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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 coordinatesof nodes and the ranging of nodes based on multidimensional scaling, it calculates the distance between any nodes exactlyaccording to the hexahedral measurement, introducing a modification factor to calibrate the measuring distance by ReceivedSignal Strength Indicator (RSSI). Results of simulation show that DR-MDS algorithm has significant improvement inlocalization accuracy compare with MDS-MAP algorithm.
Key Words: Node localization; Localization accuracy, Wireless sensor networks; Distance correction;

I. INTRODUCTION

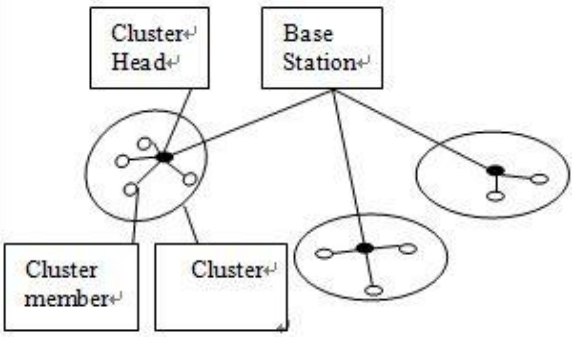
Wireless sensor network (WSN)is composed of wireless sensor nodes which can communicate and calculate[1],
because of its low cost, versatile and combined with multi-gate technology, WSN has been known as one of the mostinfluential technology in the twenty-first century. Currently,Wireless sensor networks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

The use of wireless sensornetworks to determine the importance of the wireless sensornode localization in wireless sensor network technology.Depending on whether measuring distance, current wirelesssensor node localization algorithms can be divided into two localization mechanism, range-based andrange-free[3], Range-based mainly locate the position ofnodes through the distance, range-free don't need to knowthe distance and orientation of nodes, it only locates theposition of the nodes by estimating, but the accuracy ofrange-based is higher than range-free. Basic method ofmeasuring distance includes Received Signal StrengthIndicator (RSSI),Time Difference of Arrival (TDOA) and Angle ofArrival(AOA). RSSI is widely used because it is convenientand more accurate. At present, most wireless sensor networklocalization mechanism generally only consider two-dimensional plane. But as more and more high requirementsfor positioning accuracy, localization mechanism which onlyconsiders two-dimensional plane meet the requirementsgradually. Comparing with the algorithm which onlyconsiders two-dimensional plane, localization algorithm thatconsiders three-dimensional space has more problems tosolve. The main problem is how to improve the distanceaccuracy. The common localization algorithm which considers three-dimensional space is MDS-MAP algorithmBut 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 majorcategories, e.g. flat routing protocol and clustering routingprotocol. In the flat routing protocol, relations of all wirelesssensor nodes will be in a position of equality, the advantagesof this kind of routing protocol include simple structure andgood scalability, but a position of equality means that thereis no management node, this will lead to the shortage ofresources to optimize the internal network and slow responseto changes [4], In the clustering routing protocol, the networkis composed of many clusters, The cluster is gotten togetherby a series of nodes according to the corresponding demand,cluster

is composed of a cluster head node and a plurality ofmember nodes, a plurality of cluster head consists a senior cluster, So the network can be composed of the most seniorcluster 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 mainlyhave 2 aspects [5]: (1) The underlying cluster members canchoose to close temporarily when its need, it can reduceenergy consumption of wireless sensor network. (2) Thecluster members send information to the cluster head, thecluster head forward the information after integrating all information, it can reduce the number of information. The common wireless sensor network clustering routingprotocol is divided into two categories, The clustering routing protocol based on random election and the clusteringrouting protocol based on residual energy. Analysing thecommon clustering routing protocol based on randomelection and the clustering routing protocol based on residualenergy can be found in the following.



Topology structure of the clustering routing protocol

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 moreand 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 betweenclusters, 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 he 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 timebetween sending

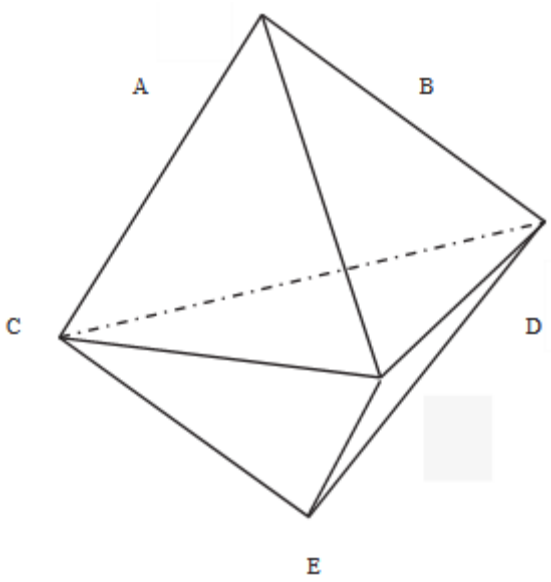
signals and receiving signals. Generally, in order to save energy of the nodes, signal transmission is carried out within one hop count, it leads to the signal propagation time becomes relatively short, therefore, TDOA requires an extremely accurate clock.
After we know the distance between wireless sensor nodes, there are three common localization method, trilateration localization algorithm,

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 ,be 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, measuring this distance by RSSI will waste a lot of energy, so we calculate the distance with hexahedralmeasurement method. The principle of hexahedral measurement method is shown in Figure , 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,0,0),D(x_d,y_d,0) and E(x_e,y_e,z_e).

