International Journal of Future Generation Communication and Networking
Vol. 8, No. 6 (2015), pp. 93-98
http://dx.doi.org/10.14257/ijfgcn.2015.8.6.09

An Improved Centroid Localization algorithm for WSN

Li ShiWei[1 2], Ding Mingli[2] and Zhao YongPing[2]

Department of Information Science and Technology, Heilongjiang University, Harbin 150086, China
Department of Automatic Test &Control, Harbin Institute of Technology Harbin 150001 China
harbinlsw@hotmail.com

Abstract

In wireless sensor networks (WSN) research area, node localization is one of the most important techniques. An improved Centroid localization algorithm is analyzed and an improved Centroid algorithm with selective anchor node localization algorithm (CSA) for WSN will proposed in this paper. The key point of the algorithm is the most discrepant estimation nodes are selected by the nearest reference anchor node around a distance unknown node. The triangle centroid and the polygon centroid are employed to calculate the coordinates of the estimation nodes to improve node locating precision. MATLAB simulation illustrate that the algorithm is valid and feasible.

Keywords: *Location Algorithms, Range-free locating centroid location algorithm, Wireless Sensor Networks (WSN)*

1. Introduction

For some WSN applications, people do not know what the nodes location meaning. Sensor node must know their position when the event occurred in a certain area, to achieve the goal of locating and tracking. People use wireless sensor networks to target tracking and locating purpose, location information can be obtained by sensor which is installed in the nodes. For moving targets, the position is continuously tracked by the nodes. It is critical to achieve the target location and tracking. On the other hand, to understand the sensor node location information can also improve routing efficiency, the network can get better deployment quality as well; network load is balanced and network topology also can be fixed from the configuration in coverage area. Although many existing positioning systems and algorithms can solve the WSN positioning issues, there are still some problems: unknown position node must located adjacent anchor directly, which leads the anchor node density too high. Positioning accuracy depends on the network deployment conditions. No distance / angle measurement error measures are taken to curb, which results in error propagation as well as error accumulation, this direct lead positioning accuracy depends on the distance / angle measurement accuracy. Rely on the loop refinement process to inhibit ranging error and improve the positioning accuracy, although the loop refinement process can significantly reduce the impact of ranging error, cost a lot of communication and computation, and the error cannot be estimated due to the circulation increases the number of uncertain computation. The algorithm’s convergence is slowly. Therefore, some mechanism must be used to improve or avoid the above problems in order to achieve more accurate position of WSN.

2. Introduction of Localization Algorithms

Since 1992, AT & T Laboratories Cambridge developed the Active Badge indoor positioning system. Among position algorithms,each positioning system and algorithm is

ISSN: 2233-7857 IJFGCN

used to solve a certain kind of problem and supports specified applications. They are used to locate the node in physical environment, the condition of network composition, energy demand, infrastructure and the complexity of space-time which is different in many aspects.Node positioning algorithm can be divided into centralized and distributed localization algorithm based on different calculation methods. Centralized location algorithm is based on the information transmitted to a central node, where the node position calculated meanly. Doherty [1] assumes that there is a certain percentage of the network anchor among all the nodes, and position method is based on convex programming (convex optimization) to estimate the uncertain position of the node. MDS-MAP [2] is a multi-dimensional scaling method used toimprove positioning accuracy. Both algorithms are typically centralized location algorithm, following by a dozen of improved algorithms to improve the node positioning accuracy. Distributed positioning algorithm depends on the nodes that exchange information between them, calculated location by the nodes. Centroid algorithm [3], in which each node listens to each other to calculate the center of the anchor to determine their own position, if the anchor layout gets better, the positioning error can be improved better. In the APIT algorithm [4], the node in the vicinity area of the anchor nodes listen to the signal, according to the signal, APIT algorithm divides the area into couples of overlapping triangle area. Then finding their location by the grid method that is close to it, if we can listen enough anchor information, this area can be very small, thereby enhance the accuracy of the positioning algorithm.

Node positioning algorithm can be divided into range-based and range-free categories. Range-Based Positioning technology measures the distance between nodes, these algorithms use trilateration, triangulation or maximum likelihood estimation (multi-lateration) positioning method to calculate the node position; Range-Free positioning method does not require distance and angle information, the network connectivity and other information is helpful by this method.

