ORIGINAL RESEARCH

Indoor localization based on iBeacon

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ABSTRACT

Global positioning system (GPS) has been widely used in positioning, vehicle navigation and other environments. However, in indoor environments, it can not achieve accurate positioning because of the weak signal through the wall. In other words, more appropriate techniques are needed in indoor scenes. Bluetooth technology has attracted more and more attention due to its advantages of low power consumption, wide coverage and fast transmission speed. Bluetooth-based indoor positioning refers to the indoor positioning technology that uses mobile terminal to receive Bluetooth signals from multiple Bluetooth devices, and calculates the location information of mobile terminal through the received information, so as to achieve high-precision positioning. In this paper, an effective optimal location algorithm is proposed. Firstly, the outlier detection algorithm is improved to remove the interference of abnormal data on the positioning accuracy; then, different filtering algorithms are used to process the received fingerprint information to ensure the accuracy of the fingerprint database establishment stage, and reduce the unnecessary construction time; finally, the average position is calculated by the average fingerprint data and judged the user's area.

Key Words: Locailization, Bluetooth, Fingerprint, iBeacon

1. INTRODUCTION

At present, location-based context-aware services have a very broad application prospects. Location system has not only been used as a simple and simple way to provide location, but also combined with other application services to provide more demand-oriented services for mobile users. At present, there are wide-area indoor and outdoor high-precision positioning technology based on mobile communication network and indoor positioning technology based on local area wireless network.

The application environment of indoor positioning is different from that of open outdoor environment. Because of the complexity of indoor environment, signals can not be transmitted as well as they can be known under ideal conditions. In the specific indoor transmission process, due to the difference of indoor environment, reflections and refractions will occur on different structures and material surfaces. Under different paths, the loss varies greatly. The attenuation degree of the signal received by the terminal to be located varies, and the related parameters such as amplitude and phase are difficult to control, and some signals are not robust enough to penetrate indoor obstacles or walls. Therefore, fingerprint map-based wireless location method has attracted more and more attention of researchers.[1]

Researchers have applied infrared, RFID, Bluetooth, WiFi and other wireless technologies to indoor positioning technology. Its main principle is to receive wireless signals through mobile terminals, and calculate the current estimated location of mobile terminals by using the corresponding indoor positioning algorithm. The application scenario of indoor

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positioning technology is very broad.[2]

2. METHOD

2.1 Pre-treatment stage

In this paper, a fingerprint signal intensity-based localization method which is used for the classical algorithm KNN will be been improved based on iBeacon. Through the analysis of various classical algorithms, we can find that the classical algorithms do not screen the collected fingerprint information when dealing with fingerprint information, but there are many interference in the indoor environment, and there may be some fingerprint information deviating from the exact value in the acquisition results.[3] Secondly, in the classical fingerprint location algorithm, fingerprint information is acquired in the same way at the fingerprint acquisition stage and the real-time location stage, which can not meet not only the requirements of data accuracy in the fingerprint acquisition stage, but also the requirements of timeliness in the real-time location stage. Thirdly, in the actual use process, users may be very sensitive to timeliness, but the classical algorithm may have a high latency when calculating large amounts of data, resulting in poor user experience. In view of the above points, this paper will divide the classical fingerprint localization algorithm into more fine partitions.

In the classical KNN algorithm, the collected data are often used directly without any processing. However, the indoor positioning scene itself is more complex, obstacles, interference from other signals, interference from artificial factors and so on. These factors will lead to fingerprint signal fluctuation. At the same time, the data acquisition process is more cumbersome, and the construction personnel may have operational errors, resulting in the collected data deviating from the real data, so we The data directly obtained is difficult to use directly. If the collected information is not pre-processed and processed directly in the next step, it will lead to a greater negative impact on the future positioning.

