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Node Hop Distance Error Optimization of Improved DV-Hop Localization Algorithm in Wireless Sensor Network

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Abstract

Based on the lower accuracy of classic DV-Hop localization algorithm, this thesis puts forward an improved DV-Hop localization algorithm. In the second phase of the improved algorithm, through selectively modifying the shortest path table, the hop distance error of a hop anchor node is reduced by using the neighbour node overlapping estimation, and the average hop distance is calculated with the two poles of whole network and local network. Meanwhile, the hop count distribution from nodes to corresponding anchor nodes within the communication range of nodes is used to modify the hop distance of N hop nodes, and the simulation experiment is conducted. The experimental results show that, in the experimental scene, the accuracy of the improved DV-Hop localization algorithm is about 10% higher on average than that of the classical DV-Hop localization algorithm.

Keywords

WSN; DV-Hop; Hop Distance Error Optimization.

1. Introduction

Wireless sensor network is a new information acquisition and processing system which integrates wireless communication, perception, embedded computing, distributed information processing and other technologies [1]. Wireless sensor network is widely used in military defense, intelligent transportation and other fields. In these application fields, it is required that wireless sensor network must have reliable positioning technology.

WSN has many positioning algorithms [2]. At present, there are three common classification methods: ranging algorithm and non-ranging algorithm, single-hop algorithm and multi-hop algorithm, distributed algorithm and centralized algorithm. It is generally believed that the algorithm classification based on distance measurement and non-distance measurement is clearer [3]. Positioning algorithm based on distance measurement is to measure the distance between nodes or angle information through ranging technology, and there are many technologies which can realize distance measurement, and the commonly used ones are RSSI ranging, TOA ranging, TDOA ranging etc. [4]. Non-ranging localization algorithm calculates the location of unknown nodes through network connectivity and the way of sending messages between nodes, and they are mainly DV-Hop algorithm, centroid algorithm, etc. [5]. These algorithms have lower power consumption and lower positioning precision [6].

2. Classical DV-Hop Localization Algorithm

The positioning process of classical DV-Hop algorithm is completely dependent on network connectivity, and it doesn't need additional hardware support. Unknown nodes have no primary or secondary distinction, and the location coordinates of the nodes are calculated by

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themselves [7]. The nodes receive the anchor node information of the whole network through the way of hop-by-hop transmission to improve the positioning accuracy [8]. DV-Hop algorithm shows a lot of advantages such as good robustness and adaptability, but it has shortcomings in positioning accuracy, which are mainly reflected in the following two aspects:

First: The error of the estimated distance between the unknown node and the anchor node basically determines the positioning accuracy of the algorithm [9]. The hop distance got by the product of average hop distance and minimum hop count is used to replace the linear distance between two nodes, so the accuracy of the network average hop distance and the tortuosity of the shortest path seriously affect the deviation degree of the hop distance .

Second: Classic DV-Hop algorithm is an algorithm which conducts self-positioning through taking the information provided by anchor nodes as the criterion, so it puts forward certain requirements for the number and distribution of anchor nodes [10]. First of all, only when the direct node monitors the information of three or more nodes can the localization process be performed normally, otherwise, the localization fails. This affects the positioning coverage of the localization algorithm. Secondly, the positioning accuracy is usually related to the topological relationship between unknown nodes and anchor nodes under the condition of the same hop distance error.

3. Improved DV-Hop Localization Algorithm

Aiming at the shortcomings of the above DV-Hop algorithm, and based on the concept of not increasing any cost of classic DV-Hop algorithm, this thesis discusses how to optimize the nodes' hop distance error of the algorithm. The improved algorithm mainly solves the following problems:

First: Seek a new controllable flooding protocol, which does not reduce the reliability of flood broadcast but reduces information implosion, overlap and other phenomena, so as to achieve the purpose of reducing the number of packets sent. The communication cost of nodes can be reduced to the maximum extent on the basis of satisfying positioning accuracy and positioning coverage.

Second: Find a balance point between the reduced traffic and positioning coverage of packet radio. More precisely, a formula is proposed to find the equilibrium point on limiting the value of the minimum hop count and the number of anchor nodes monitored by unknown nodes.

Third: Find some new methods to modify the hop distance error of nodes, and the influence of measurement error on the positioning results is reduced by means of iterative refinement.

The improved DV-Hop algorithm is divided into four stages: information broadcast, distance calculation, localization calculation and bad node localization.

Stage 1: When the network is initialized, all nodes obtain the set of neighbor nodes of the neighbor nodes. After the initialization is completed, the information is adopted, and all nodes obtain the hop count between this node and all anchor nodes and GPS coordinates of each anchor node through controllable flood broadcast. All last hop nodes ID in the shortest path from all anchor nodes.