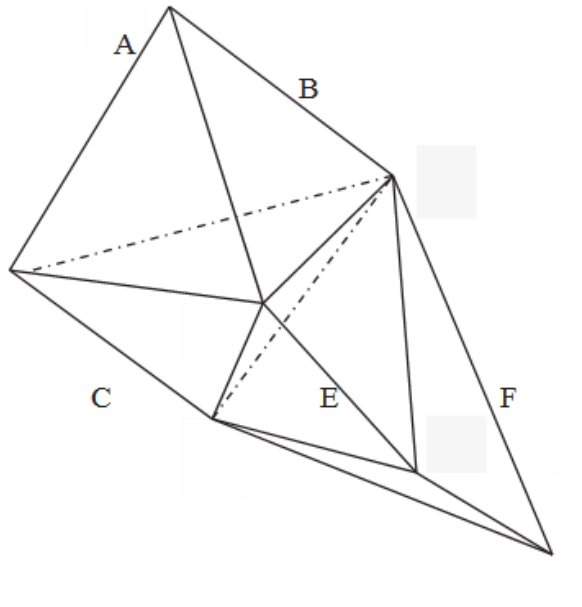
The coordinates of B,C and D are known, the coordinates of the node A can be solved by the Equation. Similarly the coordinates of node E can be solved, so we can get the distance of AE is
$(x_{a\_} x_e)^2 (y_{a\_} y_e)^2 (z_{a\_} z_e)^2$

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.



Hexahedralmeasurementmethod

Coordinates of beacon nodes are $B_1(_1,_1,z_1)$ $B_2(x_2,y_2,z_2)$,$B_3(x_3,y_3,z_3)$,...,$B_n(x_n,y_n,z_n)$, the coordinate of unknown node is M(x,y,z),$B_0(x_0,y_0,z_0)$ is the beacon node which pretends a unknown node. The actual distance between this unknown node B_0 and other beacon nodes B $_1$,B_2,B_3,...,B_n can be measured by GPS locating, e.g.s_1,s_2,s_3. We can also calculate the measuring distance between this unknown node B_0



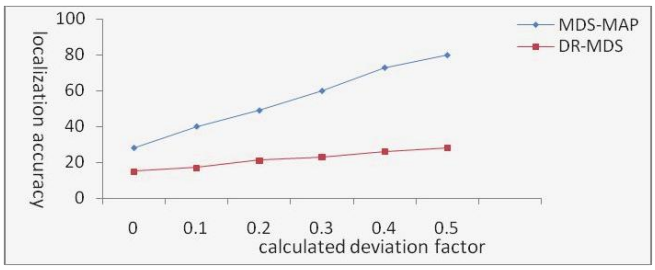
Calculatingthedistanceofeverynodes

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

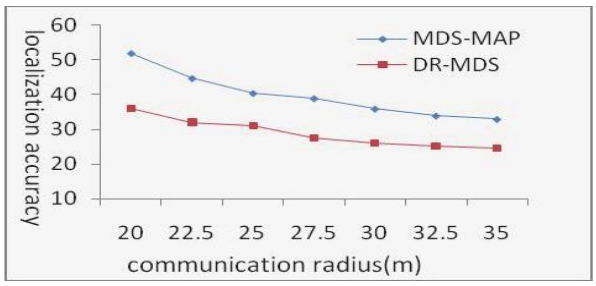
unknown node only can be got by calculating or measuring, moreover, RSSI will seriously affect the accuracy of the nodes ranging, so we can command the beacon node to pretend an unknown node, calculate the range deviation between this unknown node and another beacon node, then calculating the difference 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.

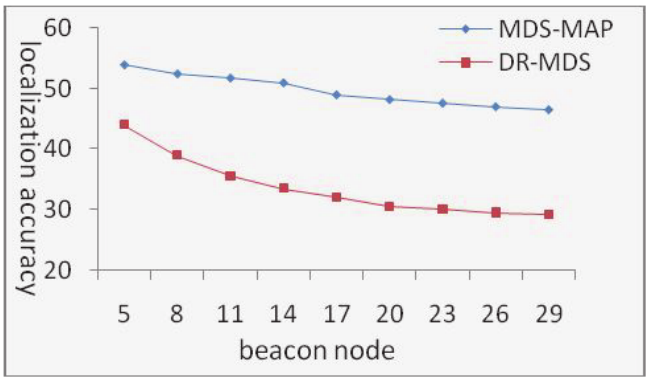
The DR-MDS algorithm and the MDS-MAP algorithm aresimulated with MATLAB, analysing the localization accuracyof two algorithms from the communication radius, the numberof beacon nodes and the calculated deviation factor under theuniform topology model. Deploying 150 nodes in the range of100*100 randomly, the number of beacon nodes is 10,considering the relationship of the communication radius andlocalization accuracy, the result is shown in Figure 7, when thecommunication distance is changed from 20m to 35m,localization accuracy of DR-M algorithm has significantlyimproved compared to the localization accuracy of MDS-MAP.With the improvement of communication radius, localization ismore and more accurate, but the difference of this two algorithmis more and\ more small. This describes that when thecommunication radius increases, the advantage of DR-MDS is not extremely huge. Furthermore, with thecommunication radius increases, the energy consumptionincrease significantly, so we need to make a reasonablechoice about the energy consumption and the localizationaccuracy.

Deploying 150 nodes in the range of 100*100 randomly,communication radius is 20 meters, considering therelationship of the number of beacon nodes and localizationaccuracy, the result is shown in Figure 8, when the numberof beacon nodes is changed from 5 to 29, localizationaccuracy of DR-MDS algorithm has significantimprovement compared to the localization accuracy of MDS-MAP. With the number of beacon nodes increasing,localization is more and more accurate. This is mainly due tomodification factor K of the measuring distance, when thenumber of beacon nodes increasing, K is more and moreaccurate. 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.



Relationship of the number of beacon nodes and localization accuracy





Relationship of the calculated deviation factor and localization accuracy

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.

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