virtual reference tags without additional real reference tags. The grid virtual reference tag is not an entity, but assumes a reference tag that exists at a point of coordinates. When grid virtual reference tags are introduced, they can be used as reference tags [5, 6]. Taking the two-dimensional grid as an example, the target tag is placed at any position in the two-dimensional grid. The real reference tags are averagely distributed in the two-dimensional space, and four reference tags are arranged here. Each grid cell covered by four real reference tags is further divided into $N \times N$ equal sized virtual grid cells (Figs. 1 and 2).

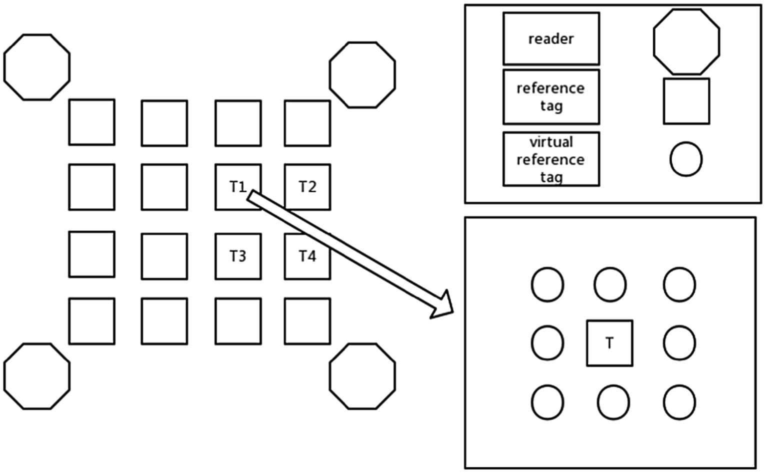

Fig. 1. VIRE system

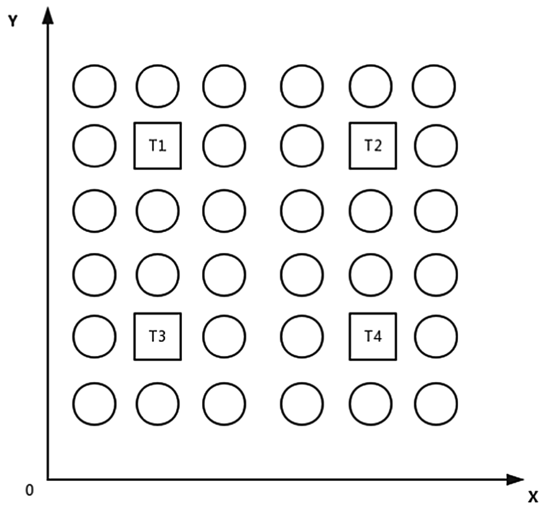

Fig. 2. Distribution of grid virtual reference tags

3 Algorithm Principle

In the indoor environment, the log-distance path loss model predicts the average attenuation degree of signal from distance:

$$PL(d)_{db} = PL(d_0) - 10n \lg \frac{d}{d_0} + X_\sigma \tag{1}$$

where $PL(d)_{db}$ denotes the free space path loss for the distance, d_0 denotes an optional reference distance, denotes the path loss exponent, X_σ is zero mean Gaussian random variable with variance in dB.

If the distance between the reader and the tag was obtained, then the received signal strength can be represented by the following expression:

$$RSSI(d) = RSSI(d_0) - 10n \lg \frac{d}{d_0} + \lambda \tag{2}$$

After obtaining the RSSI value of the real reference tags, the linear interpolation method can be used to obtain the RSSI value of the grid virtual reference tags.

At horizontal direction:

$$RSSI_k(T_{p,b}) = RSSI(T_{a,b}) + (p - a) \times \frac{RSSI(T_{a+n,b}) - RSSI(T_{a,b})}{n} \tag{3}$$

at vertical direction:

$$RSSI_k(T_{a,q}) = RSSI(T_{a,b}) + (q - b) \times \frac{RSSI(T_{a,b+n}) - RSSI(T_{a,b})}{n} \tag{4}$$

where $RSSI_k(T_{i,j})$ is the RSSI value of the grid virtual tag at the point (x, y) which read on the number k reader.

