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A NEW NODE SELF-LOCALIZATION ALGORITHM FOR WIRELESS SENSOR NETWORK USED IN THE BOREHOLE

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ABSTRACT

Determining the physical location of sensor nodes is the most basic requirement in most Wireless Sensor Networks (WSN) application. Wireless sensor network nodes' self-localization techniques are discussed and studied in this paper. At first, the organization structure of wireless sensor network, the classify of node location algorithmic and node location computing method are introduced, the significance of studying wireless sensor network node location is also stated. Considering the problem of large errors accused by beacon nodes collimation and uneven distributed beacon nodes in the process of locating, location algorithm based on radical center is put forward, by which, location errors caused by collinear beacon nodes can be natural filtrated by computing the radical centers between beacon nodes. The idea of weighted sharing is used to revise location errors and getting the position coordinates of unknown nodes, and algorithm' correctness is tested and verified by simulation experiment.

Keywords: *Wireless Sensor Networks, Node Location, Radical Center Algorithm, Cooperative Communication Technology, Computer Simulation*

1. INTRODUCTION

Wireless Sensor Networks (WSN) is a bran-new development direction in the field of information science, the technical studies of it involves is played to a close a attention, and it covers the technology of new branch of science and traditional disciplines, including embedded computing technology, wireless communication technology, microelectro-mechanical technology, distributed information processing technology, automatics, modern network technology etc.

Wireless Sensor Networks (WSN) is going to be seriously considered by both specialists and researchers as a new information collection and processing technology [1]. Wireless Sensor Networks (WSN) is characterized by self-organization, low-power consumption, inexpensive, rapid deployment, and good expansively and so on. It is appropriate for constructing information infrastructure at special moment or in special environment. Therefore, which has a broad applied prospects [2-5].

Since 1990's, the development of Wireless Sensor Networks, macrocosmically, has experienced studying sensor node, designing network communication protocol etc. It is becoming a new hot area of research and attracts researchers to make a all-around study about is and have made different progress, including large new nodes and communication protocol [6-8].

At present, wireless sensor network main research points include: energy saving as the goal of routing protocols, topology management and control, and in positioning research and simulation algorithm, with independent intellectual property rights of the content is less, the essay focuses on the research of wireless sensor network node localization algorithm itself.

(1) through the existing wireless sensor network node localization algorithm of learning and research, found that the anchor node collinear to the influence of the positioning accuracy is larger, at the same time, the use of three round heart collinear root heart does not exist mathematical theorem, the paper puts forward the localization process into round power theory to improve the positioning accuracy.

(2) in the calculation of the root due to heart,

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need to use RSSI values for distance measurement, in view of the RSSI value influenced by the environmental impact is bigger, in this paper based on RSSI range value correction, so as to reduce the environmental impact caused by the ranging error.

(3) In the root heart theorem further study and the study found that heart and round, the root between various positions, it will influence on location estimation in order to make this kind of for geometric position caused by the positioning error, this paper proposes using weighted thought for correction.

(4) at the end of the paper has also used the cycle positioning thoughts, to strive to improve the coverage of the algorithm.

2. WIRELESS SENSOR NETWORK LOCALIZATION

Generally speaking, the node localization need to bring some of the characteristics of wireless sensor network in position known reference node and is positioned between the node set up some related, such as radio or acoustic communication, etc. The sensor node localization process, unknown nodes to achieve in nearby anchor node distance, or get nearby anchor node and unknown node of the relative Angle between, often use trilateration method and triangulation method or maximum likelihood estimation method to calculate their own position. The theory basis of trilateral calculation is in three-dimensional space, know a node to more than three reference point distance, can determine the coordinates of the point. At present, many system relies on the rf signal measurement to obtain the distance between nodes, such as measuring rf signal strength, reach the time of arrival of the Angle, and so on. By this way, can provide for positioning a supplementary means, but communication signal is susceptible to environmental factors of interference.

Wireless sensor network localization using basic terms [9]:

(1)The Hop Count (Hop Count) : two nodes jump period of total, known as the two nodes of the Hop Count.

(2)The Neighbor node (Neighbor Nodes): sensor node communication radius of all other node, the node is called the Neighbor Nodes.

(3) The Time of Arrival (TOA, Time of Arrival): signal from one node to another node need Time, become signal Arrival Time.

(4)To Time (Time Difference of Arrival, TDOA) : two different propagation velocity signal from one node to another node need Time Difference, become signal Arrival Time Difference.

(5) To Angle (Angle of Arrival, AOA) : node received signals relative to their own axis Angle, called signal relative receiving node Arrival Angle.

