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AN IOT APPLICATION BASED SEARCHING TECHNIQUE - WSN LOCALIZATION ALGORITHM

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Abstract

For IOT wireless sensor networks, there is large positioning error in APIT positioning algorithm, an improved APIT positioning algorithm is proposed. APIT test is easy to produce InToOut and OutToIn errors to affect positioning accuracy, a new interior point test method is designed; the new algorithm further reduce the triangular area in the traditional APIT positioning algorithm through the median line, the positioning accuracy is improved. The algorithm does not require any additional hardware support to improve complexity. The simulation results show that the improved algorithm has high localization accuracy in the network anchor node density and different communication radius, it can meet the needs of most localization wireless sensor networks.

Keywords: Internet Of Things (IOT), Wireless Sensor Networks (WSNs), Approximate Point-In-Triangulation test (APIT), Received Signal Strength Indicator (RSSI) technology; signal strength.

1.Introduction

Wireless sensor networks (Wireless Sensor Network) is a large number of sensor nodes with information awareness is formed by a multi-hop self-organizing wireless communication network system [1]. WSNs node positioning technology is one of the main support technology, the nature of node location is determined by measuring the correlation data is positioned between the object correlation between the spatial coordinates [2]. Depending on whether the positioning process requires measuring the actual distance between nodes can be existing localization algorithm is divided into two categories: distance-based and range-free localization algorithm [3,4]. The former high positioning accuracy can be obtained, but the hardware requirements are relatively high; the latter does not need to measure the distance to the unknown node anchor nodes, has certain advantages in terms of cost and power consumption, but the positioning accuracy of less than the former.

Approximation within the triangle point test method (Approximate Point-In-Tri-angulation test, APIT) is a common distance-independent localization algorithm, the basic idea of the algorithm is simple and easy to implement, and is positioned low power consumption, low cost, has been wide range of applications and research. But there are big problems of the conventional positioning error of APIT positioning algorithm, this paper proposes to solve this problem, an improved APIT positioning algorithm.

2.APIT Location Algorithm

APIT algorithm principle [5-6]: Unknown anchor node from the adjacent nodes in the arbitrary choice of three triangles to test whether the node in the three anchor nodes thereof. APIT algorithm is repeated until the end of this test all combinations or achieve the required accuracy, the final calculation of the unknown node contains all the triangles of the overlapping area, the centroid of the overlapping area as the position of the unknown node. 1, shaded area contains all the triangles overlap unknown node, centroid position indicated by black dots will be used as the location of the unknown node.

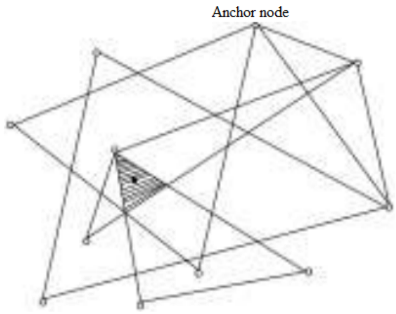

Figure 1. APIT positioning principle

APIT algorithm is the theoretical basis of the best within the triangle point test (Perfect Point-In-Triangulation test, PIT) algorithm. PIT test method shown in Figure 2. The unknown node M is moved in either direction, away from or close to the node M is at least if the anchor node A, B, C which between any one, it indicates that the node M is located in ΔABC, Figure 2 (a); if there is a direction, so that the unknown node M is moved in the direction, away from or close to the same time the three anchor nodes A, B, C, M indicates that the node is located outside ΔABC, Figure 2 (b).

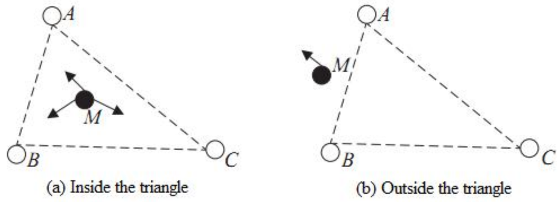

Figure 2. PIT Test Method Schematic

In practical wireless sensor networks, nodes are usually at rest or moving very slowly situation, so the above method can not be used to determine the location node to be tested, instead of using approximate PIT principle test, that test to be APIT algorithm to locate node .

APIT algorithm relies on exchange of information with neighboring nodes to simulate the movement of nodes. When the distance between neighboring nodes and anchor nodes and unknown nodes simultaneously found themselves more or less than the distance from anchor nodes, equivalent to position themselves to move to the neighboring node is located, at the same time he is away from or close to the anchor node case, determination node outside the triangle. Analyzing nodes in the triangle of the situation is based on neighbor nodes exchange information to judge.

