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Improved DV-Hop Localization Algorithm Based on Distance Correction of Anchor Nodes

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Abstract

This paper presents a kind of DV-Hop localization algorithm based on distance correction of nodes. This algorithm introduces the concept of distance correction factor and combines with the node communication radius to correct the average distance of each hop between unknown node and anchor node，and makes it be closer to the real value. The simulation results show that the proposed algorithm can reduce the average localization error of node, and when the value of distance correction factor is 0.8，the average localization error of node under DA-DV-Hop localization algorithm is reduced 15.53% than the traditional DV-Hop localization algorithm.

Keywords*: Wireless sensor networks, Localization, DV-Hop, Distance correction*

1. Introduction

The development and progress of modern sensor technology and wireless communication technology promoted the rapid development of Internet. Wireless Sensor Networks as an important part in the information acquisition stage of the Internet of things, more and more gets the favor of the industry; its application range is also expanding [1]. Master sensor nodes location information is the basis and premise condition of the successful deployment of wireless sensor network and application: on the one hand, determining the location of the sensor node is helpful to improve the efficiency of MAC and Routing protocols and reduce the overall energy consumption of the whole network, so as to prolong the service life of wireless sensor; on the other hand, the wireless sensor network (WSN) looking information acquisition as the main function, only master the position of nodes transmission information, can more clearly judge the effective range of gathering information to grasp the real situation of the specific position [2]. Therefore, node localization technology in WSNs plays a very key role for the successful implementation of network application.

2. DV-Hop Localization Algorithm in Wireless Sensor Networks

Localization in the wireless sensor network refers to the network of wireless sensor network self-organizing provides the location information of node through specific methods. The self-organizing network positioning is respectively based on the Range-based and Range-free positioning technology [3].

DV-Hop localization algorithm is a kind of typical Range-free localization algorithm, make sure the hop count of multi-hop network combined by the unknown nodes distributing between two known nodes (anchor nodes) through measuring, to estimate the distance of each hop to determine the position of each node. The algorithm mainly

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has three steps:

Step 1: Through the typical distance vector protocols, make all the unknown nodes in the network to get the minimum value of anchor node for communication, make all the anchor nodes to get location information and the minimum hop of other anchor nodes for communication;

Step 2: After each anchor node gets the location information and the minimum hop of other anchor nodes, calculate the average HopDist through equation (1) and broadcast the achieved average distance of each hop to the entire network in the form of flooding. After receipt of "average distance in each hop" of multi-anchor nodes, the unknown node only save the HopDist received for the first time. On this basis, combine with the minimum hop count to the anchor node to calculate the distance between the anchor nodes;

$$HopDist = \frac{\sum_{i \neq j} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{i \neq j} h_{ij}} \quad (1)$$

Where, (x_i, y_i) (x_j, y_j) are the coordinates of anchor nodes i and j, h_{ij} represents the minimum hop count between anchor nodes i and j.

Step 3: After each unknown node get three or more anchor nodes by calculating, use the trilateral positioning or maximum likelihood estimation method to get the coordinates of it and complete positioning finally.

Presently, scholars at home and abroad have a certain amount of research for DV-Hop localization algorithm improvement. Zheng Jiu tiger etal. proposed a kind of DV-Hop algorithm based on hop count correction, introduced preorder nodes and the concept of total average distance of each hop, through the amount of preorder nodes to calculate hop count correction coefficient from the unknown nodes to anchor nodes, the positioning precision is improved [4]. Xiaoming Li put forward a kind of DV-Hop localization algorithm based on error correction; through the particle swarm optimization algorithm, the position error was corrected [5]. Jiangtao Wen etal. proposed a kind of DV-Hop localization algorithm based on RSSI hop count correction, which uses RSSI value to refine hop count information to make hop count value be more accurate [6]. Tan Zhi and Zhang Hui put forward a kind of DV-Hop localization algorithm based on the covering relations between nodes, introduced the communication coverage between inter-nodes to the hop count coefficient, the errors in calculating the average distance of each hop was reduced [7]. Zhao Dongdong etal. proposed a kind of DV-Hop localization algorithm based on centroid iteration, get centroid for the triangle combined by anchor nodes for many times according to the hop count, which makes the average distance of each hop be closer to the hop distance, so as to reduce the positioning error [8]. Linqing Guim etal. proposed an improved DV-Hop localization algorithm, to improve the algorithm performance by defining new data format [9]. Guangjie Han etal. combined with the mobile models of anchor nodes, RWP, RD and RPGM, proposed DV-Hop localization algorithm based on MWSN, the simulation results showed that the algorithm was suiTable for MWSN application [10]. Bai Wei etal. put forward an improved DV-Hop algorithm of BA and DV-Hop algorithm fusion. The algorithm firstly uses DV-Ho algorithm to determine the coordinates of the unknown nodes preliminarily, and then uses BA to correct the error of DV-Hop localization algorithm, effectively improve the positioning precision [11]. Li Juan etal. proposed a kind of sensor network DV-Hop localization algorithm based on double communication radius. When use DV-Hop algorithm to locate, beacon node successively uses two communication radii to broadcast its own position to get the more accurate hop count between the unknown node and beacon node, to get more accurate location information [12]. Zhao Yanhang etal. put forward a kind of DV-Hop