In addition, in order to improve the accuracy of positioning, two weight factors ω_{1i} and ω_{2i} are introduced:

$$\omega_{1i} = \sum_{h=1}^{K} \frac{|RSSI_h(T_i) - \theta_h(R)|}{k \times RSSI_h(T_i)} \tag{5}$$

$$\omega_{2i} = \frac{p_i}{\sum_{i=1}^{n_a} p_i} \tag{6}$$

where $RSSI_h(T_i)$ represents the number i virtual reference tag received by the number reader, T_i represents the number i target tag received by the number reader. K is the total number of readers. p_i is the ratio of a continuous possible region to the total number of regions. n_{ci} is the number of contiguous regions. n_a is the number of selected cells in the location area. ω_{1i} represents the difference between the selected virtual reference tag and the target tag, the larger the margin, the smaller it should be. ω_{2i} represents the density of the selected virtual reference tag, the greater the density, the bigger it should be.

However, in the complex indoor environment, because of the multipath effect and shadow effect, the RSSI values of the virtual reference tags and the target tags are not stable, so ω_{1i} will have errors. But the second weight factor ω_{2i} is the density of the tags, which is not affected by the complex environment. Therefore, the second factor should account for more weight of the two weight factors. To take reciprocal of ω_{1i} and then we can meet our requirements, and make the positioning more accurate:

$$\omega'_{1i} = \frac{1}{\omega_{1i}} \tag{7}$$

The weight factor is the product of the above two weight factors, and the calculation result is the coordinates of the target tags:

$$(x, y) = \sum_{i=1}^{n_a} \omega'_{1i}\omega_{2i}(x_i, y_i) \tag{8}$$

4 Experiment and Results

Here, some experiments are shown with MATLAB 2008 to manifest the effectiveness of the proposed algorithm. The computer is Pentium dual-core processor, clock is 4 GHz, 3.25 MHz memory. The target area to be positioned is two-dimensional, covering an area of 8 m × 8 m, and the readers are placed on the four corners, so their coordinates are (0,0), (8m,0), (0,8m), (8m,8m). The simulation system will use the high frequency passive label as the reference and target tags respectively. The placement of the system is demonstrated in Fig. 3, and the estimation result is shown in Fig. 4.

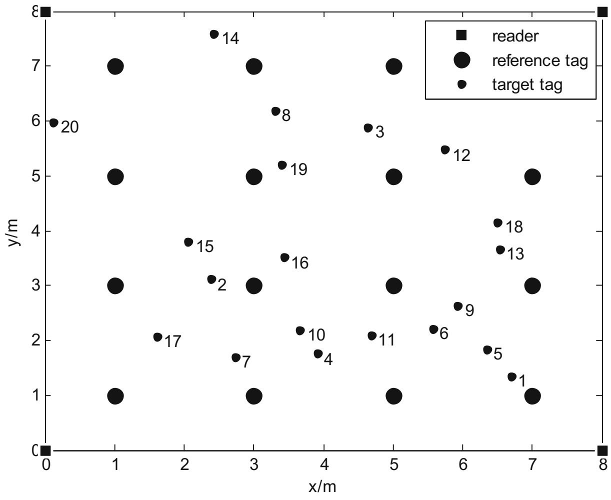

Fig. 3. Simulation environment.

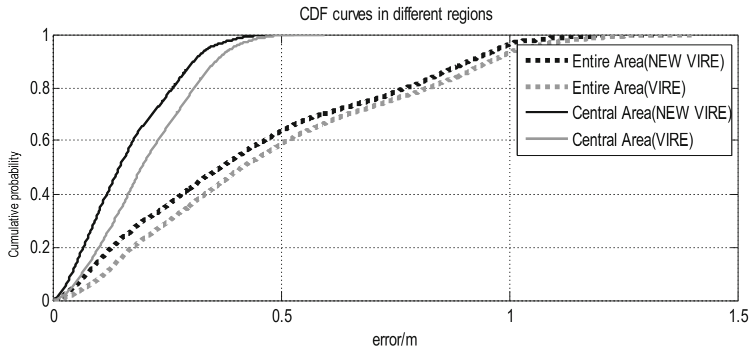

Fig. 4. CDF curves in different regions.

From Fig. 4, it can be seen that in the entire area, the probability of success of NEW_VIRE is more than 60% to lower than 0.5 m, and that of VIRE is less than 60% probability to lower than 0.5 m. So compared with LANDMARC and VIRE, the proposed NEW_VIRE has higher positioning accuracy.

5 Conclusion

In this paper, the VIRE algorithm is introduced in detail, and it can be seen that the relatively perfect positioning system mainly depends on LANDMARC and VIRE. This paper mainly improves VIRE. The concept of reference label is proposed by LANDMARC, and the adaptability of LANDMARC is greatly improved. VIRE is improved on LANDMARC, without increasing the cost and increasing the signal interference, the positioning accuracy is further improved.

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