APIT Location Algorithm The main steps are as follows: (1) collecting information: unknown node collects information about all anchor nodes within its communication range, such as the position, identification number, the signal strength. (2) APIT test: test whether combined into the unknown nodes in a different anchor nodes inside the triangle, if in, it is marked. (3) Calculate the overlapping areas: the calculation of all the overlapping area of the triangle contains unknown nodes. (4) Calculate the unknown node location: calculate the centroid position of the overlapping area, and as a location unknown node.

3.Improved APIT algorithm

New interior point test method

In traditional APIT testing, boundary effects, and low density of neighbor nodes easier to increase InToOut and OutToIn test errors. Figure 3 shows the determination of these two scenarios occurred error [4]: Figure 3 (a), the unknown node M is close to one side of the triangle, and the neighbor node 2 is located outside the triangle, Node 2 compared to the unknown node M while away anchor nodes a, B, C, according to the test theory APIT, then make the unknown node M in the wrong judgment ΔABC outside, this is a typical InToOut mistake; similar analysis method, when a neighbor node distribution node M 3 (b FIG.), a judgment is made in the wrong ΔABC M inside.

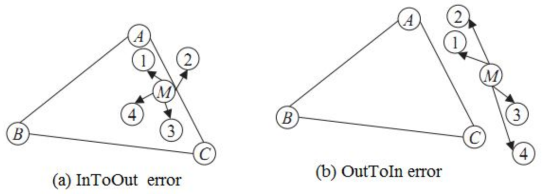

Figure 3. InToOut and OutToIn error

InToOut and OutToIn bugs affect the positioning accuracy of the algorithm, in addition, APIT algorithm grid scanning algorithm for error tolerant OutToIn poor and low efficiency. For these problems, this paper proposes a new interior point test.

The new test method within a point from the perspective of InToOut and OutToIn avoid errors of view, the use of mathematical geometry is determined by comparing the area of a point located outside the triangle method to test unknown node anchor nodes located inside or outside the triangle. As shown in Figure 4.

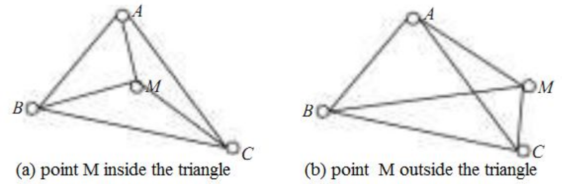

Figure 4. Compare relations of area

In Figure 4, ΔABC area set anchor nodes A, B, C composed of s, unknown node M with endpoints A, B, C consisting of three triangles is ΔAMB, ΔAMC and ΔBMC, area respectively, s_1, s_2, s_3. If $s_1 + s_2 + s_3 > s$, you can determine the point in the triangle outside; if $s_1 + s_2 + s_3 = s$, you can determine the point inside the triangle. For the triangle area calculation, you can use formulas to determine Helen triangle area [7] , as is shown in the formula(1).

$$s = \sqrt{p(p-a)(p-b)(p-c)} \qquad (1)$$

Wherein, a, b, c are the length of the three sides of the triangle, s is the area of the triangle, where p = (a + b + c) / 2.

The new test method is not affected by the interior point neighbor node density is totally dependent on the relationship between the node itself and the anchor node to the decision node anchor nodes located inside or outside the triangle, thereby improving positioning accuracy.

Median line reduced location area

This article from the reduced node and then locate the regional dimension to further improve the positioning accuracy, detailed ideas for: unknown node within communication range with three or more different anchor nodes, for a composition comprising each triangle unknown nodes, according to the same time unknown node a received signal strength anchors triangle vertices to determine the closest two anchor node, the anchor node connecting the midpoint of the two opposite sides of the bit lines are formed to reduce targeted area. The small area of the bit lines and the last two anchor node is formed as a positioning region node, as shown in Fig. FIG regions ABED region is positioned, wherein E, D is the midpoint, A, B, C for the anchor node, M is the unknown node, Rss (A), Rss (B), Rss (C), respectively, for the unknown node M received from the anchor node a, B, C to the signal strength.

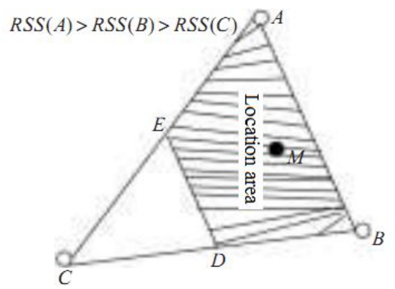

Figure 5. Median line reduced area

Analysis of the median line method is feasible reduce targeted area. In wireless sensor networks, the farther away from one node to another node (near), the received signal strength is weaker (stronger). As has been known the unknown node receives the signal strength of the three anchor nodes triangle vertices, it can determine the specific area where the unknown nodes by comparing the signal strength. As shown in Figure 6.

