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Node Localization using 3D coordinates in Wireless Sensor Networks

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Abstract

Sensor network provide heterogeneous information through the physical world. Sensor nodes are large in numbers; it gives the location information from where the data is taken. The location information is calculated through localization algorithm. The algorithm is process on every node for getting exact location of every fixed or mobile node devices. It calculate it position every time when the data is send through it. For localization many algorithm are introduced with the basis of two dimensions, this paper based on Ring Overlapping Based on Comparison of Received Signal Strength Indicator (ROCRSSI) algorithm that work on three dimensions coordinates. ROCRSSI is isotropic in nature so it provides equal range to all nodes, it does not effect from signal fading. Our work to implements this algorithm with finger-print method for finding node position.

1. Introduction

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Wireless sensor network is the emerging trends in wireless field. Sensor nodes are autonomy in nature where human interaction is less. It sense and monitor the physical world condition and relay to the interested base station. Earlier it used in military field but now a days it used in many applications as environmental monitoring to measurement of environmental temperature, earth quakes and volcanoes, home automation application, disaster relief operation and health application etc. The sensor position is not preplanned by earlier. After the deployment process sensor needs to localize him with in the area. Localization process is doing with the help of references node or anchor node (who knows there position earlier). Through it gives the location information with the sending data to base station. Localization provides the actual location information from where the data is coming. Without localization it difficult to identify the information location because nodes are in large numbers it is difficult to identify by the BS from which location the data is coming, it also help in geographic routing, identification and correlation data. Earlier method is based on Global Positioning System which is not feasible because GPS system uses the satellite signal for knowing there position. It is not helpful for all nodes its antenna increases the sensor node size factor, but Sensor nodes are required to be small. The power consumption is also high which reduce the battery life of the sensor nodes and also reduce the effective lifetime of the entire network. Localization algorithm is used for finding positions with the reference node. There are many algorithms have implemented for localization process. Localization algorithm is basically classified in range-based and range-free. Range based nodes are in anisotropic in nature, in their inter node distance calculation is done through ranging hardware. Range based provides high accuracy. For short distance it give good result, but It deviate significantly from true distance it's occur due to several interferences as irregular radio propagation, obstacles, low sensor density, terrain condition which effect the localization accuracy. Range based schemes are ToA, TDoA, AoA, RSSI, lateration, and angulation. Range-free method is based on isotropic in nature, it estimate their position using the hop count and connectivity information between nodes. No additional hardware is needed in this method. Algorithm works on coordinates. There are lot of algorithm is implemented on two dimensional coordinates of node just as MDS (multi dimension scaling), bounded box, APIT etc., through 2D algorithm nodes gives correctness in flat terrain. The 2D system is basically parallel to the z axis means altitude is fixed. It randomly rotates the two coordinates x, y for finding node position, which create

variation with actual position and affect the accuracy. The 2D localization algorithm location estimation process is less complex not based on real world view. The new concept is 3-dimension localization included extra plane as height, where it can be applied on harsh and hilly terrains to provide good accuracy and it based on real world view. 3D applications are surveillance network deployed in mountainous battlefield, sensor network floating in air for pollution monitoring.

Fingerprint technology provides large number of node adopt finger-print matching for location determination. The idea behind is to take finger-print as signal strength of node called as signatures from every location then build a finger-print database. Database is then used to estimate the position.

2. Literature Review

Fingerprinting based systems generally have two phases – offline called training phase and online called location estimation phase. During the offline phase, the location fingerprints (i.e., signal strength samples) are collected, so-called radio map which act as a database which stores the information of Received Signal Strength Indicator (RSSI) from nodes. During the online location determination phase, the signal strength samples collected by the access points (APs) from the nodes, and sent to a central server or AP act as server. The server then uses some algorithm to estimate the MN's position, and reports it back to the MN (or the application requesting the location information). In the second phase online phase, the normal network operation is done here; in their normal network operation contains the temperature measurements, humidity measurements, light measurements and sending messages to the base station. The new measurements are taken and calculate with stored fingerprint in order to estimate accurate position. Online phase protocol divides into two stages that can be run separately, the first stage Anchor node (AN) who knowing their position earlier, they broadcast the message to other anchor and unknown nodes(UN) in there they does not known their position earlier from they send calculated RSSI to particular AN. The AN calculating their individual RSSI value. Similarly the unknown node broadcast the message for knowing there position. When the anchors receive they send packet with the calculated averaged RSSI of the UN and its known position to the UN. For getting higher accuracy the second stage is used. The UN sends the calculated averaged RSSI values to the anchor node from which it received the strongest RSSI value. The selected AN calculate the position of UN using the received RSSI value from UN and from stored value in database. During this execution through anchor node the UN become into sleep mode. In their UN wake up if needed for asking for its position. Then the selected anchor node sends the result calculated by the fingerprint technique.

3. Research methodology

The RSSI algorithm is used for calculation of node position through fingerprint system. RSSI provides the range based method for calculation. The drawback is it affects from multipath and shadowing, it also affected from attenuation and line-of-sight. Main is that it cannot use for long distance, its performance is degraded in long distance. This paper proposes Ring Overlapping Based on Comparison of Received Signal Strength Indicator (ROCRSSI) algorithm in fingerprint for 3D localization. ROCRSSI is isotropic in nature, gives constant signal to node. ROCRSSI algorithm is a range-free method where the no additional hardware is needed. In ROCRSSI algorithm the anchor node send signal strength to all known and unknown nodes. The all neighbouring nodes send back the strength value, from it the anchor node generate ring with known node where unknown node in between them through it the position is calculated with set of overlapping ring. Figure 1 shows ROCRSSI ring generation.

