The Expansion of 3D wireless sensor network Bumps localization

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Abstract:
Bump localization of wireless sensor network is a hot topic, but present algorithms of 3D wireless sensor node localization arenot accurate enough. In this paper, the DR-MDS algorithm is proposed. DR-MDS algorithm mainly calibrates the coordinates of nodes and the ranging of nodes based on multidimensional scaling, it calculates the distance between any nodes exactly according to the hexahedral measurement, introducing a modification factor to calibrate the measuring distance by Received Signal Strength Indicator (RSSI). Results of simulation show that DR-MDS algorithm has significant improvement in localization accuracy compare with MDS-MAP algorithm.

Key Words: Node localization; Localization accuracy, Wireless sensor networks; Distance correction;

I. INTRODUCTION
Wireless sensor network (WSN) is composed of wireless sensor nodes which can communicate and calculate [1], because of its low cost, versatile and combined with multi-gate technology, WSN has been known as one of the most influential technology in the twenty-first century. Currently, Wireless sensor networks are widely used in national defines and environmental monitoring [2].

The use of wireless sensor networks to determine the importance of the wireless sensor node localization in wireless sensor network technology. Depending on whether measuring distance, current wireless sensor node localization algorithms can be divided into two localization mechanism, range-based and range-free [3]. Range-based mainly locate the position of nodes through the distance, range-free don’t need to know the distance and orientation of nodes, it only locates the position of the nodes by estimating, but the accuracy of range-based is higher than range-free. Basic method of measuring distance includes Received Signal Strength Indicator (RSSI), Time Difference of Arrival (TDOA) and Angle of Arrival (AOA). RSSI is widely used because it is convenient and more accurate. At present, most wireless sensor network localization mechanism generally only consider two-dimensional plane. But as more and more high requirements for positioning accuracy, localization mechanism which only considers two-dimensional plane meet the requirements gradually. Comparing with the algorithm which only considers two-dimensional plane, localization algorithm that considers three-dimensional space has more problems to solve. The main problem is how to improve the distance accuracy. The common localization algorithm which considers three-dimensional space is MDS-MAP algorithm. But MDS-MAP algorithm are not very accurate, it has a distance deviation. In this paper, A novel localization algorithm in three-dimensional space is proposed, the new algorithm named DR-MDS algorithm. IN this algorithm, measuring the distance by Received Signal Strength Indicator when the distance of two nodes within 1 hop count, measuring the distance by hexahedral algorithm when the distance between two nodes over 1 hop count, thus, we can calculate the distance of all nodes. After that we can locate the position of wireless sensor nodes by MDS technology. Lastly, using MATLAB to simulate the DR-MDS algorithm.

II. EXISTING CLUSTERING ROUTING PROTOCOL FOR WSNS
According to the topology, routing protocols in wireless sensor networks can be approximately divided into two major categories, e.g. flat routing protocol and clustering routing protocol. In the flat routing protocol, relations of all wireless sensor nodes will be in a position of equality, the advantages of this kind of routing protocol include simple structure and good scalability, but a position of equality means that there is no management node, this will lead to the shortage of resources to optimize the internal network and slow response to changes [4]. In the clustering routing protocol, the network is composed of many clusters, The cluster is gotten together by a series of nodes according to the corresponding demand, cluster...
is composed of a cluster head node and a plurality of member nodes, a plurality of cluster head consists a senior cluster. So the network can be composed of the most senior cluster head and a network base station finally. The topology structure of the clustering routing protocol is shown in Figure, the advantages of the clustering routing protocols mainly have 2 aspects [5]: (1) The underlying cluster members can choose to close temporarily when its need, it can reduce energy consumption of wireless sensor network. (2) The cluster members send information to the cluster head, the cluster head forward the information after integrating all information, it can reduce the number of information. The common wireless sensor network clustering routing protocol is divided into two categories, The clustering routing protocol based on random election and the clustering routing protocol based on residual energy. Analyzing the common clustering routing protocol based on random election and the clustering routing protocol based on residual energy can be found in the following.