Range-Based Positioning commonly uses distance technology like RSSI, TOA, TDOA and AOA. RSSI (received signal strength indicator) although these technologies have characters of low-power, low-cost, Range-Based Positioning may produce 50%± ranging error [5]. TOA (time of arrival) require accurate time synchronization between nodes, so TOA cannot be used for distributed positioning purpose; TDOA (time difference on arrival) has a limitation in the ultrasonic propagation application. Because WSN is usually used in ultrasonic signal propagation distance around 20 to 30 feet, which requires intensive network deployment; AOA (angle of arrival) position method can also be affected by external influences, and requires additional hardware, the oversized hardware and high power consumption may not be used on sensor nodes. Besides the distance limitation of range-based positioning system, researchers uase a variety of algorithms to reduce the impact on positioning ranging errors, including repeated measurements [6], loop positioning refinement [7], these methods produce a large amount of computation and communication. Therefore, range-based positioning mechanism has its merit on the positioning accuracy, but not suitable for low-power, low-cost applications.

Due to power consumption and cost factors as well as coarse positioning accuracy is sufficient for most applications (when the position error less than the radius of wireless sensor nodes 40%,the positioning error of the routing performance and target tracking accuracy less than 15% and 7% respectively [8]), range-free positioning scheme has drawn great attention. AD-Hoc [9, 10], convex position estimation [11] and MDS-MAP [12] are the typical range-free localization algorithms, which MDS-MAP can also adopt range-based conditions to achieve more accurate positioning.

In China, Zhang Lu [13] proposed a low-cost and practical positioning strategy by GPRS. This strategy can increase the number of beacon nodes as well as hops number between nodes. The node can estimate the distance between the beacons, each node can be calculated out the specific location ranging from the triangulation principle. Among many positioning algorithms, there are some classic algorithms, such as Convex programming estimation algorithm Doherty University of California, Berkeley, who deemed the point of communication links between nodes as geometric constraints, put the entire network into a convex set, thus transformed node positioning problem as a convex constrained optimization problem, and then used the semi-statutory planning and linear programming method to get a global optimization solution, determining the node position. He also gives a method for calculating the unknown nodes which are called possible rectangle method. Figure 1 show that the algorithm can calculate the unknown node whether exists in the region (shaded) or not, or in the corresponding rectangular area, according to the unknown nodes and anchor nodes as well as communication links between the nodes in the wireless range. Finally the algorithm can centralized the rectangle area as an unknown node position.

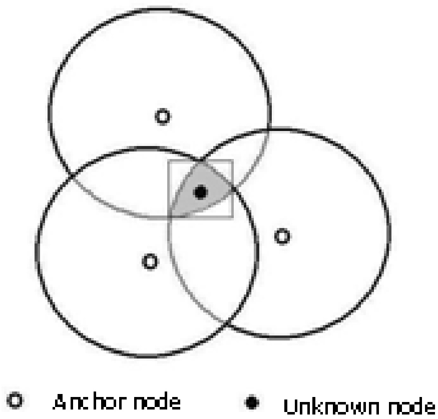

Figure 1. Possible Rectangle Method

Convex program is a centralized location algorithm, anchor nodes in the proportion of around 10%. The positioning accuracy can achieve 100%.If the network under conditions works out efficiently, the anchor nodes must be deployed at the edge of the network, otherwise the node position estimation will shift to the network center.

3. An Improved Centroid Localization Algorithm

There are three steps in the Improved Centroid Localization Algorithm.

1. If we accept that the ratio of the number of the node receives a packet number of sending node to sending packets is greater than CM_threshold, these two nodes are neighbor nodes.
2. Unknown node is positioned act as the anchor node function, the estimated coordinate information sent to neighbors.
3. Unknown node is equally treated as the positioning of the unknown nodes and anchor nodes.

4. Simulation Results

MATLAB7.0.4tool will be used as simulation. By past experiment, the impact of non-ranged localization algorithm estimation error parameters is defined as follows.Random spreading 100 nodes in 1000 × 1000 square meters area. Anchor node is 20% out of the total nodeloop 100 times. Node Radio Range =200；Communication radius of the anchor node=200m；Number of Results point to send packets=20; Connectivitythreshold =0.9: 300 nodes, including 60 anchor nodes. Red * denotes anchor nodes, red O for unknown node; blue O for the estimated location of the unknown node;

Black unknown node O cannot be located; blue - said the unknown node location error (connection to the estimated location of the unknown node and the true position). A total of 300 nodes: 60 anchors, 240 unknown nodes, 0 cannot be located unknown node.

