IJCSC 0973-7391 Vol 6 • Number 2 April - Sep 2015 pp. 258-263 **Impact Factor: 2.5** **Available at** www.csjournals.com

Weighted Approach for 3-D/2-D Localization Method in WSN using Fuzzy Modeling with Parameter Analysis

Nidhi Agarwal
agarwal_nidhi@yahoo.com

Abstract: Wireless sensor network consists of a large number of sensor nodes. Determining the actual position of each sensor node is thus difficult. Finding the exact position of each sensor forms the basis of localization. Localization in wireless sensor network refers to finding position of unknown nodes based on position of known nodes known as anchors or reference nodes. This paper propose centroid localization method using edge weights of adjacent nodes based on fuzzy modeling for 3D environment. In proposed method neighboring adjacent anchor nodes that are near to unknown sensor node are detected first and then fuzzy membership functions for edge weights based on received signal strength is developed. After calculating edge weights, weighted centroid method is used to localize unknown node position in 3D environment. Results are then compared with weighted centroid approach for unknown sensor nodes in 2D environment for various combinations of reference nodes , unknown sensor nodes and received signal strength range.

Keywords: WSN, fuzzy modeling, weighted centroid method.

I. INTRODUCTION

Wireless sensor networks commonly known as WSNs, consists of a large number of sensor nodes. These nodes are quite smaller in size, often in µm. Every sensor node is capable of sensing a unique quantity, these may include pressure, temperature, vibration, motion, detection, traffic monitoring in real time, target tracking etc. Due to their small size, battery operations and deployment often in remote area, it is essential to know the exact location of each sensor node because if the exact position of node is known it becomes easier to track any node. But this location finding task for all sensors is not easy due to large number of sensor node presence in any area. Most of these networks consist of hundreds of sensors in any particular area. So it is not easy to feed location information into each and every sensor node. Moreover many times these sensor nodes may vary their positions slightly. Hence some method is needed to locate exact position of these sensors.[12]

Localization deals with this problem. Here not all but some nodes are given position information. Rest all nodes find their location depending upon known positions of reference nodes or anchors.

Depending upon range, localization can be divided into two categories, range base localization and range free localization methods. Range base systems deals with distance estimation between reference and unknown nodes. They may use: (i) Received signal strength, (ii) Time of arrival, (iii) Time difference of arrival. Received signal strength indication (RSSI) based estimation rely on signal strength between two nodes but include some other parameters also those are not easy to measure. TOA rely on measuring time of radio signal arrival and TDOA method although gives more accurate results but needs two separate pairs of transmitter and receiver which is costly and needs complex circuitry. All these range based methods depends upon environment conditions, medium of transmission and generally need complex hardware although they gives absolute point to point distances.

On the other hand range free localization schemes are not based upon measuring distances between nodes. They works upon quality of received signal strength (RSS) and try to locate the unknown point with or without some error. These methods cannot measure absolute point to point position but as they are deployed in some large area, these location estimation errors results in no error or quite small error that can be tolerated easily. As these methods are not focused on absolute detection, they are simple, needs less complex hardware and needs small calculations. These range free localization uses knowledge of pre allocated positions of reference nodes to calculate unknown sensor node position. One method of doing this is centroid localization method. This method is simple to implement but consists of large errors. To solve large errors weighted centroid method is proposed that uses edge weights of neighboring reference nodes based on fuzzy modeling[]. But this related work is limited to only 2 dimensional plane. Real world is 3 dimensional and hence it is quite difficult to place nodes in 2D only. Here a method is proposed which deals with range free, edge weighted, centroid method of location finding using fuzzy modeling.

In propose method an area is taken where some reference nodes are placed with known positions and then some unknown nodes are placed.

First reference nodes neighboring unknown nodes are found. Then a fuzzy membership function will be developed based on RSSI between ref. nodes and unknown node. Using edge weights, position of unknown node will be calculated using weighted centroid method.

Fuzzy system is used here to take advantage of fuzzy rules, as only a small number of these rules can give better results with less error and hence more accurate results.

Coming sections of this paper are organized as follows. Section-2 deals with centroid localization method and fuzzy modeling. Section-3 consists of centroid localization method using fuzzy approach and section-4 consists of simulation results to show performance of proposed method. Finally conclusion is drawn in section 5.