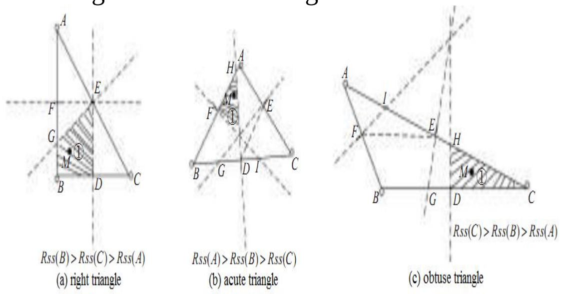

Figure 6. Locate areas of different triangles schematic

Figure 6 Rss (A), Rss (B), Rss (C), respectively, received from an unknown node M anchor node A, B, C to the signal strength. Point D, E, F, respectively were side BC, AB, AC of vertical. If the unknown node received signal strength comparison result Rss (B)> Rss (C)> Rss (A), the vertical according to the nature of [8] any (the vertical distance from one point to the line on the two end points equal) that the point perpendicular to the left (right) is closer to the left end point (right end point), resulting in unknown node M precise positioning region for the region ①, but in order to reduce the computational complexity, the paper slightly expanded this area point method to connect the signal strength of the largest and the second largest anchor node B, C on the side of the midpoint of the E, F, namely the median line EF, the region as a node M EFBC final positioning area. For other comparison result signal strength can be reduced by the unknown node location areas such methods. In acute triangle, obtuse triangle, this method can row, shown in Figure 6 (b), FIG. 6 (c), straight DH, EG, FI is the side BC, AC, AB the perpendicular. Figure 6 (b) can be seen in the Rss (A)> Rss (B)> Rss (C) signal strength comparison result, the unknown node M precise positioning region ① in the median line DE (connection anchor node A, DEAB region B on the side of the midpoint D, E) and formed in the side AB. Figure 6 (c), under the Rss (C)> Rss (B)> Rss (A) of the case, the region containing the M FECB precise positioning area ①.

By the analysis, the median line reduced location area always contains the unknown node M's pinpoint area, thereby indicating that the method is not only feasible, but also compared to the literature [9] The method reduces the computational complexity.

RSSI ranging error correction method

RSSI (Received Signal Strength Indicator) ranging technique uses a known node to transmit the signal strength of signal propagation model [10-11], the receiving node based on the signal strength of the received signal in the communication process to calculate the losses, the use of theory or experience will converted to distance the propagation loss. However, in practical applications, RSSI ranging by environmental, reflection, multipath propagation, affecting NLOS antenna gain and other factors, so the ranging error is large, ranging error for the RSSI big problem, this paper presents a error correction method to improve the range accuracy.

In DNs, the position of anchor nodes is known, you can calculate the actual distance between nodes d_r any anchor the coordinates of nodes, but also measure the distance can be calculated according to d_e RSSI ranging technology, measurement Comparative anchor nodes through distance and actual distance ranging error to get RSSI value Δd, namely $\Delta d = d_e - d_r$, then the node according to the received values ranging error correcting itself to measure the distance to other nodes. Ranging error and distance relationship as formula (2).

$$\Delta d = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{m}\sum_{j=1}^{m}(d_{ij}^{'} - d_{ij})\right) \qquad (2)$$

Wherein, D is the average RSSI ranging network error values; n is the number of nodes in the network anchor; m is the number of nodes in the other anchor anchor node communication range; d'_{ij} anchor anchor node j to node i measuring distance; d_{ij} anchor node i to the actual distance of the anchor node j. After the obtained RSSI value ranging error, correcting itself to measured distance node to other nodes, such as the formula (3) below.

$$\hat{d}_u = \begin{cases} d_u - \Delta d, \Delta d > 0 \\ d_u + |\Delta d|, \Delta d < 0 \end{cases} \qquad (3)$$

Where, $\hat{d}_u$ is the measurement distance between nodes as amended; du node to measure the distance to other nodes. RSSI ranging error correction method in this paper to improve the measurement accuracy and reduce measurement errors in the network at any distance between nodes, the nodes will help improve the positioning accuracy.

Improved algorithm processes

Improved APIT algorithm from two aspects to improve the interior point methods of testing and reduce the region to improve the positioning accuracy of the positioning node, detailed steps are as follows:

The first step: the anchor node periodically broadcasts its own information, including the location, identification number ID, signal strength. Each anchor node receives information other anchor nodes within its communication range, unknown node M receives all anchor nodes within its communication range of information, assuming receipt anchor node number is n, if n ≥ 3, proceed to the next step. Otherwise node M positioning end.