The algorithm adopted $P_R(d) = P_T - PL(d_0) - 10\eta \log_{10}(\frac{d}{d_0})$ transmission model. Where P_R is the received signal power, P_T is the transmit power, and $PL(d_0)$ is the path loss for a reference distance of d_0, η is the path loss exponent. The average connectivity value of the network: 33.3; Average number of neighbors anchor of the network: 6.1867; Location error 0.26598. Then we adopted the improved centroid location algorithm, we can see the average connectivity value of the network is 31.9533; Average number of neighbors anchor of the network is 6.25, Location error 0.31331

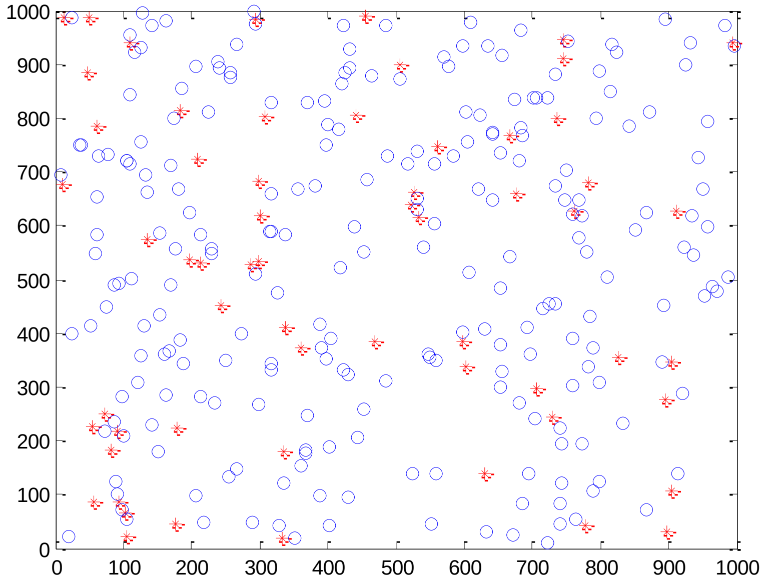

Figure 2. Node Distribution Diagram

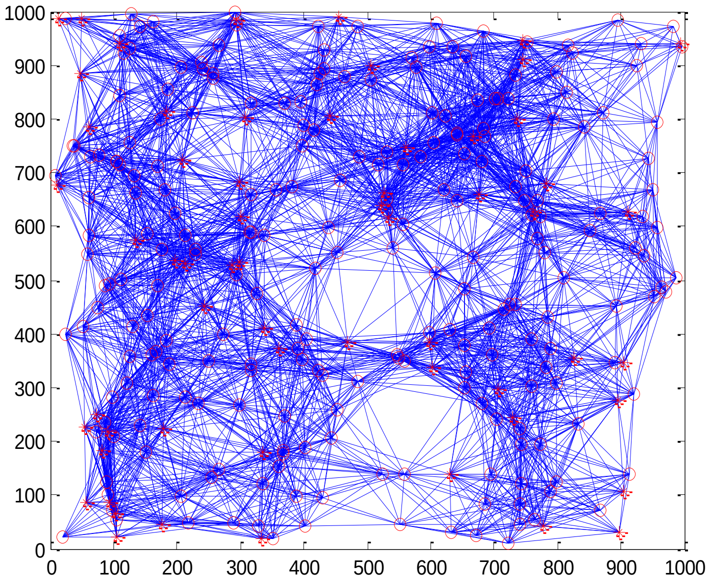

Figure 3. Neighbor Diagram

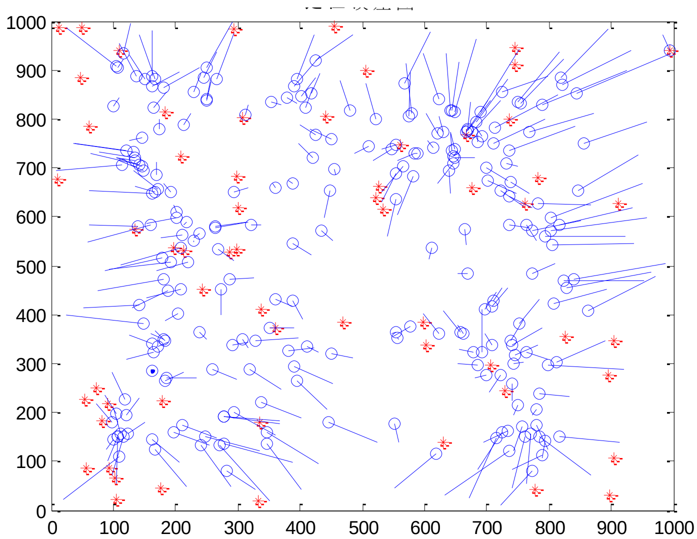

Figure 4. Positioning Error Map

5. Conclusion:

In this paper, we illustrated weighted centroid algorithm and DV algorithm. Hop algorithm is based on an improved hybrid algorithm and the algorithm for the simulation analysis with MATLAB software. The results show that in the basis of node number is fixed but unknown number of nodes. Head variable conditions, the positioning accuracy of the hybrid algorithm is higher than the DV-hop algorithm, an average increase of 20 percent, 15 percent more than the average centroid algorithm; in a fixed number of unknown nodes, and the base node is in variable number of conditions, the hybrid positioning accuracy of the algorithm compared with The DV-hop algorithm is improved by an average of 15%, an average of 10 percent more than the centroid algorithm. Therefore, this algorithm can has high performance on the positioning accuracy. In addition, because this study is based on the ideal signal propagation model, the simulation results do not reflect the real scenario, the positioning affects the future we should also study the application of real-life scenarios.

References

[1] L. Doherty, K.S.J. Pister and L.E. Ghaoui, "Convex position estimation in wireless sensor networks. In: Proc. of the IEEE INFOCOM 2001", Anchorage: IEEE Computer and Communications Societies, vol. 3, **(2001)**, pp. 1655-1663.

[2] Y. Shang, W. Ruml, Y. Zhang and M.P.J. Fromherz, "Localization from mere connectivity", In: Proc. of the 4th ACM Int'l Symp. on Mobile Ad Hoc Networking & Computing, Annapolis: ACM Press, **(2003)**.

