Application of Soft Computing Techniques for Localization Algorithms in Wireless Sensor Networks

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Objectives

1. To survey the present Wireless Sensor Network localization techniques experimentally to document the performance measures.
2. To propose a localization algorithm using soft computing techniques for Wireless Sensor Networks improving on accuracy, power consumption and communication overhead.
3. To design and implement a WSN using the proposed algorithm to illustrate the strengths and applicability of the proposed algorithm.

Introduction

Wireless sensor network is a network consisting of thousands of sensors within a particular area. These sensors are able to communicate with each other. They can detect different objects, collect information, and transmit Messages.

Problem

To assign coordinates to the network nodes

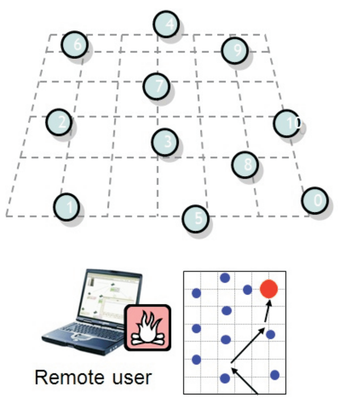

Figure 1. Wireless Sensor Network

Sensors are usually small in size and have many physical limitations.

- In many applications it is important to know a node's location.
- The most accurate and reliable way to obtain this information is to equip each node with a GPS receiver.
- This method is expensive and not feasible for sensor nodes due to the power constraint

Methodology

Friis free space propagation, fixed the TX power, the RX power decreases a function of $(1/d)^2$

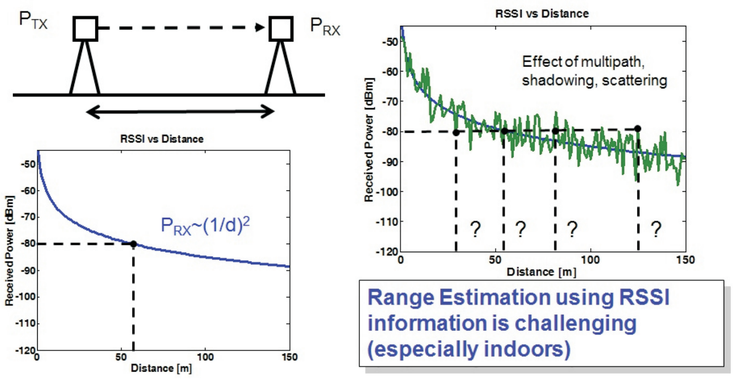

Figure 2. Range Estimation using RSSI information

Here we consider two types of approaches for localization in wireless sensor networks.

1. **Non Soft Computing Approach for Localization-** In this approach three methods have been implemented. They are
   - Centroid Method.
   - Weighted Centroid Method.
   - Circle Intersection combined with Weighted Centroid Method.
2. **Soft Computing Approach for Localization-** In this approach three methods have been implemented. They are
   - Fuzzy Weighted Centroid Method.(Using Mamdani)
   - Combined Mamdani – Sugeno Fuzzy Method
   - Circle intersection combined with Fuzzy Weighted Centroid Method.

Centroid Method

$$(X_{est}, Y_{est}) = \left(\frac{(X_1+X_2+\cdots X_n)}{n}, \frac{(Y_1+Y_2+\cdots+Y_n)}{n}\right)$$

Weighted Centroid Method

$$(X_{est}, Y_{est}) = \left(\frac{W_1.X_1+\cdots+W_n.X_n}{\sum_{i=1}^{n} W_i}, \frac{W_1.Y_1+\cdots+W_n.Y_n}{\sum_{i=1}^{n} W_i}\right)$$