localization algorithm based on hop distance adjustment particle swarm optimization. Through improving data group of anchor node broadcasting, make weight processing for the error of the average distance of each hop for reference of anchor node, and use improved PSO algorithm to optimize the iterative process of positioning, the positioning accuracy of the algorithm is improved [13]. Hui-min Song etal. proposed a kind of DV-Hop localization algorithm based on artificial neural network, combined with the radial basis function (RBF) and node count theory, through the process of near to far positioning gradually, the positioning precision is improved [14]. Jiang Yusheng etal. proposed a kind of DV-Ho calibration algorithm based on trusted neighbor distance estimation. It defines a new neighbor distance estimation algorithm according to combine the distance between neighbor nodes and network connectivity differences, the more accurate neighbor distance is calculated; And a trusted neighbor distance as the calibration standard to correct estimation position of the unknown node [15]. In this paper, the research is at the basis of a summary of the preorder research, look the node distance correction as the breakthrough point to study.

3. DV-Hop Localization Algorithm based on Node Distance Correction

To some extent, although DV-Hop localization algorithm estimated the location information of the unknown node, and in the algorithm, the average distance of each hop is implemented simply in the form of a simple division between the actual distance of two anchor nodes and their hop count. It is obviously that, in most cases, the calculated average distance of each hop is significantly reduced compared with the actual value. In the traditional DV-Hop localization algorithm, the average distance of each hop is implemented by the actual distance between two communication-capable anchor nodes dividing the hop count of them. The premise of the calculation method with high accuracy is the anchor node and intermediate nodes are on the same straight line, it is shown in Figure 1. In the actual network structure, it often does not have the problem, unless the hop count between two anchor nodes is 1, that is, the two anchor nodes are adjacent communication-capable nodes. When intermediate node and anchor node are not in the same line, obviously, the average distance of each jump is reduced using this kind of method to calculate, it is shown in Figure 2. The deviation is led to the deviation of positioning results. In most cases, the influence caused by the deviation for positioning accuracy is very big.

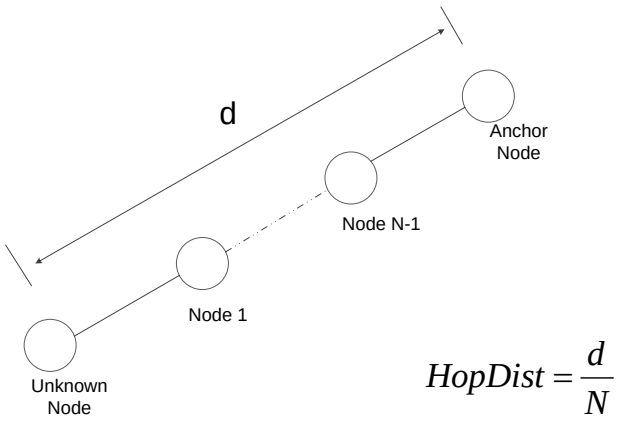

Figure 1. Linear Structure Diagram of Anchor Node, Intermediate Node and Unknown Node (Ideal)

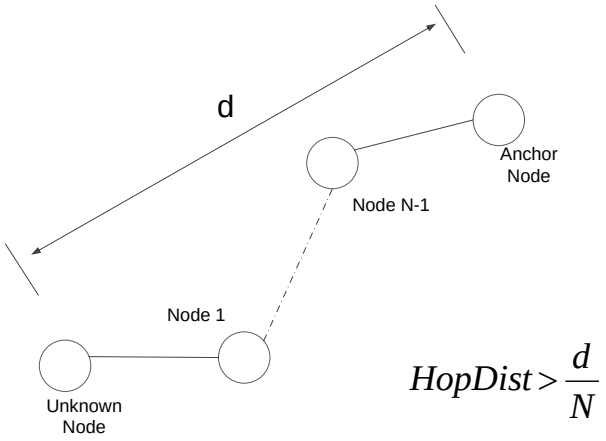

Figure 2. Nonlinear Structure Diagram of Anchor Node, Intermediate Node and Unknown Node (Actual)

