AN ADAPTIVE LOCALIZATION ALGORITHM BASED ON RSSI IN WIRELESS SENSOR NETWORKS

Haihui Zhang[1], Jiaming Zhang[1], Huarui Wu[2]

[1]College of Mechanical and Electronic Engineering,
Northwest A&F University, Yangling, Shaanxi 712100, China
[2]National Engineering Research Center for Information Technology in Agriculture, Beijing 100097, China
zhanghh@nwsuaf.edu.cn, zjm1011love@126.com, wuhr@nercita.org.cn

Abstract: Wireless sensor networks (WSN) have been used in various application areas and will be more prosperous in the future. The technology of localization, by which the position of blind node can be acquired, is a significant factor and one of the supporting technologies in WSN. Most of the existing localization algorithms in sensor networks mainly depend on one simple model and can only be used in a given condition, which cannot be adapted to the complex environment and thus restrict their application. In this paper, a novel adaptive scheme, based on the relationship between the RSSI (Received Signal Strength Indication) values and the spread distance of RF signal, is presented by fusing the experience model and the theoretical model in traditional RSSI-Based localization methods for improving the adaptability to different environments and enhances the pointing accuracy in WSN. The key method of this scheme is that through dividing the entire testing set into several pieces and placing characteristic node in every zone, one of the two models will be dynamically selected after comparing the error between the real distance the RF signal traveled and the distance computed from each of the two models by the characteristic node to minimize the positioning error.

Keywords: Wireless sensor networks; Node localization; RSSI; Adaptive method

1 Introduction

As a new kind of technology in data sensing and processing, wireless sensor networks (WSN) [1] can sense and collect the information of all kinds of objects to monitor in the networks in real time, which have been widely used in military defense, agricultural production, environmental monitoring, industrial control, and many other fields and will have a broader application prospect in the future [2].

The technology of localization, by which the position of blind node can be acquired, is a significant factor and one of the supporting technologies in wireless sensor networks [3]. Only when combined the data processed by sensor nodes with the location information, can it be practical, thus the technology of localization is meaningful and worthwhile to be explored. Among varieties of researches in wireless sensor networks, the study on technology of localization has become a popular direction.

In recent years, a lot of positioning technology for wireless sensor networks based on different principles has been put forward and many new positioning technologies have aroused people's widely concern, but most of them can only be used in a given condition [4]. The existing localization methods can be classified from different perspectives. It is generally believed that it's clearer to classify the localization technology from the rang-based and rang-free angle. Positioning schemes based on the RSSI [5] values mainly belong to the rang-based methods. The RSSI-based localization process is discussed in this article.

In the RSSI-based localization process [6], the anchor node, whose position has been confirmed in the networks, computes the distance that the RF signal has traveled since it was launched by the blind node, whose position is unknown and would be acquired. This method is low-cost, because each of the wireless sensor nodes has the communication module and thus it's easy to get the RSSI value without requiring for additional hardware. There are two kinds of computing methods in traditional RSSI-Based localization methods to transfer the signal strength to the transform distance, the experience model and the theoretical model [7] which will be introduced below. To improve the adaptability to complex environments and to enhance the pointing accuracy, an adaptive localization algorithm based on the RSSI values is proposed in the paper.

The paper is organized as follows: Section 2 introduces the two positioning approaches in traditional RSSI-based localization methods. Section 3 describes the basic principle of the adaptive location algorithm based on the RSSI values put forward in this paper. The process of the algorithm is described in detail and the main flow charts of the algorithm are given in Section 4. In Section 5 the final conclusion of the paper is given and future work is discussed.

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2 Traditional RSSI-based localization methods

Traditional localization technology based on the RSSI values can be classified into two positioning models [8]: the empirical model and the theoretical model. The former depends on the offline database established before and acquires the location information by matching the RSSI values with the stored signal strength in the database. The latter is based on the RF signal transmission loss model and gets the travel distance of the RF signal, thus to acquire the node position information. The two models are discussed in the following sections.

2.1 Method based on the empirical model

Several steps are needed in the empirical model to get the position information. First, several anchor node should be placed in the distributed area and parts of them would be selected as the testing nodes. Before starting the system, those anchor nodes collect the signal strength of the testing nodes to establish the off-line database. Then when the system works, the anchor nodes get the RSSI values of the blind nodes and match the values with the record in the database, and calculate the variance of the values and choose the record location with the minimum variance as the location of the blind nodes.