II. Centroid Localization

This scheme uses information of reference nodes that are adjacent to unknown node [11]. All reference nodes send beacons of their respective positions, which are received by all unknown nodes. Based on this position information all unknown nodes calculate their respective positions using centroid method [11]. Here an unknown node having positions as (X_{un}, Y_{un}, Z_{un}) uses reference node's position (X_i, Y_i, Z_i) to estimate their position, after receiving respective beacons from them as

$$(X_{un}, Y_{un}, Z_{un}) = \frac{X1+X2+\cdots.Xn}{n}, \frac{Y1+Y2+\cdots.Yn}{n}, \frac{Z1+Z2+\cdots.Zn}{n} \ldots\ldots.(1)$$

Where **n** is the number of reference node whose beacons are received by unknown node.

Out of all reference nodes present in any given area not all, but only some reference nodes (depending upon their RSS values) will take part in position calculation. Hence this number **n** will vary for each calculation. A small area around each unknown sensor is taken into consideration as only closely located reference nodes can provide acceptable signal strength.

Advantage of centroid method is its simplicity and ease of implementation [11]. But location estimation error is higher which may be unacceptable to cases where actual positioning is required.

(a) Weighted Centroid Method or Fuzzy Modeling

An improved method of centriod method is weighted centroid method [3,9]. Here edge weights are calculated based upon RSS from reference nodes using their edge weights and known positions. Hence unknown sensor node position is estimated using given equation [3,9,11].

$$(X_{un}, Y_{un}, Z_{un}) = \frac{W1X1 + W2X2 +\ldots.WnXn}{\sum_{i=1}^{n} Wi}, \frac{W1Y1 + W2Y2 +\ldots.WnYn}{\sum_{i=1}^{n} Wi}, \frac{W1Z1 + W2Z2 +\ldots.WnZn}{\sum_{i=1}^{n} Wi} \ldots..(2)$$

Where W_i is edge weight of i^{th} reference node adjacent to unknown node.

Fuzzy Approach to Centroid localization Method

Connectivity based approach is used to find adjacent reference nodes that are adjacent to unknown node. RSSI based approach is then used to find edge weights using fuzzy modeling [9].

III. Connectivity approach for finding adjacent reference nodes

Known reference nodes form overlapping regions of coverage having multiple nodes in a given area or network. All these known points can be identified by (X_i, Y_i, Z_i) where i is any number from 1 to maximum number of reference nodes. All these nodes may form any regular pattern like mesh. These nodes periodically transmit beacons containing their position information. Mostly all these beacons are received by adjacent unknown nodes, that helps them locating their position. A care must be taken in synchronizing beacons so that neighboring beacons may not coincide with each other. Each node activates itself for a fixed period of time and listen for beacon and collect RSSI information. All such information received from neighboring nodes forms the basis of position calculation.[9]

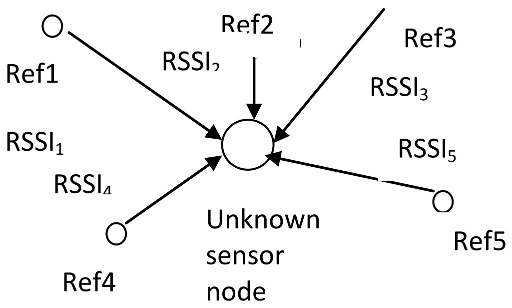

Figure :1

IV. Measurement of RSSI information i.e. Calculation of Edge Weights using Fuzzy system

Some fuzzy rules are formed using IF-THEN to find edge weights associated with neighboring reference nodes based upon RSSI received by unknown node.

Rule$_i$: IF RSSI value is A_i THEN Edge Weight = B_i

Here RSSI value is input and edge weight is output. Fuzzy membership function based on RSSI information between the reference node and unknown sensor node are developed as per given table [2].

Table1: Fuzzy approach

Rule	RSSI Value	Edge Weight
1	Very Low	Very Low
2	Low	Low
3	Medium	Medium
4	High	High
5	Very High	Very High

Higher RSSI values will be received from those reference nodes that are closer to unknown node and hence given higher weightage. Similarly those reference nodes that are far from sensor node will be given lower weightage. Far nodes will give lesser amount of RSSI.[2,3]

V. Localization Algorithm

After calculating edge weights of neighboring reference nodes for any unknown node, position of unknown node is calculated as discussed in section-II(a) using weighted centroid formula.

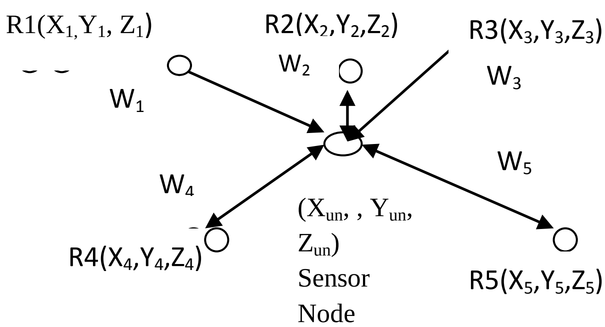

Figure:2

Accuracy of estimation can be given by localization error, which is the difference of estimated position (using weighted centroid method) and actual or real position.