![Topology structure of the clustering routing protocol](image)

2.1 The Clustering Routing Protocol Based On Random Election

The most representative clustering routing protocol based on random election is LEACH [6] (Low-energy adaptive clustering hierarchy), LEACH use a cycle mode, each cycle is composed of cluster establishment and data communication, next is specific process, The first step is the cluster head election, Base station notice other nodes in the wireless sensor network that this node is a cluster head, the ordinary cluster members select recent cluster head according to the distance, then the cluster is created. After a round of cycle, \( T_n \) been elected cluster head will be set to 0, thus the node that has been elected to cluster head will not be elected again. As more and more nodes were selected as the cluster head, the probability of node that has not been selected is bigger. This method ensures that every node can be elected to cluster head, when the cluster head is elected, nodes start communication within cluster, cluster members send the information to the cluster head, and cluster head integrates the information and send to the base station. The cluster is dismissed until the end of the cycle, wireless sensor nodes re-select cluster head and reorganize cluster.

LEACH is very simple, the threshold ensures the chance that each node is selected as the cluster head is equal, all nodes share energy consumption of cluster head, effectively extending the network lifetime, LEACH is a clustering algorithm, a lot of communication energy of nodes can be saved. But LEACH also has disadvantages. First, nodes consume a lot of energy when they elect cluster head, the LEACH requires the restructuring every circle, it wastes a lot of energy. Second, the chance of each node which is selected as the cluster head is equal, but it does not consider the residual energy of nodes, and there is no law about the distribution of cluster head, the "dead node" will appear in wireless sensor networks, the entire wireless sensor network will be split, even lead to paralysis of wireless sensor networks. Although LEACH is simple enough, it is not suitable for large networks. Based on the inadequate LEACH, the ERP (efficient routing protocol) [7] is put forward, it is quite suitable for large networks. The ERP mainly uses a smart algorithm to cluster networks, in order to ensure wireless sensor networks is more robust and stable, it uses a double layer routing mechanism, the first layer is using a distributed algorithm within cluster, the second layer is use ant colony optimization algorithm between clusters, although this algorithm can increase the stability of the network, but the "dead node" will appear on wireless sensor networks also, it is not ideal to extend the life of the entire wireless sensor network.

2.2 The Clustering Routing Protocol Based On Residual Energy

With the development of wireless sensor network technology, the increasing requirements of wireless sensor node localization accurate results in the widely usage of localization mechanism of range-based. We must know the distance between the wireless sensor nodes, before the wireless sensor node localization. Generally, we measure the distance by Received Signal Strength Indicator, measuring distance between the nodes by RSSI is based on the consumption between sending signals and receiving signals. If the power of transmission is 1 and the power of acceptance the distance between the nodes can be calculated out by using the formula of the Two Ray radio wave propagation loss. The product of sending antenna gain magnitude and receiving antenna gain magnitude is the wavelength of the radio wave, \( S \) is the transmission distance, \( K \) is the adjustment factor which is unrelated with the distance of nodes between the nodes by TDOA is based on the difference of time between sending
III. DR-MDS ALGORITHM

When locating the wireless sensor nodes in three-dimensional space, how to improve the accuracy of the metrical distance between the wireless sensor nodes is a pivotal problem. Generally, it can be processed by measuring the distance with RSSI. But hardware of ranging will seriously affect the accuracy of the nodes ranging. Measuring the distance with RSSI when the distance between two nodes over 1 hop count will waste a lot of energy. According to these two problems, this paper proposes an algorithm by regulating the distance of measurement method and hexahedral measurement method, named DR-MDS algorithm.