Knowing from the above method, when using the empirical model to estimate the location of the blind node, we can calculate the average signal strength after several repeated measures to enhance the positioning accuracy. The advantage of the empirical model is that only a small amount of calculating is needed in actual positioning and a simple table look-up or a fitting curve is required, thus the location information can be simply estimated with low energy consumption. From the perspective of actual effects, high positioning accuracy can be achieved by this method, but it has a lot to do with the distribution of the nodes [7] and the selection of the testing nodes in the networks. The disadvantage is that a great deal of preparation work should be done before the experiment and as soon as the environment changes, the pre-established offline database will fail and a new database is needed to create.

2.2 Method based on the theoretical model

Since the impact of a variety of factors, when the RF signal transforms in the atmosphere, the signal strength will decrease as the distance increases, on which the relationship between the signal strength and the propagation distance can be established. The relationship can be described by the mathematical model of wireless channel using the Eq. (1),

$$PL(d)=PL(d0)-10n\log(d/d0)-X\sigma \qquad (1)$$

Where d is the distance between the transmitter and the receiver, d0 is the reference distance and n is the channel attenuation index whose general value is from 2 to 4, Xσ is a Gaussian random variable whose mean is 0 and the variance is σ; PL(d0) is the signal strength in a distance of d0 far from the transmitter, which can be acquired through experience or obtained from the hardware standard definition; PL(d) is the signal strength at a d distance from the transmitter.

In practical application, after getting the RSSI values of the blind nodes the distance between the anchor nodes and the blind ones can be calculated, and then the location of the blind nodes can be acquired. The method has an advantage of higher adaptability, low energy consumption, low cost and a good fit for unattended areas. What's more, it need not establish a database in advance. The insufficiency of this method is that complex calculation process may be acquired, what's worse, its positioning accuracy is inferior to the method based on the empirical one. Moreover, multipath reflection and the NLOS issues may affect the measuring accuracy.

3 An adaptive localization algorithm on RSSI

The RSSI localization algorithm based on the empirical model can achieve a high accuracy, but at the situation of environment changing the advanced database may be invalidated and updating the database requires a lot of testing, which limits the application of the algorithm. Though the algorithm based on the theoretical model is easy to realize and need not establish a database ahead of time, the pointing accuracy of the algorithm is susceptible to the interference of environment factors. By fusing two models, an adaptive localization algorithm based on received signal strength (RSSI) is presented to improve the adaptability to different environments and enhance the pointing accuracy. The algorithm is based on the received signal strength (RSSI) through dividing the entire testing set into multiple zones, dynamically adjusting the model basing on the error of the characteristic nodes. The basic principle of the algorithm will be introduced as follows.

After dividing the entire testing set into several zones and getting the location information of the anchor nodes, parts of the anchor nodes will be chosen as the testing nodes in the area. The dividing Scenario diagram can be described as Figure 1. Then depending on the obtained RSSI values by those testing nodes, the positioning process will be launched from the perspective of empirical model and theoretical model separately. By comparing the computed distance by two different schemes with the real distance, the error of each scheme can be obtained. At last, the scheme with small deviation will be selected as the computing model in the area.

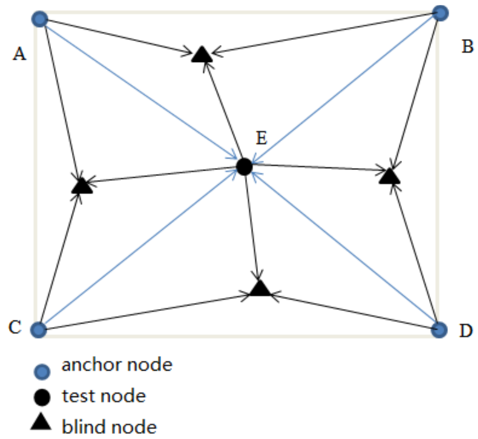

Figure 1 Scenario diagram of the set dividing

4 The process of the adaptive algorithm

The sensor networks are consisted of anchor nodes, parts of which are chosen as the test nodes, and blind nodes. Different kinds of nodes have different work model and function.

The so-called anchor nodes, other than those chosen as the test nodes, are the ones whose location has been acquired and their main function is broadcasting its location information to provide a reference in both position and signal strength information in the location process. The positioning algorithm flowchart of the anchor node is shown in Figure 2.