(6) The Line of Sight relations (Line of Sight, LOS): between two nodes without any obstacles in the interval, can direct communication, known as the two nodes between Line of Sight relationship.

(7) The relationship between the line of sight (No LOS, NLOS) : between two nodes obstacles.

(8) Received Signal Strength (Received Signal Strength Indicator, RSSI) : node receives wireless Signal Strength size, called the Received Signal Strength.

2.1 Node location algorithm

(1) Dilatation and multilateral positioning

Measuring distance and then determining the node location.

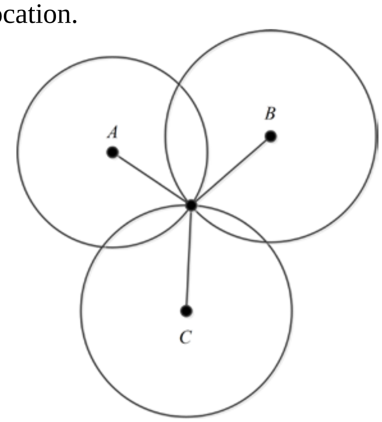

Fig.1 Triangular Measurement Icon

The principle of trilateration is shown as follows: as if the coordinate of beacon nodes A、B、C are (xa,ya)、(xb,yb)、(xc,yc), and the distance of A to D, B to D, and C to D are da, db, dc. D is the unknow node. Assuming D's coordinate is (x,y). then buildding up equations as below:

$$\begin{cases} \sqrt{(x-x_a)^2+(y-y_a)^2}=d_a \\ \sqrt{(x-x_b)^2+(y-y_b)^2}=d_b \\ \sqrt{(x-x_c)^2+(y-y_c)^2}=d_c \end{cases}$$

And we can get the coordinate of D from the fraction:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2(x_a-x_c) & 2(y_a-y_c) \\ 2(x_b-x_c) & 2(y_b-y_c) \end{bmatrix}^{-1} \begin{bmatrix} x_a^2-x_c^2+y_a^2-y_c^2+d_c^2-d_a^2 \\ x_b^2-x_c^2+y_b^2-y_c^2+d_c^2-d_b^2 \end{bmatrix}$$

(2) Triangulation

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The principle of triangulation is shown as chart 3-2, the coordinate of beacon nodes A、B、C are (xa,ya)、(xb,yb)、(xc,yc), The Angles between the A and D, B and D, C and D are ∠ADB，∠ADC，∠BDC, Assuming D's coordinate is (x,y).

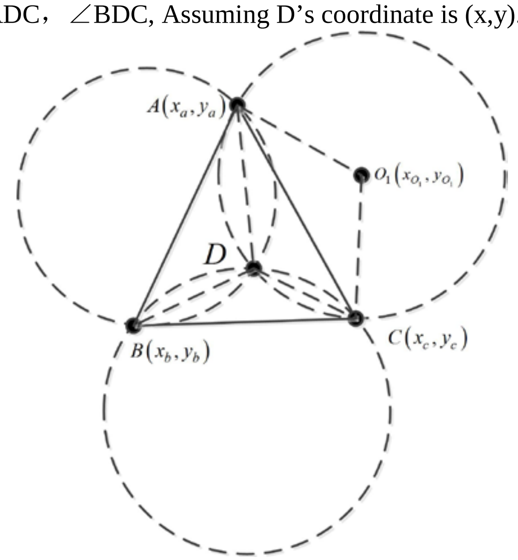

Fig.2 Measurement Triangle Icon

About node A and C, if segmental arc AC in the △ABC, then we can determine the only circle. Assuming the centre of a circle O1(xo1,yo1), the radius is r1,then α =∠AO1C=(2Π-2∠ADC)，and getting the formula as following shows:

$$\begin{cases}\sqrt{(x_{o1}-x_a)^2+(y_{o1}-y_a)^2}=r_1\\ \sqrt{(x_{o1}-x_c)^2+(y_{o1}-y_c)^2}=r_1\\ (x_a-x_c)^2+(y_a-y_c)^2=2r_1^2-2r_1^2\cos\alpha\end{cases}$$

We can determine the coordinate of the centre of a circle O1(xo1,yo1), the radius is r1. In a similar way, according to A， B， ∠ADB and B,C, ∠BDC, we can determine the centre of a circle O2(xO2,yO2), the radius r2, the centre of a circle O3(xO3,yO3),the radius r3 .

Finally, using trilateration, the coordinate of D is determined by D(x,y),O1(x_{o1},y_{o1}),O2(x_{o2},y_{o2}) and O3(x_{o3},y_{o3}).