There are some data objects in the collected data. Their general behavior is significantly different from other data objects. These data objects are outliers. Outliers are the observation values, but they are obviously different from most of the observation values. These outliers will greatly affect the accuracy of the data. This paper improves the clustering-based outlier method. The basic idea of clustering-based outlier detection algorithm is to cluster the input data, in which the small clusters or points far away from other clusters are outliers generated by the interference of occasional factors of signal intensity. After clustering several times, an approximate optimal solution is obtained. The typical method is DBSCAN algorithm. However, the special scene of indoor location requires higher outlier detection algorithm. Indoor location service is a kind of service that requires high timeliness. In the information acquisition stage and location calculation stage, the influence of outliers on data accuracy should be considered. Therefore, the efficiency of DBSCAN algorithm will also affect the user's feeling of using indoor location service.[4]

This paper will improve DBSCAN algorithm from the following two aspects. In parameter selection, MinPts value is set to be half of normal data, and scanning range needs to cover at least half of normal data. Through the analysis of a large number of experimental data, the values of minPts and EPS can be roughly determined. In terms of algorithm efficiency, when we find a core point, we will re-scan all points in the neighborhood of the core point. Obviously, this is not necessary. We only need to find the point farthest from the core point in the neighborhood. At the same time, the distribution of fingerprint information is relatively regular, generally there will only be a normal value of the cluster, so indoor positioning is very suitable for selecting representative points in the core neighborhood to expand the cluster. The fingerprint information we are dealing with now refers to the signal strength of an iBeacon in the fingerprint location. Therefore, we can take the core point as the center point, and the maximum and minimum signal values in the radius of EPS as the representative points to expand the cluster outward.

Experiments show that the improved outlier detection algorithm can effectively eliminate outliers. The experimental results are shown in Figure 1 and Figure 2. It is obvious from the graph that outliers in the samples are basically eliminated after outlier detection algorithm is used.

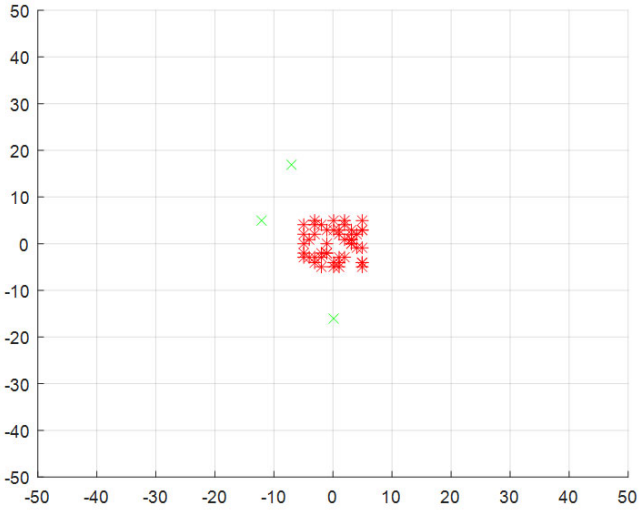

Figure 1. No use outlier algorithm

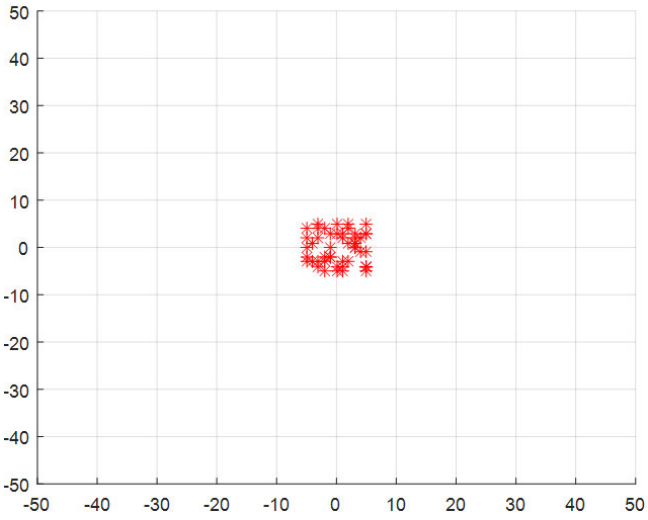

Figure 2. Use outlier algorithm

2.2 Filter storage phase

After the pre-processing stage, we have screened out the outliers that affect the establishment of fingerprint database. Now we need to get the relative true values in the sampling set after the outliers are removed. After obtaining accurate data, we can build a fingerprint database, and also make data preparation for the subsequent improved location algorithm.