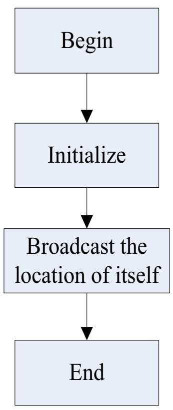

Figure 2 The positioning algorithm flowchart of the anchor node

The location of the test nodes in WSN is also known and in the process they receive the location information and the signal strength of the anchor nodes to locate themselves. Their main function is to determine the localization algorithm model in the region by comparing the positioning error of the two models, in order to minimize the positioning error of the blind nodes. When the model in the region has been confirmed, those test nodes will be promoted as the anchor nodes. The Figure 3 describes the positioning algorithm flowchart of the test node.

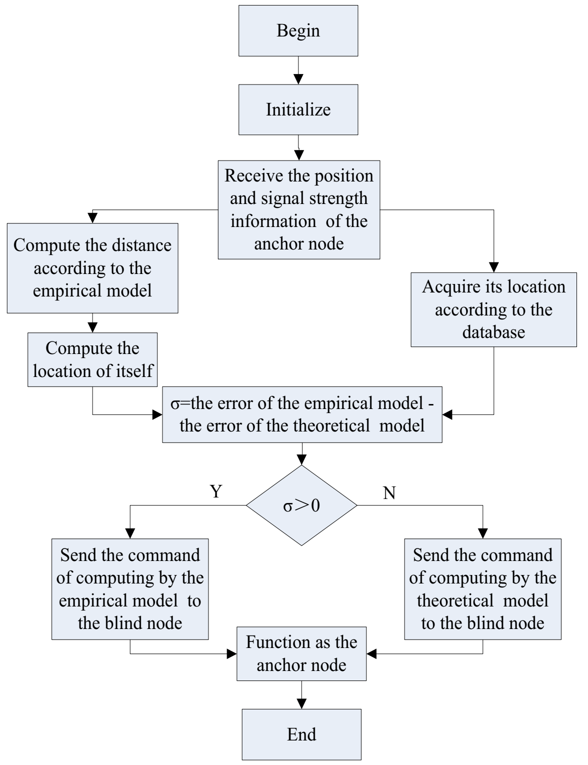

Figure 3 The positioning algorithm flowchart of the test node

The blind nodes, whose location is unknown, work according to the command of the test nodes and information from the anchor nodes to localize themselves. The positioning algorithm flowchart of the blind node is described in Figure 4.

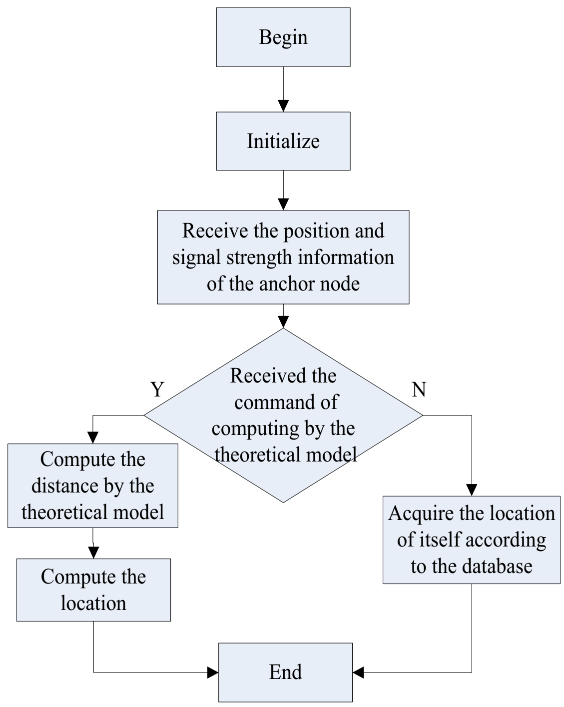

Figure 4 The positioning algorithm flowchart of the blind node

5 Conclusions

An adaptive localization method based on the RSSI values by fusing the two transmission models of RF signal is proposed in this paper to improve the adaptability to complex environments and enhance the positioning accuracy in WSN. The basic principle and both the advantages and disadvantages of the two transmission models of RF signal are analyzed before proposing the adaptive algorithm. Though the proposed adaptive scheme is a little more complex than the algorithm based on one simple model, as the improvement of the hardware platform, it is easily realized in nowadays and the proposed one will achieve better localization accuracy than each of them. What's more, this scheme can be adapted to various localization application and environment. Although the algorithm may have a better performance, the details of how to realize the adaptive still need to be explored and improved.

Acknowledgements

The work described in this paper was partly supported by National Natural Science Foundation of China (No. 61101210), Beijing Natural Science Foundation (Grant No. 4122034), China Spark Key Program (No. 2011GA850003).

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