Step two: average RSSI ranging error value according to equation (2) to calculate the Δd, and broadcast to the network each node. N anchor nodes from any of the three components of the triangle taken A_i (i = 1,2, ... ,$C^3{}_n$), for each triangle using RSSI technology to calculate the distance A_i triangle three anchor nodes between vertices, and according to formula (3) be corrected, the corrected value of a, b, c, that is, three sides of the triangle A_i length, and substituting into equation (1), to give an area of s. The same distance using Equation (3) Fixed unknown nodes M and triangle vertices A_i three anchor nodes, the revised value of d_1, d_2, d_3. A_i unknown nodes M and three sides of the triangle formed three triangles, these three triangle side lengths are substituted into the formula (1), to give an area of s_1, s_2, s_3. If $s_1 + s_2 + s_3 > s$, it is determined that node M in the triangle outside; if $s_1 + s_2 + s_3 = s$, it is determined that node M in the triangle.

The third step: in the triangle of the unknown node M receives the signal strength triangle vertices of the three anchor nodes to determine the closest two anchor nodes B_1 according to the same time, B_2, connection anchor node B_1, B_2 on the side of the midpoint D_1, D_2, and the side of the median line B_1B_2 D_1D_2 region formed constitute D_1D_2 B_1B_2, and this region as a node M's targeted area.

Step 4: Use the grid scanning algorithm to calculate the overlapping area is available to all small regions after the reduction, that is the intersection of all available M contains unknown nodes small area.

Fifth step: calculation of centroid position overlap region (overlapping region calculation of each of all small mesh centroid position, and obtaining an arithmetic mean value), the position coordinates of the centroid M as the unknown node position coordinates, node M to complete positioning.

Simulation and Analysis of Results

Simulation experiment, simulation scenarios to the 1 000 m × 1 000 m in area 300 randomly deployed sensor nodes (where the anchor node is tentatively scheduled for 60) consisting of a wireless sensor network, which is tentatively scheduled for the unknown node communication radius of 200 m anchor node communication radius to 1.2 times the radius of the unknown node communication. In this paper, Matlab simulation tool for improved APIT APIT algorithm and the original algorithm, the improved algorithm[9], as well as literature on the perpendicular bisector of [12] . Based on the midline improved algorithm for the simulation experiments and contrast, in the monitoring area, studies in different proportions anchor node communication radius and positioning error of several positioning algorithms. For different situations, article 50 simulations were carried out, then the simulation results were statistically, taking the average as the final result.

Figure 7 is a different anchor node proportions, different algorithms compare the average positioning error, wherein the unknown nodes as communication radius 200 m. With the increase in the proportion of anchor nodes, these types of algorithms are positioning error decreases until stabilized, but this article improved algorithm compared with the other three algorithms, positioning errors fall faster, higher positioning accuracy.

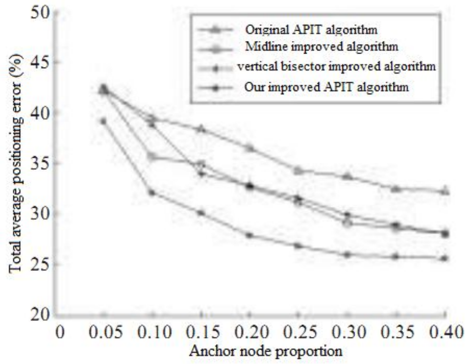

Figure 7. Comparison chart of positioning error ratio under different anchor node

Figure 8 is a different communication radius positioning error of different algorithms comparison chart, wherein the anchor node ratio as 0.2. Positioning precision of these types of algorithms are communicating with the increasing radius increase, and gradually stabilized, but the figure can be seen, the paper improved positioning effect algorithm is better than the other three algorithms, average location error smaller.

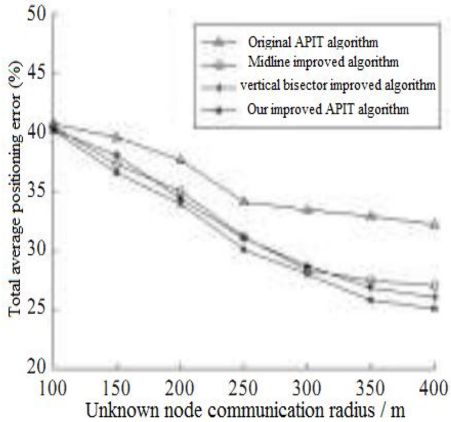

Figure 8. Figure headings

4.Conclusion

Two aspects of this article from point test method and location area reduce will be improved, and an improved APIT algorithm. The algorithm determines the mathematical geometry point in the process of the triangle and outside the technology combined with the RSSI proposed a new interior point test method, and based on the test method, and further reduce the use of the median line to locate regional nodes, and in the All available cells within the reduced overlapping area calculation, the estimated node position, complete node location. Improved APIT algorithm smaller computational overhead to achieve a more accurate estimate of the node position, showing good positioning performance in different anchor node communication radius and the proportion of the network.

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