(3) Maximum likehood estimation(MLE)

Maximum Likelihood Estimation is shown as chart 3-3, the coordinate of 1,2,3,……n are (x_1,y_1),(x_2,y_2),(x_3,y_3)……(x_n，y_n),the distance between them and D are d_1,d_2,d_3……d_n，assuming the node's coordinate is (x,y).

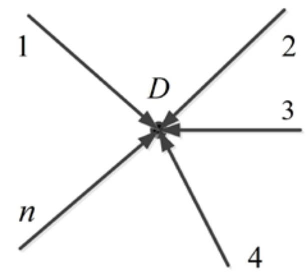

Fig.3 Maximum Likelihood Estimation Method

Then, we can getting the formulas as following shows:

$$\begin{cases}(x_1-x)^2+(y_1-y)^2=d_1^2\\ \vdots\\ (x_n-x)^2+(y_n-y)^2=d_n^2\end{cases}$$

The front equation minus the latter one by one from the first to the last, and getting

$$\begin{cases}x_1^2-x_n^2-2(x_1-x_n)x-y_1^2\\ -y_n^2-2(y_1-y_n)y=d_1^2-d_n^2\\ \vdots\\ x_{n-1}^2-x_n^2-2(x_{n-1}-x_n)x-y_{n-1}^2\\ -y_n^2-2(y_{n-1}-y_n)y=d_{n-1}^2-d_n^2\end{cases}$$

The linear equation is shown as AX=b,

$$A=\begin{bmatrix}2(x_1-x_n) & 2(y_1-y_n)\\ \vdots & \vdots\\ 2(x_{n-1}-x_n) & 2(y_{n-1}-y_n)\end{bmatrix},$$

$$b=\begin{bmatrix}x_1^2-x_n^2+y_1^2-y_n^2+d_n^2-d_1^2\\ \vdots\\ x_{n-1}^2-x_n^2+y_{n-1}^2-y_n^2+d_n^2-d_{n-1}^2\end{bmatrix},$$

$$X=\begin{bmatrix}x\\ y\end{bmatrix}$$

Using standard minimum mean-square error estimation we can getting the coordinate of D：：

$$\hat{X}=(A^TA)^{-1}A^Tb$$

3. LOCATION ALGORITHM BASED ON RADICAL CENTER

Wireless Sensor Network(WSN) is large-scale distributed self-organization network which is made

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of embedded sensor nodes. These nodes are cheap and able to perceive, compute. Location technique is the basis of wireless sensor network(WSN)' application, and is one of the main supporting technology of wireless sensor network(WSN). The location technique of wireless sensor network(WSN) is made up of internal node location and external target location from location technique. It is divided into Range-based[10] and Range-free[11] from location means.

What is the distance measurement method considers is how to estimate the observed variables between it to the given node which is next to anchor node. localization algorithm based on distance measurement need to use RSSI, AOA, TDOA and other techniques to measure the information about distance or angle between anchor node and given no is no need extra hardware on positioning method which based on RSSI, it deduces the distance between sending or receiving nodes according to the strength of the received radio signal[12]. Distance measurement method based on RSSI is used in this paper, because commercial wireless transceiver chip has the functionality of computing the strength of wireless signal, it meets the requirements of low-cost, low-power dissipation of Wireless Sensor Network. Compared to the Positioning methods based on distance measurement, the method which has nothing to do with distance measurement can locate just according to information about the proximity relation and connectivity between nodes in the network, it is also characterized in little influence from environment, and however, the positioning accuracy is lower.

Topology shape between the node (bad node) which can not be determined the location of the network and beacon nodes, as well as the topology shape between the locator beacon nodes will largely affect the results of the unknown node positioning.

If beacon nodes are collinear, the mistake of estimated position wills bigger, the reason for it is considered for the beacon nodes can not meet for go to special. As the figure 4 shows, when the unknown node is D or D', the beacon nodes A, B, C are collinear, the estimated position of centered algorithm will be collinear with A,B and C, it lead to the difference between estimated position and the real one.

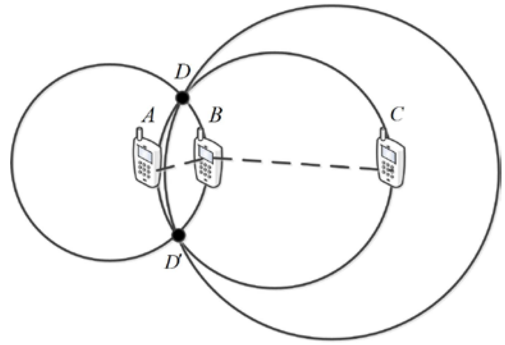

Fig.4 A Total Of Three Beacon Nodes In The Case Of Line

3.1 Mathematical Model

Radical center theorem: as the figure 5 shows, the arbitrarily circle in the plane, the radical axis of them are parallel or just intersect in one point, the point we call it radical center. If centers of the three circles are non-collinear, then the radical anises are intersect in one point; if centers of the three circles are collinear then the radical axis's are parallel.