In order to reduce the deviation shown in Figure 2 on the influence of the positioning accuracy, this paper proposes a DV-Hop localization algorithm based on node distance correction, that is DA-DV-Hop (Distance Adjustment DV-Hop). Its basic idea is the distance calculated in correction DV-Hop location between the unknown node and anchor node as the goal. Through introducing node communication radius R to DV-Hop positioning and adjusting the value of distance correction factor to adjust the distance calculated in the original DV-Hop positioning between the unknown node and anchor node, make it be closer to the real value, the specific calculation method is shown in equation (2).

$$\hat{d} = (1 + \frac{hop - \frac{d}{\alpha R}}{hop})d \qquad 2$$

Where, $\hat{d}$ is the distance of the unknown node and anchor node after correction, d is the distance calculated in the original DV-Hop positioning between the unknown node and anchor node, R is the communication radius of the node, αis the distance correction factor ($0<\alpha\leq 1$), hop represents the hop count the unknown node is away from the anchor node.

From the above, it can be known that,

$$\begin{aligned} \hat{d} &= (1 + \frac{hop - \frac{d}{\alpha R}}{hop})d \\ &= (1 + 1 - \frac{d}{\alpha R hop})d \\ &= (2 - \frac{HopDist \cdot hop}{\alpha R hop})d \\ &= (2 - \frac{HopDist}{\alpha R})d \end{aligned} \qquad 3$$

From (3) shows that the adjusted distance is the function about the average distance of each hop, the original distance, node communication radius and distance correction factor. The only assumption the article based is that all node communication radii are uniform.

4. Simulation Analysis

This paper uses simulation tools Matlab7.1 for comparing the traditional DV-Hop localization algorithm and DV - Hop localization algorithm based on the anchor node distance correction, and the simulation specific simulation scenario is as follows:

(1) Arrange 200 sensor nodes randomly in the area of 1000 x 1000 random;

(2) All sensor nodes have the same structure and the same communication radius;

(3) All sensor nodes are uniform distribution and mobile;

The concrete network parameter setting in the simulation is shown in Table 1.

Table 1. The Concrete Simulation Parameter Setting of Network

Simulation parameter	setting
Packet length	1000Byte
Space propagation model	Free Space Propagation
Modulation method	DSSS
MAC layer	802.11b DCF（RTS/CTS）
Network layer	AODV
service types	CBR

In order to explore the performance of the algorithm, the author sets up the positioning network with anchor node density respectively being10%, 20%, 30% and 40%. When the anchor node density is10%, 20%, 30%, 40%, the distance correction factor αon the influence of position error, is shown in Figure 3.

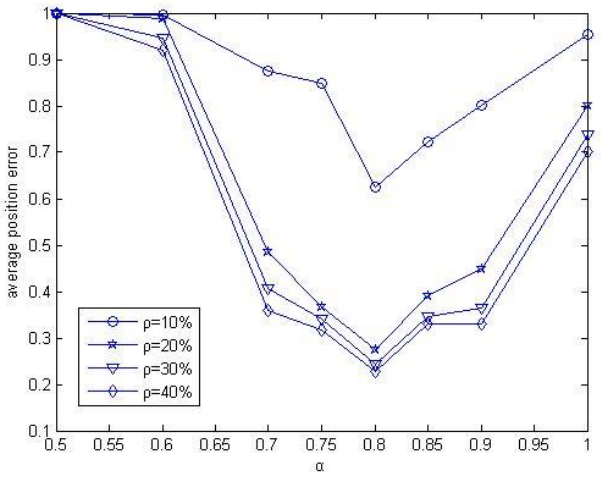

Figure 3. The Distance Correction Factorαon the Influence of DV-Hop Positioning Error

From Figure 3, the average positioning error decreases with the increase of the anchor node density ρ, which shows that algorithm performance improves with the increase of the node density in a certain range. Even though the above anchor node

density difference exists, and the positioning performance change trend the algorithm shows is the same; that is in the near of distance correction factorα=0.8, the positioning error DA-DV-Hop algorithm is small, until close to the optimum. However, near the value range, under the condition of value quantity difference ±0.05fluctuation, would cause the positioning error of the algorithm increase.