Localization error in meters

$$LE= \sqrt{(X_{un}-X_r)^2 +(Y_{un}- Y_r)^2 +(Z_{un}- Z_r)^2} ......(3)$$

Position error

$$PE=\sum \frac{LE}{nR} \text{ ……….(4)}$$

Average Localization error

ALE=∑LE/No. of Unknown nodes…….(5)

VII. Simulation Results

This section presents simulation results to evaluate proposed method and to compare effect of different parameters such as no. of reference nodes, no. of unknown nodes and effective range of received signal strength for 2 D and 3 D environment. MATLAB is used for above describe simulations where mamdani fuzzy toolbox is used for fuzzy modeling. Reference nodes and unknown sensor nodes both are distributed randomly into 100x100x100unit area. RSS model used is as described under[2]

$$R_{ij}=kd_{ij}^{-\alpha},$$

Where R_{ij} is the RSS value between ith unknown node and jth reference node, k is carrier frequency , taken here as 50 and α is the attenuation constant , taken here as -1.

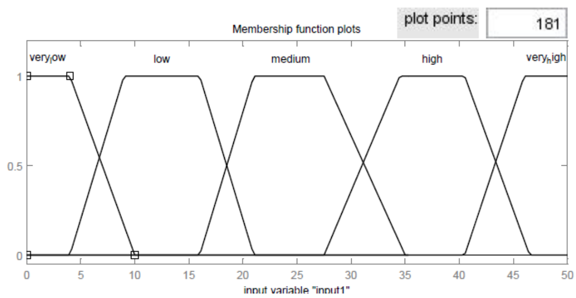

Figure3:FIS input as RSS

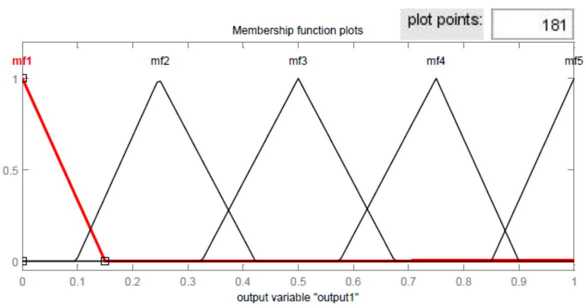

Figure4:FIS output as Edge weights

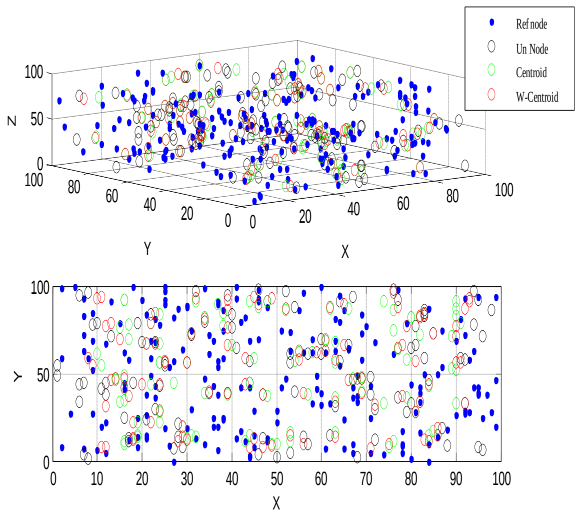

Figure5: Range 20 units, 200 Ref nodes, 100 unknown nodes random distribution for 3D and 2D,showing centroid and weighted centroid distribution of nodes as per model used.

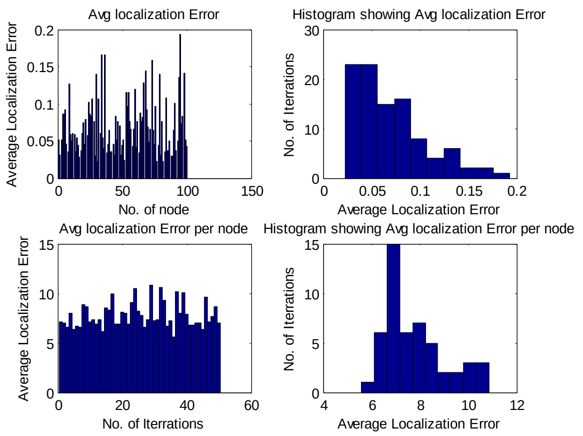

Figure6: Range 20 units, 200 Ref nodes, 100 unknown nodes random distribution for 3D and 2D,showing average errors in 50 independent itterations.