Stage 2: First of all, selectively modify the shortest path table and correct the minimum hop count which is probably too large. Secondly, the optimal unbiased estimation method is used to calculate the average hop distance of the whole network and broadcast to the network. When calculating the average hop distance with anchor nodes, the unknown nodes are used to calculate the hop distance of the anchor nodes with the minimum hop in the shortest path table by the overlapping degree of neighbor nodes. Thirdly, after the unknown nodes receive the average hop distance of the entire network broadcast by each anchor node, the node's average hop distance of two-stage optimal and unbiased estimation which takes into account both

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whole network and local network is calculated. Finally, the hop distance between this node and non-hop anchor nodes is calculated.

Stage 3: Obtain more than three nodes with anchor node information, and use anchor node selection optimal strategy to select the appropriate anchor node group. Then the maximum likelihood estimation method is used to calculate the localization.

Stage 4: After completing localization, the unknown nodes failed to conduct self-positioning send localization request to their neighbour nodes, obtain the coordinates information of neighbouring unknown nodes which have localized, and then the hop distance is calculated by using neighbour node overlapping. Self-positioning is carried out when the obtained anchor node information is greater than three.

4. Simulation Experiment Analysis and Results

Under the circumstance of no special instructions, the following scenario layout is adopted for the experiment in this chapter: (1) Monitoring area: 1000 m * 1000 m;(2) Node communication radius R: 200 meters;(3) Total number of nodes: 200;(4) Ratio of anchor nodes: 10%.

The above parameters are selected to make the network connectivity and the total number of nodes present a linear relationship. Currently, the average network connectivity basically maintains at around 20. When the total number of nodes changes by 10, the average connectivity of the network changes by 1.

4.1. Hop Distance Error of One Hop Nodes

In order to verify the accuracy of calculating the hop distance of one hop nodes with the node overlap degree, Compare the true distance corresponded by the overlap degree of all nodes in the network and the estimated distance calculated by using the fitting function, see Figure 1.

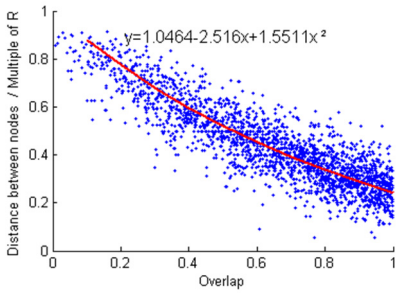

Figure 1. The relationship between overlap and the distance

The point set is the true hop distance corresponded by the overlap degree of nodes, and the curve is the fitting curve. From Figure 1, it can be seen that the trend of fitting curve basically conforms to the correspondence between the overlapping degree of nodes and actual hop distance, and there is only a certain error range.

Under the experimental scenario where the ratio of anchor nodes is 10% and the connectivity of networks is different, the hop distance error of one hop distance of the classical algorithm and improved algorithm in this paper, see Figure 2.

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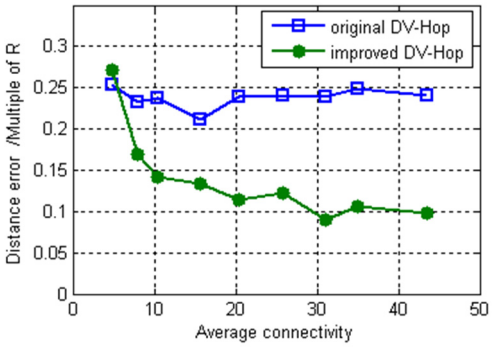

Figure 2. Distance error of one hop nodes

It can be seen from the experimental results that when the density of network nodes is large, the accuracy of calculating the distance between nodes by the overlapping degree of nodes is higher. When the network connectivity is over 20, the hop distance error can reach about 10%, and the precision is basically about 10% higher than that of the original algorithm. However, when the connectivity is below 5, the improved algorithm is slightly inferior to the original one. This is because the higher the density of nodes is, the more accurate the distance is in the overlapping area where the overlap degree is closer to the two nodes.

4.2. Hop Distance Error of N Hop Nodes

When the ratio of anchor nodes is 10% and network connectivity is different, the hop distance error of n-hop nodes of the classical algorithm and the improved algorithm in this paper, see Figure 3.

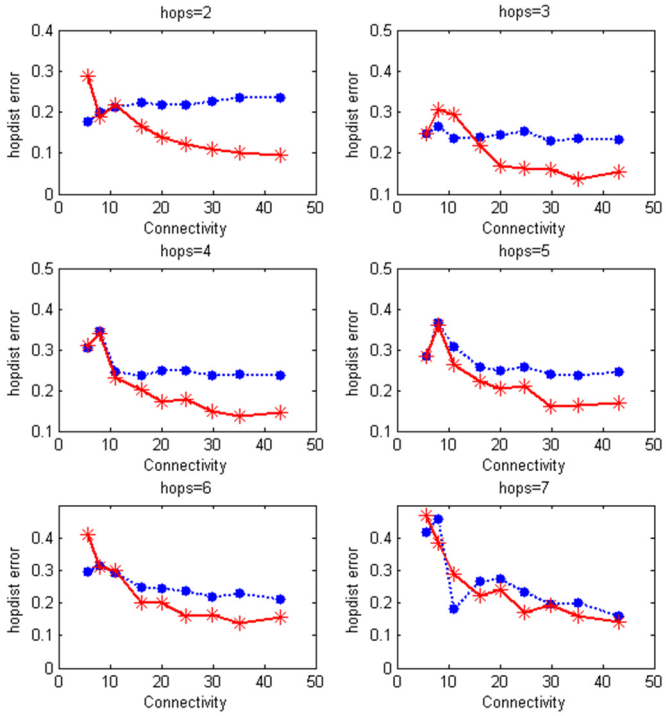

Figure 3. Hop distance error of N hop node

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As can be seen from the figure, when the network connectivity is greater than 10, the hop distance of the improved algorithm is obviously better than that of the classical algorithm. But when the hop count increases, the error decreases less.