As shown in Figure 1, acorn nodes B,C,D and unknown node A are neighbour nodes, beacon nodes B,C,D and unknown node E are neighbour nodes, the distance between A and E over 1 hop count, so we calculate the distance with hexahedral measurement method. The principle of hexahedral measurement method is shown in Figure 1, building a three-dimensional coordinate system, the node B is coordinate origin, X-axis is BC, Δ BCD plane is X-Y plane, coordinates of the nodes are A(x_a, y_a, z_a), B(0,0,0), C(x_c, y_c, 0), D(x_d, y_d, 0) and E(x_e, y_e, z_e).

The coordinates of B,C and D are known, the coordinates of the node A can be solved by the Equation. Similarly the coordinates of node E can be solved, so we can get the distance of AE is

\[(x_{a_e})^2 \quad (y_{a_e})^2 \quad (z_{a_e})^2 \]

there are two obvious solutions of AE when A and E lie the same side of Δ BCD and the different side of Δ BCD. Because of the distance between two nodes over 1 hop count, so A and E lying the different side of Δ BCD. As shown in Figure 6, we can get the distance of any two wireless sensor network nodes by multiple calculate.

Calculating the distance of every nodes

Into 3D wireless sensor networks, the distance between the beacon nodes can be got with GPS, but the distance between the beacon node and the
unknown node only can be got by calculating or measuring, moreover, RSSI will seriously affect the accuracy of the nodes ranging, so we can command the beacon node to pretend an unknown node, calculate the range deviation between this unknown node and another beacon node, then calculating the difference of the actual distance and the calculative distance. After that, we can calculate the coordinates with MDS, the difference of the actual coordinates and the calculative coordinates is calculated. So we can improve the accuracy of wireless sensor node localization by these two methods.

The DR-MDS algorithm and the MDS-MAP algorithm are simulated with MATLAB, analysing the localization accuracy of two algorithms from the communication radius, the number of beacon nodes and the calculated deviation factor under the uniform topology model. Deploying 150 nodes in the range of 100*100 randomly, the number of beacon nodes is 10, considering the relationship of the communication radius and localization accuracy, the result is shown in Figure 7, when the communication distance is changed from 20m to 35m, localization accuracy of DR-M algorithm has significantly improved compared to the localization accuracy of MDS-MAP. With the improvement of communication radius, localization is more accurate, but the difference of this two algorithms is more and more small. This describes that when the communication radius increases, the advantage of DR-MDS is not extremely huge. Furthermore, with the communication radius increases, the energy consumption increases significantly, so we need to make a reasonable choice about the energy consumption and the localization accuracy.

Deploying 150 nodes in the range of 100*100 randomly, communication radius is 20 meters, considering the relationship of the number of beacon nodes and localization accuracy, the result is shown in Figure 8, when the number of beacon nodes is changed from 5 to 29, localization accuracy of DR-MDS algorithm has significantly improved compared to the localization accuracy of MDS-MAP. With the number of beacon nodes increasing, localization is more and more accurate. This mainly due to the modification factor K of the measuring distance, when the number of beacon nodes increasing, K is more and more accurate. But when the number of beacon nodes increases enough, the improvement of the localization accuracy is not manifest since the cost of the beacon node is more expensive than ordinary nodes. There is no necessary to deploy a large number of beacon nodes.

IV. CONCLUSIONS AND DISCUSSIONS

This DR-MDS algorithm is introduced in order to improve the localization accuracy of 3D wireless sensor networks in this article. DR-MDS algorithm mainly calibrates the Coordinates of nodes and the ranging of nodes. The DR-MDS algorithm and the MDS-MAP are simulated with MATLAB, analysing the localization accuracy of two algorithms under the uniform topology model from the communication radius, the number of beacon nodes and the calculated deviation factor. The conclusion can be made that the DR-MDS algorithm can significantly improve the localization accuracy of 3D wireless sensor networks, DR-MDS algorithm has dramatically advantages compared with other localization algorithms. Furthermore, the DR-MDS algorithm has a positive effect in the relatively bad environment.
REFERENCES