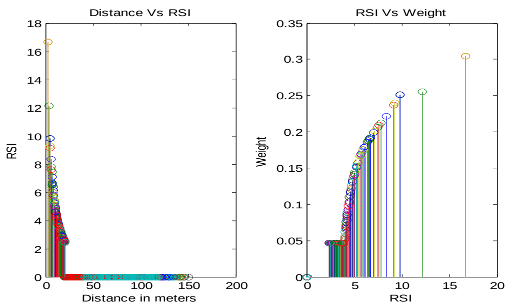

Figure7: Relation between distance between nodes, RSS and edge weights (using fuzzy modeling).

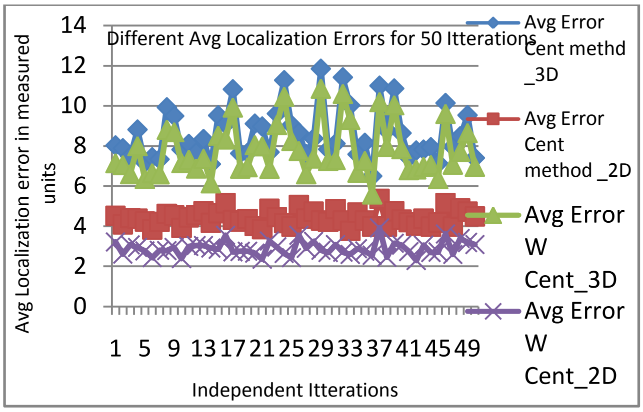

Figure8: Different average localization errors for 50 itterations.

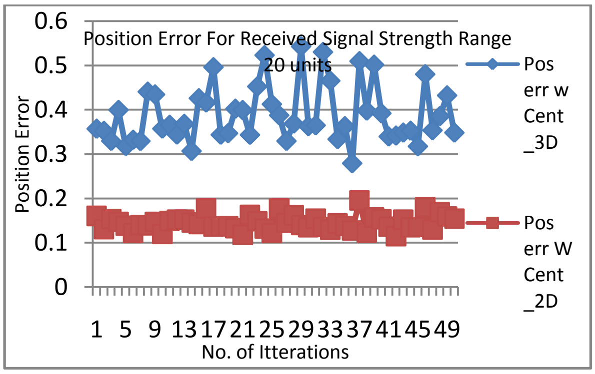

Figure9: Position error for 50 itterations

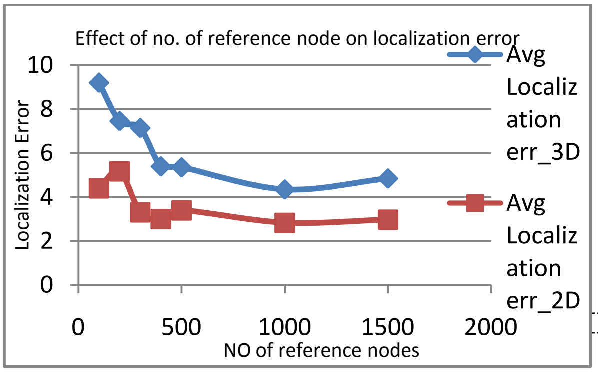

Figure10: Effect of no. of reference node on localization error.

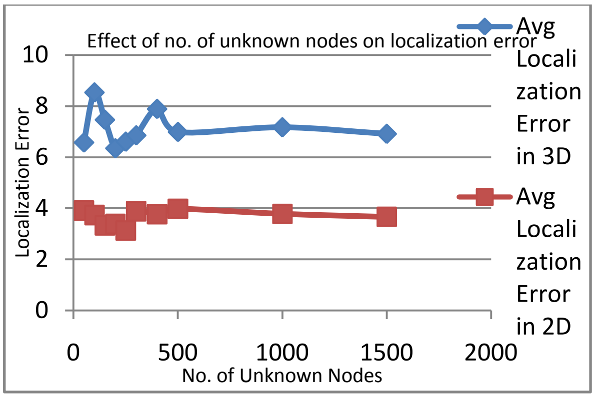

Figure11: Effect of no. of unknown node on localization error.