When the network connectivity is 20 and the ratio of anchor nodes is different, the hop distance error of n-hop nodes of the classical algorithm and the modified algorithm in this paper, see Figure 4.

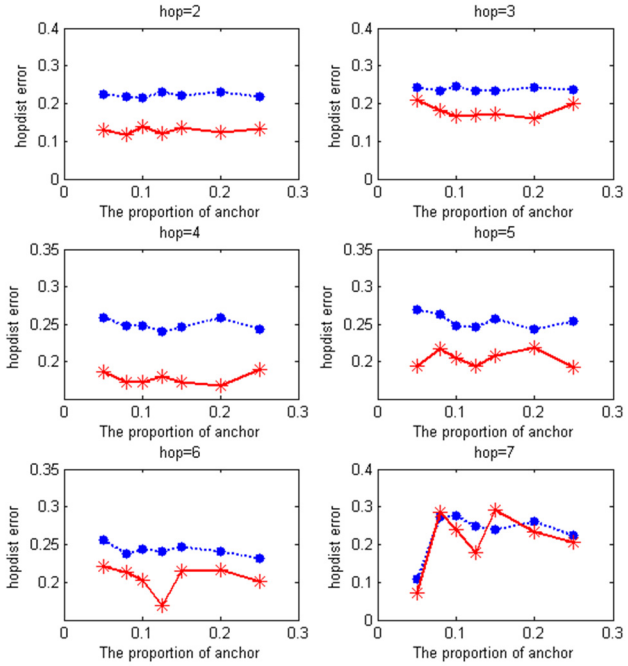

Figure 4. Hop distance error of N hop node

As can be seen from the figure above, the hop distance error of N hop nodes is basically independent on the ratio of anchor nodes.

4.3. Average Hop Distance Error of the Network

When the ratio of anchor nodes is 10% and the network connectivity is different, and when the network connectivity is 20 and the ratio of anchor nodes is different, the network average hop distance error of the classic DV-Hop algorithm and the improved algorithm in this paper, see Figure 5.

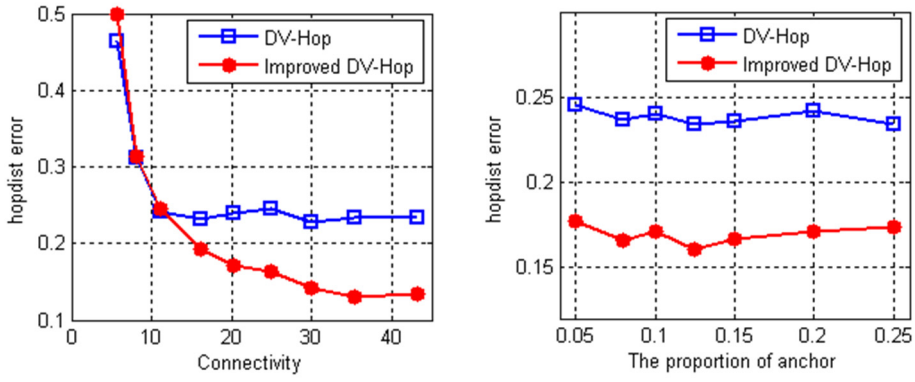

Figure 5. Hop distance error of network

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As can be seen from the figure above, the calculation method of hop distance in this paper reduces the average hop distance error of the network by about 10%. With the increase of network connectivity, the improvement effect is better.

5. Conclusion

This thesis puts forward an improved DV-Hop localization algorithm, which mainly proposes to use the overlap degree of neighboring nodes to replace overlapping area and calculate node spacing according to the conversion relation between the overlapping area of the node communication coverage and the center distance. So, it can more correctly modify the hop distance of one hop nodes under the circumstance of increasing the minimum traffic. According to the relationship between the overlapping area of N hop area of anchor nodes and communication coverage of nodes and the distance between two points, a conversion relation between hop count distribution proportion and distance of neighbour nodes is proposed, to more accurately modify the hop distance of nodes of two hops and more than two hops. The experimental results show that in the experimental scenario, the accuracy of improved DV-Hop localization algorithm is about 10% higher than that of the classic DV-Hop localization algorithm, and the improved algorithm has higher localization accuracy than the classical DV-Hop algorithm, achieving the purpose of improving precision.

Acknowledgments

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