Optimization Wifi Indoor Positioning KNN Algorithm Location-based Fingerprint

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Abstract— **Location-based services have been deep into all aspects of life and it provides a convenient and efficient service experience for people. Currently, technology is relatively mature and widely used in the outdoor positioning. By contrast, for indoor positioning, although there are a lot of hot technology,but they are mostly insufficient lead to it is hard to popularize.So how to improve the popularity of indoor positioning in the case of improve the positioning accuracy has bacame a hot research topoc. This paper analyzes and studies several typical fingerprint localization algorithm, including NN, KNN and WKNN, and then propose an algorithmic improvement program，it introduces signal propagation model, finds and narrows the K-gon.**

Keywords-fingerprint; indoor positioning; KNN algorithm; Signal transmission model

I. INTRODUCTION

With the popularity of smart phones and mobile Internet, people demand for location-based services is also increasing. At home and abroad a number of large companies and research institutes have developed an indoor wireless location systems, mainly in the infrared, ultrasonic, Bluetooth, WIFI, radio frequency identification (RFID), ultra-wideband (UWB) short-range wireless technology, etc. Among them, much attention has been paid to wireless location technology based on WIFI network because of the low deployed widely and low cost, it uses fingerprint positioning methods can usually achieve better positioning effect. But the location fingerprinting positioning method at this stage in the offline stage takes a lot of manpower and resources, selects a large number of the reference position, and collects a large amount of data in each direction each reference point to establish the position fingerprint database, and the positional accuracy of the positioning of the algorithm is not high enough so that it brings a lot of obstacles to the popularity of indoor positioning system.This paper analyzes and studies several typical fingerprint localization algorithm,and proposed having a more accurate algorithm to improve the effect of positioning.

II. THE BASIC PRINCIPLE OF INDOOR POSITIONING

WLAN indoor positioning based on the location of the fingerprint is roughly divided into two phases: offline sampling stage and online positioning stage(or real-time positioning stage).Offline sampling stage is to build a database about the relationship between signal strength and the sampling point location. To build the database, the operators need to determine the number of sampling points in the located environment, and then through all sampling points recorded at each sampling point for the measurement radio signal characteristic that the signal strength from all the access points, and finally they saved in the database in some way.In the second stage,when a user moves to a position,based on his real time received signal strength information,get the user’s location by matching and comparing it with the position fingerprint database information using the localization algorithm.It can be shown in the following Figure 1.

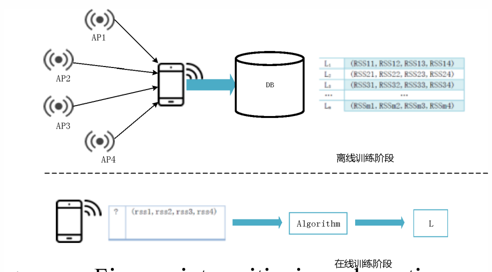

Figure 1. Fingerprint positioning schematic

A. *Offline sampling stage*

The goal is to create a positional fingerprint database. First,positioning systems deployers traverse all positions in the positioning environment, at the same time collect RSSI values from different APs (Accept Point) in each of the reference position, and then put AP's MAC address, RSSI value and position information of the reference point into the fingerprint database as a triple associated data respectively.

B. *Online positioning stage*

When a subscriber stands in location area, collect RSSI values from all different APs in real time as the input data of position matching algorithm,then we can estimate his or her real position with a specific matching algorithm.

III. INTRODUCTION OF TYPICAL ONLINE MATCHING ALGORITHN

Nearest Neighbor algorithm(NN), K-Nearest Neighbor algorithm(KNN), K-weighted K-Neighbor

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algorithm(WKNN) can be collectively referred to as data correlation algorithm. The following are analyze to these several algorithms:

Suppose there are l position fingerprints corresponding to m position { $L_1, L_2, L_3, \dots, L_m$ }. $F_i=(r_1^i, r_2^i, r_3^i, \dots, r_n^i, L_i)$ indicates the signal strength of the i-th (i<=m)sampling point of the n-th AP. The signal intensity of the experimental sample is S=($s_1, s_2, s_3, \dots, s_n$) .

A. Nearest Neighbor algorithm(NN)

It is the most basic fingerprint localization algorithm. This method firstly calculates Euclidean distance D between the received signal strength vecyor and vectors in the database in the following way, then select the minimum distance vector corresponding database, finally output the position coordinates it represents as a result.

$$D(S, F_i) = \sqrt{\sum_{j=1}^{n} (s_j - r_j^i)^2}$$

Among them, s_j and r_j^i represent the anchor point and fingerprint vector signal strength respectively,n represents the number of wireless access points.

B. K-Nearest Neighbor algorithm(KNN)

Unlike the NN algorithm, it is to find K (K> 2) data bases vectors which are nearest to the resulting vector p osition measurement, then figure up the average of posi tion coordinates which the K databases vectors represen ting, finally output the average position.

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

Among them, represents the coordinate of the i-th selected fingerprint information,represents the positioning result coordinates.