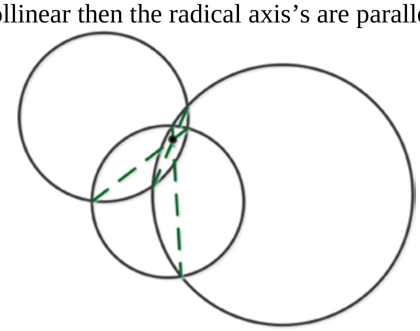

Fig.5 Root Heart Theorem

3.2 RSSI

RSSI measures the distance on the basis of the strength of received signal and theory or experience path loss propagation model, the base statistic model is shown as following shows:

$$P(d)=P0-10*n_p*\log 10\frac{d}{d_0}$$

P(d) is the signal strength of point d; np is rode loss factor, the value is between 2 and 4; P0 is the signal strength （dBm）of reference distance d0; the value of each parameter will be introduced in the next section.

RSSI needs a few of hardware equipments, the radius of anchor node's Communication circle can be obtained by revising the value of RSSI.

3.3 Revising Range Value

However, the value of RSSI will be disturbanced by environment or somen others, then

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the positioning accuracy will lower. From the Shadowing model of radio-propagation we can see, the Shadowing model is divided into two parts, the first one is the path loss model, it forecasts that if the distance is d, the average energy received is Pr(d), it sets d0 which is the distance to sender as reference, and the average anergy is Pr(d0)at d0,the relationship between Pr(d) and Pr(d0) is

$$\frac{\Pr(d_0)}{\Pr(d)} = \left(\frac{d}{d_0}\right)^{\alpha}$$

α is the path loss index, it used to be empirical value from measureing. The second part of Shadowing model will be ignored for simplification.

The real environment with a RSSI value, representative of the distance between different pairs of nodes in the same network topology distribution is different. If the unknown node position calculation considered only unknown node to a beacon node RSSI value and did not join the other correction method, algorithm on the existence of a certain degree of error.

In order to further reduce the ranging errors, improve positioning accuracy. We consider that the fixed beacon node the distance between the two types of information and signal strength at the same time on the basis of the above-described method as a reference for correcting the values of the RSSI ranging.

3.4 Computing Weight

There are radical centers, it can be divided into the following two kinds of circumstance:

There are three circles which centered at beacon nodes with RSSI range value in radius. Radical center be in the circles.

There are three circles which centered at beacon nodes with RSSI range value in radius.

Radical center be out of the circles. Since the root Centroid algorithm-based positioning process, there are more than two kinds of relationships between the radical centers with setting circle. Experimental results show that the radical centers in three setting circle inside at the same time, higher positioning accuracy.To further improve positioning accuracy, we use weighted thought that the introduction of weighting factors in each set of location coordinates.

Taking into account the cost of the wireless sensor network node, computing and storage often subject to certain restrictions, each node can not be too heavy burden on the communications and computing, Otherwise it will lead to a node excessive energy consumption, and ultimately makes the node failure due to run out of power, high-precision positioning and high coverage need more to get the number of anchor nodes.

We use the radical center theorem to calculate the estimated coordinates of radical center which as unknown node in the case of not increasing the number of anchor node, thereby improving positioning accuracy.

The positioning algorithm based on radical center is a ranging positioning algorithm, so we revise the RSSI ranging value to lower RSSI ranging error value, then locate the unknow node primarily use radical center computation formula, When it reaches a threshold in root heart calculation process, the calculated amount of node can be minimized, life cycle of network will be extended, and Preliminary positioning value will be weighted.

We do sorting process about the positioned unknown nodes, Positioning part of the initial conditions of relatively full, high positioning accuracy node upgrade for the anchor node to increase the number of unknown node localization anchor nodes, and thus improve the positioning accuracy and coverage. we upgrade part of the high-precision node be anchor node which remits the sparse anchor nodes problem, while it brings the problem of accumulation of scale error. We specify in detail the position of the unknown node receives estimate and upgrade conditions for anchor nodes to reduce the impact on the positioning accuracy and reduce the accumulated error.