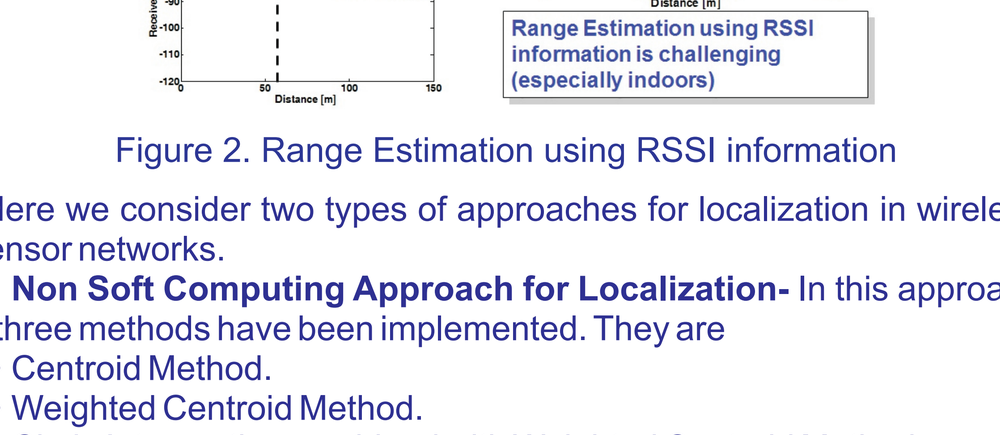

Figure 3. Centroid Method Flowchart & Weighted Centroid Method Flowchart Circle Intersection Combined with Weighted Centroid Method

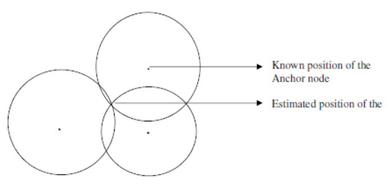

Figure 4. Circle Intersection Combined with Weighted Centroid Method

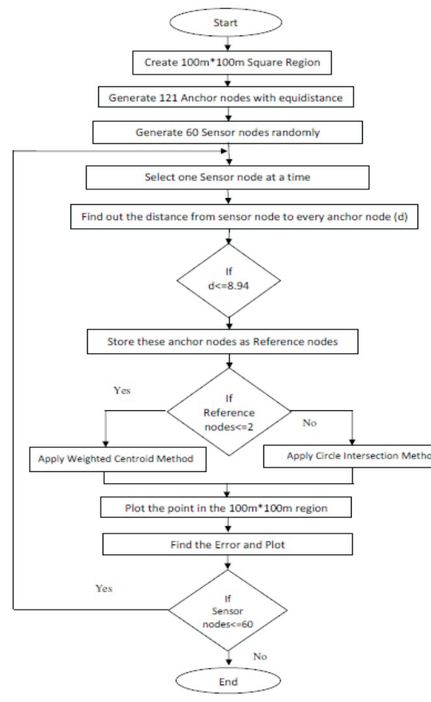

Figure 5. Circle Intersection Combined with Weighted Centroid Method Flowchart

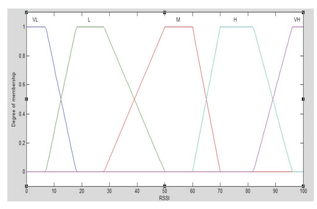

Figure 6. Membership Function for RSSI

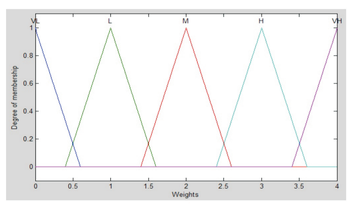

Figure 7.Membership function of Weights

Rule	IF : RSS is ~	THEN :weight is ~
Rule1	Very low	Very low
Rule 2	Low	Low
Rule 3	Medium	Medium
Rule 4	High	High
Rule 5	Very high	Very high

Figure 8.Fuzzy Rules

Fuzzy Method - Mamdami

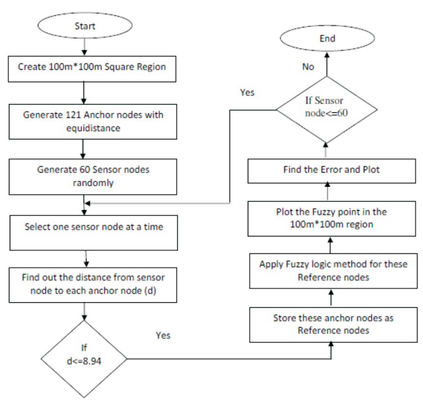

Figure 9. Fuzzy Method Mamdami - Flowchart

Circle Intersection Combined with Fuzzy Weighted Method

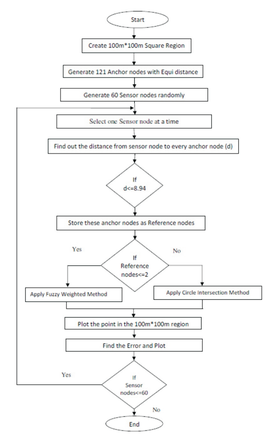

Figure 10.Circle Intersection Combined with Fuzzy Weighted Method

Results

Simulation Results of the Non Soft Computing Techniques:

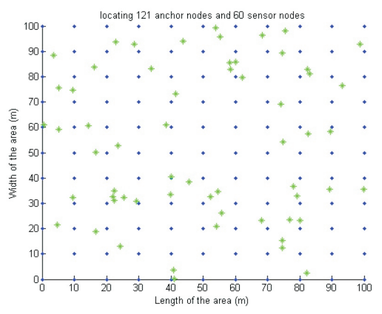

Figure 11. 60 sensor nodes with unknown position and 121 anchor nodes with known position are distributed randomly with in 100m * 100m area

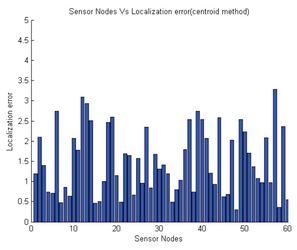

Figure 12. Error Results of the Centroid Method

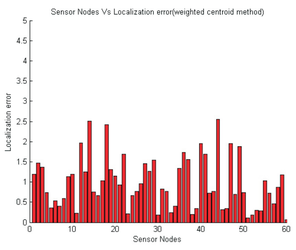

Figure 13. Error Results of the Weighted Centrod

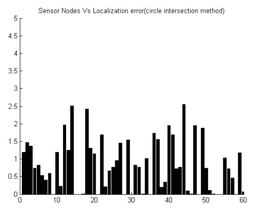

Figure 14. Error Results of the Circle Intersection method

Simulation Results of the Soft Computing Techniques:

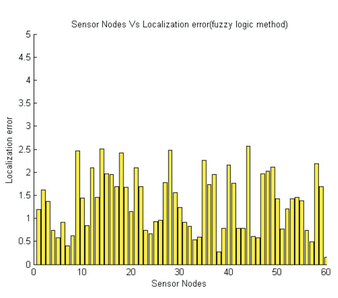

Figure 15. Error Results of the Fuzzy Logic Method

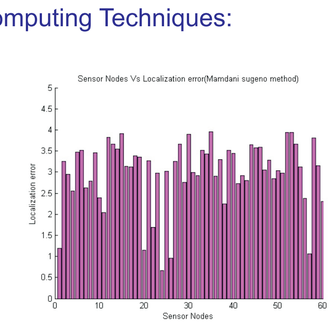

Figure 16. Error Results of the Mamdani-Sugeno Method

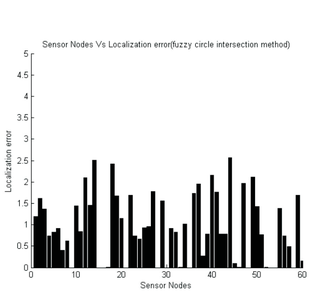

Figure 17. Error Results of the Circle Intersection combined with Fuzzy logic Method

Comparison of simulation results

Method	Max. Error	Min Error	Average Error
Centroid	3.2856	0.2788	1.728685
Weighted Centroid	2.7769	0.2061	0.900102
Circle Intersection with Weighted Centroid	2.7790	0.0000	0.893821
Fuzzy Logic System (Mamdani)	2.7789	0.3023	1.274080
Combined Mamdani-Sugeno	3.9384	0.6620	2.990807
Circle Intersection with Fuzzy Logic Systems	2.7790	0.0000	0.893830

Figure 18. Table showing results

Visible Research Output

[1] Mohan Kumar.J, Jeane Marina D'Souza , Dr. P.R.Venketeshwaran, Dr. Gopalakrishna Kini and M.Madhusudan Reddy, "Combined Circle intersection with Weighted Centroid method for localization of sensor nodes in Wireless Sensor Network", International Conference on Innovations in Electrical and Electronics Engineering(ICIEE'2012) Oct 6-7,2012,pp 268 - 271 Dubai (UAE).[Won the Session Best Paper Award]

[2] Mohan Kumar.J, Dr. P.R.Venkateshwaran, Dr. N.Gopalakrishna Kini,Sundaresan.C, " Circle Intersection method combined with Fuzzy Weighted centroid method for localization in WSNs", Sensor & Transducers Journal, Vol 142,Issue 7,July 2012,pp 61 – 68.

[3] Mohan Kumar.J, Dr.P.R.Venkateswaran, Sundaresan.C, "A survey on range based Localization Algorithms", paper no- NCCNC067, National Conference on Communication, Networking and Computing (NCCNC-2010) Mobile. Coimbatore Institute of Technology, 2nd and 3rd July, 2010.

[4] Mohan Kumar.J, Dr.P.R.Venkateswaran, Sundaresan.C, "A survey on range Free Localization Methods in Wireless Sensor Networks", pg no 181, International Conference on System Dynamics and Control (ICSDC 2010) 2010,Manipal University.