In order to improve the accuracy of data acquisition, the relative true value of fingerprint information at the current position should be calculated under the condition of as many sampling data as possible. When enough fingerprint data are processed, an approximate value can be obtained by some way to represent the strength value of an AP signal at that point. The commonly used method is to calculate an average value of the data collected many times as the estimation value of the signal strength of an AP at that point. However, this method can not avoid the interference of excessive fluctuation of signal intensity on the accuracy of data.[5,6]

In order to avoid the influence of excessive fluctuation of signal intensity on data, this paper uses the arithmetic of limited amplitude arithmetic average filtering to calculate the estimated signal intensity of this point in the construction of fingerprint database. Firstly, a maximum allowable deviation value is set. Each time, a difference is made between the current data value and the last data value. If it is larger than the maximum deviation value, the measurement value is considered invalid. On the contrary, the current value is considered effective. After processing all the data, the processed data set is filtered by arithmetic average. The final value is recorded as an estimate of the AP signal strength at that point. Since all AP signal intensities at each point are independent of each other, fingerprints contain all AP signals on the map. If they are not received beyond the range, they can be set a default signal value at the farthest distance. In indoor positioning scenarios, the environment may be supermarkets, parking lots, shopping malls and other large areas, and the cost of fingerprint calculation is also high. So after calculating the fingerprint signals of each point in the area, we divide the area to be measured according to a larger block, and pre-store the fingerprints of the large area. Mean value of signal is convenient to locate the area quickly and avoid unnecessary calculation.

3. Experiments

In this subsection, we show the results of our optimized localization algorithm (see Figure 3). The experimental steps and procedures are as follows:

(1) Set reference point coordinates, access point coordinates and environmental parameters.
(2) Traverse the reference points, calculate the RSSI values received from each AP at the reference points, and store the fingerprint library.
(3) Firstly, we select the number of classes and the initial class center manually, and use our method to pretreat the collected fingerprints.
(4) Then the fingerprint database is constructed by using the optimization algorithm proposed in this paper, and the fingerprint database is clustered by KNN algorithm.
(5) Randomly generate a number of positioning test points in the positioning area to record the actual coordinates.
(6) Calculate the coordinates of the test points and record the experimental results.

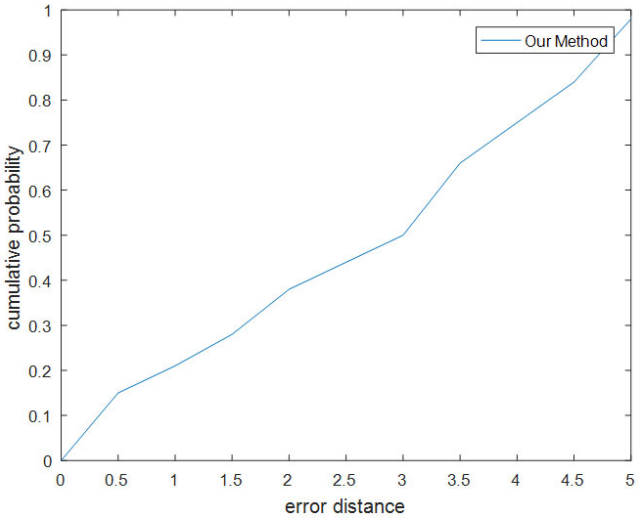

Figure 3. The results of our approach

4. Conclusions

In this paper, the improved outlier detection algorithm is introduced to eliminate outliers, and different filtering algorithms are adopted at different stages of the localization algorithm to eliminate the interference as far as possible. Morover, in the face of complex data structures, the efficiency of data query becomes the bottleneck of the system. Use relational database to improve the efficiency of query and storage of complex data, which improves the efficiency and accuracy of the algorithm.

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