At the same time, the author has also explored, under the different distance correction factor, the change of the algorithm positioning error the paper put forward with the anchor node density, is shown in Figure 4.

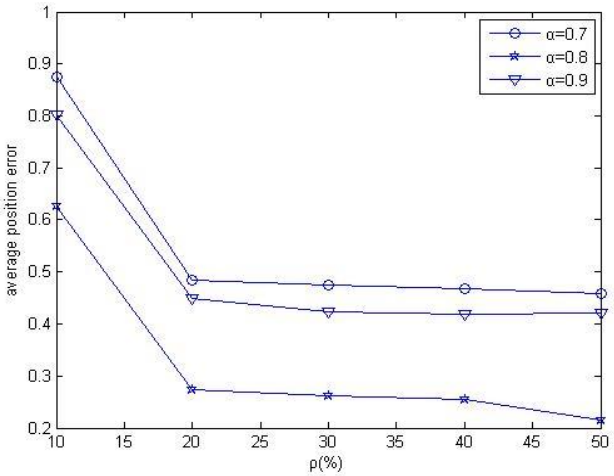

Figure 4. Different Correction Factor α value DV-Hop Positioning Error Effect

From Figure 4, when α is 0.7, 0.8 and 0.9 respectively, the average positioning error of the node decreases with the increase of the anchor node density, and the positioning effect is not consistent. When α=0.8, the average positioning error of the node are excellent relatively to other α values.

Comprehensively, the simulation results of Figures 3 and 4 show that, under the same density condition of anchor node, the influence of different distance correction factor on improving algorithm positioning precision is different; In such a case that the anchor node density and distance correction factor changes at the same time, there exists that improve α value of the improved algorithm positioning precision to make the positioning precision of the improved algorithm improve much.

Finally, the author compares the DA-DV-Hop localization algorithm the paper put forward with the traditional DV-hop localization algorithm and the average positioning error of node in the network of the TC-DV-Hop localization algorithm proposed in the literature [12], is shown in Figure 5.

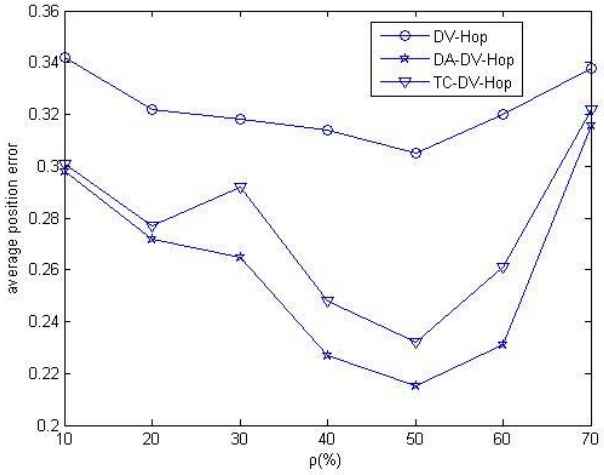

Figure 5 The Average Positioning Error Comparison of the Node in the Network

In Figure 5, the value of distance correction factorαof DA-DV-Hop localization algorithm is 0.8. It can be seen in the Figure that due to the introduction of the concept of distance correction, the positioning accuracy of DA-DV-Hop algorithm is significantly higher than the traditional DV-Hop localization algorithm. The average localization error of node in DA-DV-Hop algorithm is reduced 15.53% than the traditional DV-Hop localization algorithm. Simultaneously, the average localization error of node in DA-DV-Hop algorithm is slightly better than the localization algorithm proposed in the literature [12].

5. Conclusion

This paper proposes a DV-Hop positioning algorithm based on node distance correction, by introducing the concept of distance correction factor and combining the node communication radius between the unknown node and anchor node distance to adjust the average distance of each hop to make the average distance of each hop is closer to the reality. The simulation results show that DA-DV-Hop algorithm can effectively reduce the average positioning error of network nodes. In the case of distance correction factorα=0.8, positioning precision is improved 15.53%.

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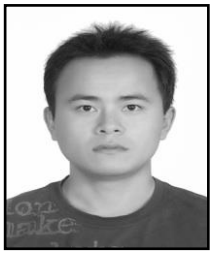

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