4. THE SIMULATION TEST ANALYSIS

We use VC + + and Matlab algorithm as simulation and data processing software in the Windows platform. Matlab has graphics processing ability and with the C + + interface good interaction flexibility and display the results of algorithm simulation comparison experiments.
In order to simplify the simulation model, in this paper, it is only the positioning module of the application layer for simulation, not from the sensor nodes of the communication in the ground floor.

Scene parameter Settings in simulation experiment is shown as follows:

Setting 200 sensor nodes in a 10m × 10m units plane, Using MATLAB in regular two-dimensional planar area and the irregular two-dimensional planar area (C-type network region), respectively test the performance of the algorithm, and the experimental data are taken from the average of several simulation experiments.

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In the simulation experiments, we use the following parameters to measure the performance of the positioning algorithm:

Anchor node density: it means the ratio of the anchor node number in the sensor network to all nodes. Anchor nodes in a sensor network, the position come with a GPS device, or manual deployment have been identified, the location information is no error.

Positioning accuracy: this is indicated by the ratio of the error value (the distance between the actual position and the estimated position) to the node radio range (communication radius).

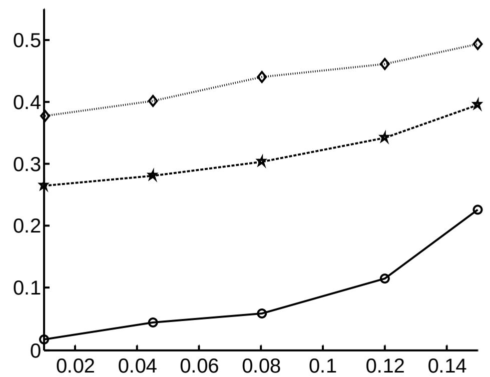

Fig.6 Beacon Node Density Is 3%, The Measurement Error On The Positioning Accuracy

The figure6 means the Changes with the communication radius of the positioning error caused by the change. Seen from Figure 5-3, the number of the able letter radius increases, can be used to locate the beacon node is greater, so that the positioning accuracy is improved. However, the increase in the number of beacon nodes will inevitably introduce new errors. So when the positioning accuracy down to a certain extent, this would be stabilize. Therefore, RSSI values are arranged from small to large, the front 10 coordinate of radical center are used to estimate the coordinate of unknow node, Thus, this reduces With the able letter radius increases introduced a new error, but also a corresponding reduction in positioning errors.

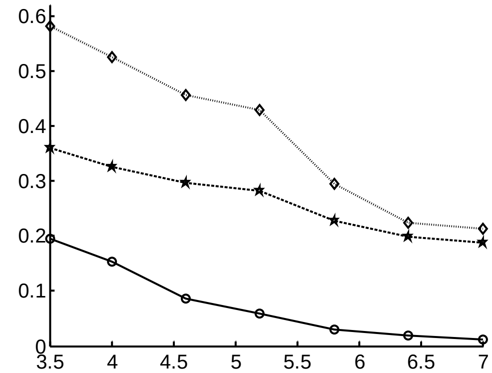

Fig.7 The Relationship Between Communication Radius And Location Error

Distributing random 200 nodes in the region of the C-shape in the area of irregular 10R × 10R units, the uncertainty error is 0.05, the distribution of nodes as shown in Figure 5. Asterisk represents the position of all the nodes.

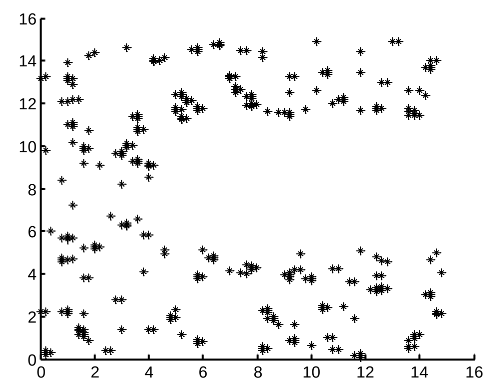

Fig.8 C Shape Of The Regional Distribution Of Nodes

5. CONCLUSION

This article is focused on wireless sensor network node positioning algorithm-depth study, to looking for an effective algorithm to solve the practical problems that exist in the node localization. The beacon nodes collinear beacon node distribution uneven will cause positioning error is too large in the positioning process, then we put forward a positioning algorithm based on the root heart in this paper. The method can naturally filtered out of the positioning error caused by the collinear beacon nodes by calculating the beacon nodes between the root of the heart. This paper also introduces weighted ideological to correct positioning error eventually getting the position coordinates of the unknown node, and the correctness of the algorithm is verified by simulation experiment.

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