[3] N. Bulusu, J. Heidemann and D. Estrin, "GPS-less Low Cost Outdoor Localization for Very Small Devices", IEEE Personal Communications Magazine, **(2000)**.

[4] T. He, C. Huang, B.M. Blum, J.A. Stankovic and TarekAbdelzaher, "Range-free Localization Schemes for Large Scale Sensor Networks", MobiCom, **(2003)**.

[5] S. Meguerdichian, S. Slijepcevic, V. Karayan and M. Potkonjak, "Localized algorithms in wireless ad-hoc networks: Location discovery and sensor exposure", In: Proc. of the 2nd ACM Int'l Symp. on Mobile Ad Hoc Networking & Computing. Long Beach: ACM Press, **(2001)**.

[6] P. Bergamo and G. Mazzini, "Localization in sensor networks with fading and mobility in: Proc. of the 13th IEEE Int'l Symp. on Personal", Indoor and Mobile Radio Communications, Lisbon: IEEE Communications Society, vol. 2, **(2002)**, pp. 750-754

[7] C. Savarese, J. Rabay and K. Langendoen, "Robust positioning algorithms for distributed ad-hoc wireless sensor networks", In: Ellis CS, ed. Proc. of the USENIX Technical Annual Conf. Monterey: USENIX Press, **(2002)**.

[8] T. He, C.D. Huang, B.M. Blum, J.A. Stankovic and T. Abdelzaher, "Range-Free localization schemes in large scale sensor networks", In: Proc. of the 9th Annual Int'l Conf. on Mobile Computing and Networking. San Diego: ACM Press, **(2003)**, pp. 81-95

[9] D. Nicolescu and B. Nath, "Ad-Hoc positioning systems (APS)", In: Proc. of the 2001 IEEE Global Telecommunications Conf., San Antonio: IEEE Communications Society, vol. 5, **(2001),** pp. 2926-2931.

[10] D. Niculescu and B. Nath, "DV based positioning in ad hoc networks", Journal of Telecommunication Systems, vol. 22, no. ¼, **(2003)**, pp. 267- 280.

[11] A. Savvides, H. Park and M.B. Srivastava, "The bits and flops of the N-hop multilateration primitive for node localization problems", In: Proc. of the 1st ACM Int'l Workshop on Wireless Sensor Networks and Applications. Atlanta: ACM Press, **(2002)**, pp. 112-121

[12] A. Savvides, C.C. Han and M.B. Srivastava, "Dynamic fine-grained localization in ad-hoc networks of sensors", In: Proc. of the 7th Annual Int'l Conf. on Mobile Computing and Networking. Rome: ACM Press, **(2001)**, pp. 166-179.

[13] Z. Lu, "GPRS-less low-cost indoor localization for very small devices", In: Personal Communications, IEEE, vol. 7, no. 5, **(2000)**, pp. 28-34.