C. weighted K-Neighbor algorithm(WKNN)

Unlike the K-Nearest Neighbor algorithm, after that select the K (K> 2) database vectors, to each database v ector corresponding coordinate is multiplied by a weigh ting factor. There are a lot of weighted method, but the basic principle is to increase the weight value of the nea rer point in the k points.The most frequently used weigh t calculation formula is:

$$w_i = \frac{\frac{1}{(dist(S, F_i) + \varepsilon)}}{\sum_{j=1}^{k} \frac{1}{dist(S, F_j) + 1}}$$

Among them, ε is a constant close to zero, its purpose is to make the denominator is not zero when the distance is zero, thereby it can maintain the weight is effective. Physical coordinates of the point to be located is:

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

IV. IMPROVED ALGORITHM

A. Offline sampling stage

Introduce the indoor wifi wireless signal propagation model:

$$R_d = A - 10n_p \lg\left(\frac{d}{d_0}\right) - \begin{cases} W * WAF, W \le C \\ C * WAF, W \ge C \end{cases}$$

Among them, d is the distance between the AP and the measuring point, R_d is the signal strength of measurement point, A is the generated path loss after signal spread referenced distance $d_0(d_0 = 1m)$, n_p is the loss coefficient and its value related to the communication environment, W is the number of obstacles between the test point and AP,C is the critical value of the number of obstacles which can make the attenuation factor change, WAF is the attenuation factor of the obstacle.

Put the AP location information hidden in fingerprint points(I.e. collecting signal strength information for each AP location), obtain received signal strength A at a distance of referenced distance $d_0(d_0 = 1m)$ from the each AP and the path loss coefficient n_p n this environment.

Similarly, introduce error constant θ: Calculated in the fingerprint acquisition phase, means Euclidean distance of two points distance of d(d is acceptable error range).

B. Online positioning stage

1) Determine the optimal k-gon.Traversing each fingerprint in the database ,find k(k>2) adjacent points to the measuring point and they can constitute a k-gon. First, determine whether the measuring point in the n-gon interior(or at the edge of the k-gon), if the answer is yes, the k-gon is the optimal k-gon. If the measuring point is not inside the k-gon, discard the point which has maximum Euclidean distance and select the point which has the minimum Euclidean distance in the remaining fingerprint points,then they can constitute a new k-gon. Then determine positional relationship between the measuring point and the k-gon again, until you find the k-gon containing the measuring point is the optimal k-gon(If you did not find the k-gon after traversing the fingerprints point,the measurement point will be seen as a edge point, KNN algorithm can be used for location estimation at this time, does not apply to our improved algorithm).

2) Compare and signal strength Euclidean distance between vertices of the k-gon and the measuring point,if exist one or more vertices,its signal strength Euclidean distance is less than ,we can choose the vertex which has the minimum Euclidean distance and take its physical coordinates as final positioning position.In contrast,if the vertex does not exit,the midpoint of the k-gon instead of the vertex which farthest away from the measuring point and then they can constitute a new k-gon again. Using the signal model calculating the signal strength of the midpoint, recalculate the Euclidean distance between this midpoint and the measuring point until you find a point which its Euclidean distance is less than θ.

V. SIMULATION AND ANALYSIS

Experimental environment is Lanzhou University Feiyun floor 220 laboratory and part of the corridor(An area of 20m × 12m).

A. *Offline sampling stage*

Measure the uncertainties in propagation model. A takes 999dbm(signal strength level 1000dbm), takes 3.0,W takes 1, the attenuation factor of the wall takes 40db, measured error constant θ when acceptable distance 1.5m is 26.4015. The experimental environment is divided into 70 block area of 1.2 × 1.2, in it,collect RSSI values from 3 Aps and constitute the fingerprint database. Hidden AP physical location is (1,6),(6,1)(10,7). It can be shown in the following Figure 2.

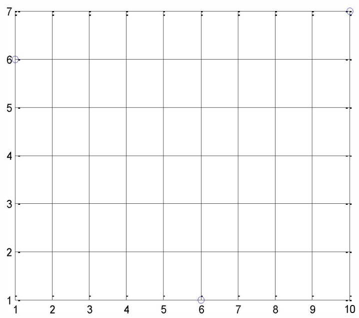

Figure 2.

B. *Online positioning stage*

In this area randomly selected 30,gathering the signal strength of each point. When the number of fingerprint points is 3, executive the localization algorithm to measurement point, yields the following comparison chart Figure 3:

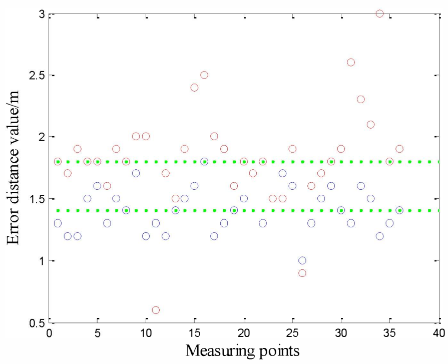

Figure 3.

Among them, red dot is an error distance between anchor points and test points based on KNN algorithm, blue dot is the error distance based on optimized KNN algorithm. Two conclusions can be drawn: First, the average error of the optimized algorithm is less than the average error of KNN algorithm; Second, the error of the optimized algorithm is relatively stable;It proves the enforceability and effectiveness of the improved algorithm in terms of the positioning performance.

VI. CONCLUSION

This article first introduces the background and the existing indoor location positioning algorithm,then presents an optimization algorithm of KNN ,it hides the AP points and introduces the indoor wifi wireless signal propagation model. Theoretical analysis and experimental results show that the KNN optimization algorithm has a certain degree of enforceability ,the original algorithm has improved greatly in terms of positioning accuracy. Since the optimization algorithm is introduced by external factors at the expense of part-time, but it does not affect the real time of the positioning. However, because of the time, also to be studied for different values of K brings precision differences.

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