The Research of Bayesian Indoor Location Algorithm based on RSSI

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Abstract

To improve the accuracy of indoor positioning system based on the received signal strength indicator (RSSI), this paper proposes a Bayesian indoor localization algorithm based on RSSI. First of all, the algorithm preprocesses RSSI signal by Gaussian filtering, and calculates the initial coordinates of target node using KNN algorithm. Then, in order to obtain more accurate coordinates, the initial coordinate is processed by Bayesian filtering. The simulation results show that the algorithm can reduce the positioning error, and improve the positioning accuracy.

Keywords

Indoor positioning; Bayesian filtering algorithm; Gaussian filtering algorithm; Received signal strength indicator.

1. Introduction

In recent years, with the development of mobile Internet, people's demand for positioning and navigation is increasing. Especially in a complex indoor environment, such as underground warehouses, supermarkets, libraries, exhibition halls, we often need to determine the indoor location of the mobile terminal or its holders, facilities and items. As a result, the indoor wireless positioning system has a considerable demand, and also has very important practical significance.

Indoor localization algorithm based on RSS is to realize positioning by comparing the difference between the known fingerprint database and the signal of target location. The algorithm is based on the traditional location fingerprint identification, which includes two stages: offline collection stage and online positioning stage. The offline phase preprocess the acquisition signal and make them form fingerprint database. The online phase obtain the target location by comparing its signal with the fingerprint database. Bayesian filtering theory is mainly for nonlinear systems, so this paper put forward a new indoor localization optimization algorithm based on Bayesian filtering, by getting prior probability and posteriori probability of the target location.

2. The establishment and positioning of Fingerprint database establishment and positioning

The establishment of the fingerprint database belongs to the offline stage. In the selected location area, suppose that there are n wireless access point AP, m sampling reference point. Signal strength data is collected in fixed acquisition time (such as 3 min) at each sampling point, and then we adopt average filter to obtain the signal strength value RSSI of the reference point, as shown in equation 1. We need to traverse all the sampling points and get m fingerprints which is each corresponding to a unique fingerprint position, expressed in l = (x, y). So the location fingerprint database is shown in equation 2.

$$r_i = \left(rssi_{i1}, rssi_{i2}, rssi_{i3} \cdots rssi_{in}\right)(i = 1,2,3...m) \tag{1}$$

$$LFDB = \begin{bmatrix} (x_1, y_1) & r_1 \\ (x_2, y_2) & r_2 \\ \cdots & \cdots \\ (x_m, y_m) & r_m \end{bmatrix} \tag{2}$$

Fingerprint database positioning belongs to the online stage. To determine the location of the target node by querying fingerprint database is the process of realizing localization. When mobile node appears in the location area, we can obtain real-time RSSI value of each AP, namely ($rssi_1$, $rssi_2$, and rssi3...$resi_n$). As is shown in Fig.1, the location of the mobile node in position area can be worked out .

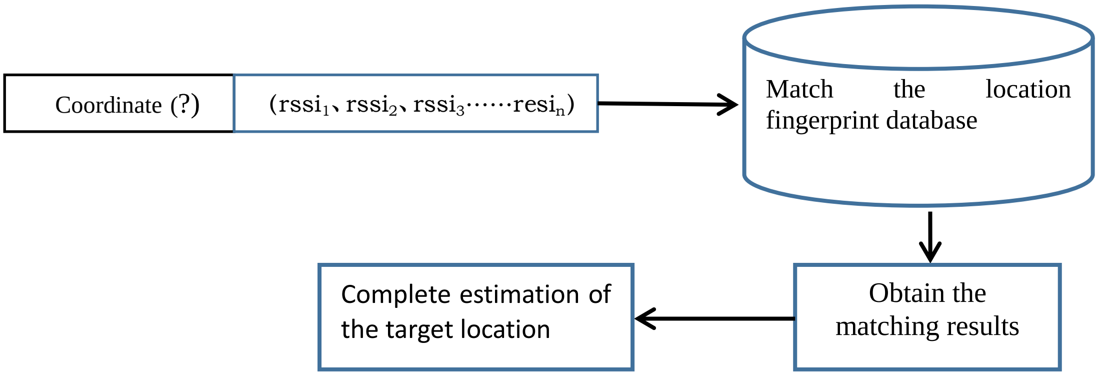

Fig.1 The principle of the fingerprint database positioning stage

3. The Bayesian Location Improved Algorithm

Bayesian algorithm estimates target position based on the theory of Bayesian statistical analysis theory. It is a probability algorithm. But the premise of the algorithm is that the probability distribution of the reference node and RSS distribution of the location node are known. Therefore, suppose the position l has a prior probability P (l), and all of the prior probability in the location area is the same. As is shown in 3, the posteriori probability of the position l can be calculated using the Bayesian theory, namely, the conditional probability of the fingerprint f at this position l:

$$P(l_i \mid r) = \frac{P(r \mid l_i) \times P(l_i)}{P(r)} = \frac{P(r \mid l_i) \times P(l_i)}{\sum_{i=1}^{m} P(r \mid l_i) \times P(l_i)} \tag{3}$$

$P(l_i)$ is the prior probability of the position l_i. There are m position in the location area, where actually we usually assume that the probability of each location is equally possible. Therefore, $P(l_i)$ don’t participate in calculation as a constant, equation 4 can be used to mean the posteriori probability of location l_i.

$$P(l_i \mid r) = \frac{P(r \mid l_i)}{\sum_{i=1}^{m} P(r \mid l_i)} \tag{4}$$

It is shown that the greater posteriori probability, the closer corresponding coordinates. In naive Bayesian algorithm, the biggest $P(l_i \mid r)$ said positioning output, namely the formula 5.

$$L(x, y) = \max P(l_i \mid r) \tag{5}$$

On the basis of the naive Bayesian algorithm, k locations with the maximum posteriori probability are chosen, and then we can obtain the coordinates of the target location, as shown in6.

$$(x, y) = \frac{\sum_{i=1}^{k} P(l_i \mid r) \times (x_i, y_i)}{\sum_{i=1}^{k} P(l_i \mid r)} (i = 1, 2 \ldots k) \tag{6}$$

Where $P(l_i \mid r)$ represents the weight of the ith reference point.

4. Experimental Results And Analysis

The experiment is proceeding in the indoor environment (20 m *15 m), node layout of positioning system in the experiment is shown in Fig.2.

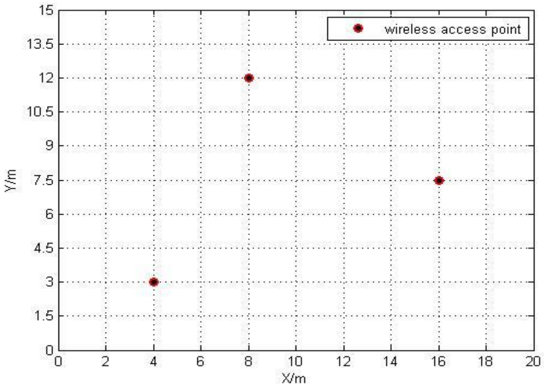

Fig.2 node layout of positioning system

In order to compare the result of the test, the positioning error equations are set to formula7.

$$E = \sqrt{(x_0 - x)^2 + (y_0 - y)^2} \tag{7}$$

Where (x0, y0) is true position, and (x, y) is the estimated position.

First set up two position (8, 6), (12, 3) to be measured, then obtain RSSI values via multi-measurement and work out coordinates through two kinds of algorithms respectively. Comparison result of two algorithms is shown in Table.1.

Table.1 Comparison result of two algorithms

actual coordinates	nave bayesian algorithm	Improved bayesian algorithm
(8,6)	(7.4246,5.5712)	(7.6254,5.6024)
error/m	0.7176	0.5463
(12,3)	(10.9853,2.8164)	(11.3529,3.1204)
error/m	1.0312	0.6582

Therefore, improved algorithm increase the precision of positioning further.

5. Conclusion

RSSI signal is relatively sensitive to the change of the various factors in the indoor environment, so the measurement is prone to error. Positioning error based on RSSI is mainly appear in the measuring phase and calculating coordinate phase. During the measure phase, the RSSI values with big error are eliminated by Gaussian filter, and then the geometric mean of RSSI is acquired. This enhances the accuracy of positioning information. In calculating coordinate phase, according to the bayesian theory, the accuracy is higher through the establishment of the prior probability model and the posteriori probability model to solve the target coordinate. The experimental results show that the improved algorithm make the positioning results to further improve, enhance the accuracy and stability of the indoor positioning system.

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