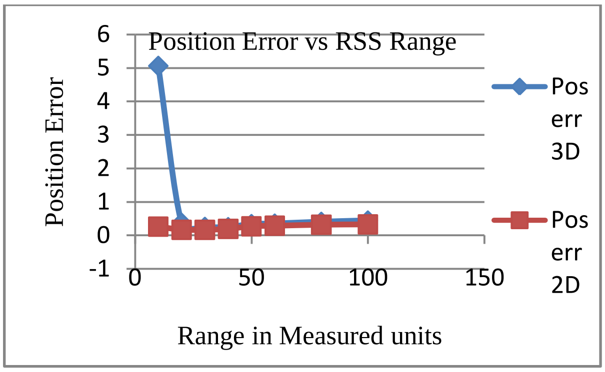

Figure12: Effect of position error on different RSS ranges

Table2: Simulation Results

Approach	Max. Error	Min. Error	Avg. Error
Simple Centroid 2D	5.366633	3.770363	4.393228
Weighted Centroid 2D	3.909176	2.290805	2.888933
Simple Centroid 3D	11.83764	6.501656	8.598295
Weighted Centroid 3D	10.86175	5.587469	7.77321

I. Conclusion

Range free sensor localization for wireless sensor network is easy, simple and effective method of sensor localization. Weighted centroid approach is proposed here to evaluate sensor location for 3D environment. Comparison with 2D environment is done for weighted as well as simple centroid method. Results shows greater error for 3D, which is justified, as number of unknown variable increases, it results in increased error. 3D have 3 coordinates to be find out as compared to 2 coordinates for 2D and thus justifies the increased errors in results.

Reduction in error may be achieved with complex algorithms.

IX. References

1. **Localization Algorithms in Wireless Sensor Networks: Current Approaches and Future Challenges** Amitangshu Pal, Department of Electrical and Computer Engineering, University of North Carolina at Charlotte.
2. **A New Fuzzy Based Localization Error Minimization Approach with Optimized Beacon Range**, Vinay Kumar, Ashok kumar, Surendar Soni, NIIT Hamirpur .ICWET 2011
3. **Localization method for low-power wireless sensor networks** Diego Fco. Larios, Julio Barbancho, Fco. Javier Molina and Carlos Leo´n Senior Member, IEEE. Department of Electronic Technology, "Escuela Polite´cnica Superior" University of Seville, Seville, Spain,
4. **CHEATS: A Cluster-Head Election Algorithm for WSN Using a Takagi-Sugeno Fuzzy System,** Adonias Pires, Claudio Silva, Eduardo Cerqueira , Dionne Monteiro and Raimundo Viegas Jr.,Federal University of Para (UFPA) Belem, Brazil.
5. **Weighted Centroid Location in Wireless Sensor Network**, Lixiong Tan1, Fei Luo2, Kai Liu1
   1 Key Laboratoty of Specialty Fiber Optical Access Networks Shanghai University Shanghai**.**
6. **Adaptive Distance Estimation and Localization in WSN using RSSI Measures,** Abdalkarim Awad, Thorsten Frunzke and Falko Dressler, Autonomic Networking Group, Dept. of Computer Sciences, University of Erlengen, **2007 IEEE.**
7. **Range-free Localization Schemes for Large Scale Sensor Networks,** Tian He, Chengdu Huang, Brain M. Blum, John A. Stankovic, Tarek Abdelzaher, Computer Science Dept., University of Virginia, 2003.
8. **D-FLER: A Distributed Fuzzy Logic Engine for Rule-based Wireless Sensor Networks** Mihai Marin-Perianu and Paul Havinga, University of Twente, Enschede, The Netherlands.
9. **Centroid Localization Method in Wireless Sensor Networks using TSK Fuzzy Modeling,** Sukhyun Yun, Jaehun Lee, Wooyong Chung and Euntai Kim, Department of Electrical and Electronic Engineering, Yonsei University Seoul, Korea.
10. **Wireless Sensor Node Localization,** Akos Ledeczi and Miklos Maroti, Institute for software Integrated Systems, Venderbilt University, Nashville TN, USA.
11. **GPS-less Low-Cost Outdoor Localization for Very Small Devices,** Nirupama Bulusu, John Heidemann, and Deborah Estrin University of Southern California, Information Sciences Institute
12. **Protocols and Architecture for Wireless Sensor Network** by: Holger Karl, Andreas Willig, John Wiley & Sons Publications
13. **Fuzzy Logic for Embedded Systems Applications** by: Ahmad M.Ibrahim, Newnes Publications
14. **Neural Networks, Fuzzy Logic and Genetic Alorithms, Synthesis and Applications** by: S. Rajasekaran, G.A. Vijayalakshmi Pai.
15. **MATLAB** tutorial and tool box.