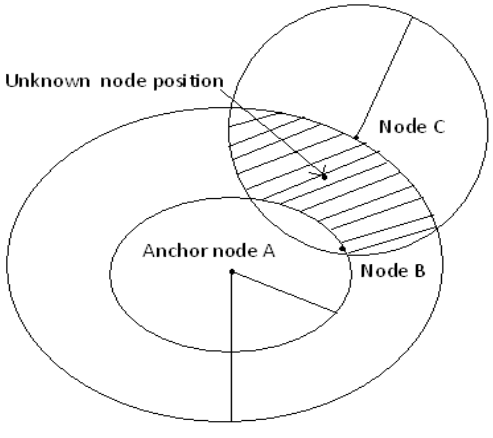

Figure1: ROCRSSI ring generation

It has three phases first is RSSI measurement second is Anchor node data distribution third is Sensor node location estimation. These three phases is distributed on offline and online process.

A. Offline process contain RSSI measurement

Each anchor node calculates the RSSI value other nodes and vice versa and collect the samples. These samples are store in database. The dataset are generated

and collected during the offline phase. First the database which contain the generated fingerprint from nodes represent as set of D as database,

D= {F1, F2, F3, Fn};

Where n represent the n number of fingerprint in the database.

F = { *Pn, Dn* };

Pn contains the coordinates of the position and *Dn* contain the information about temperature, humidity, pressure, etc.

B. Online process contains Anchor node data distribution and Sensor node location estimation phase.

During online phase new measurement Dn is taken. That will be used for searching the correct fingerprints from the database from where the information is coming. For position finding these two phases work differently.

1) Anchor node data distribution:

Each anchor node transmits its location information including its xyz coordinates and calculated average RSSI data from other nodes. UN stores the information for position estimation.

2) Sensor node location estimation:

In final process the ring is generated with the AN position information. Ring contain the unknown sensor in between anchor node and other known node after it calculating location where the unknown sensor is present. UN send the calculated value to AN, then AN estimate the position of UN using stored value in the database.

4. Experimental result

In the experimental result we assume all the anchor nodes have fixed sensor transmission range R. In offline phase we have taken from signal strength, position from three axis, light, humidity, temperature from all sensors and send to AN.

Offline Phase Implementation							
	Location						
data	X	Y	Z	RSSI	Temp	Humidity	Light
1	250.6	215.9	498.8	16.5	48.6	17.9	6.88
2	195	463.7	458.8	20	61.8	6.87	46.8
3	62.39	365.3	323.2	16.5	39.8	15	41.76
4	161.2	276.1	489.6	20	33	12.4	18.03
5	378.3	207	246.2	20	97.3	6.56	41.89
6	369.5	477.1	15.96	29.5	66.3	5.63	11.52
7	355.6	312.3	295.3	20	4.76	6.98	22.57
8	120.5	357.5	428.1	29.5	73.1	2.76	41.84
9	69.3	294.1	183.1	16.5	50.4	9.79	43.85
10	176.6	224.7	481.8	22.9	97.3	3.78	33.36

Figure 2: Offline phase

In online phase the new measurement is taken as humidity, temperature, light where every time calculates the new position of node from where the information is coming. In project figure 3 the two results is showing for location from where the information is coming one is with ROCRSSI and other is RSSI. Here also showing signal strength value of that node. The ROC-RSSI position is calculated in three-dimension area with described online phase process. Here ring radius reduced and ring radius increased is used to check node is come under the ring or not with value means how much the node inside the range or outside the range. Some results are showing for online phase.

Output of ROC-RSSI in online phase						
Time	Temperat	Humidity	Light	Estimated Location of Node		
				ROC-RSSI	RSSI Only	RSSI
0	58.64	13.5	18.05	2(195.00,463.68,458.75)	2(195.00,463.68,458.75)	19.96/19.96
Ring Radius reduced to 19						
0.1	62.03	16.22	0.96	2(195.00,463.68,458.75)	2(195.00,463.68,458.75)	19.96/19.96
0.2	8.39	19.5	32.57	10(176.57,224.72,481.77)	7(355.56,312.29,295.30)	22.86/19.96
0.3	23.12	8.07	6.1	2(195.00,463.68,458.75)	4(161.23,276.13,489.56)	19.96/19.96
Ring Radius increased to 20						
0.4	26.84	5.16	16.58	6(369.54,477.09,15.96)	4(161.23,276.13,489.56)	29.52/19.96
Ring Radius increased to 21						
0.7	39.9	0.95	17.12	6(369.54,477.09,15.96)	3(62.39,365.29,323.24)	29.52/16.45
0.8	73.6	15.89	27.25	6(369.54,477.09,15.96)	8(120.45,357.52,428.09)	29.52/29.52
Ring Radius reduced to 18						
1.7	64.68	6.15	6.94	6(369.54,477.09,15.96)	6(369.54,477.09,15.96)	29.52/29.52
1.8	47.56	7.25	39.41	2(195.00,463.68,458.75)	1(250.64,215.86,498.78)	19.96/16.45
1.9	78.03	13.37	6.68	6(369.54,477.09,15.96)	8(120.45,357.52,428.09)	29.52/29.52
Ring Radius reduced to 17						
5.2	13.43	1.21	4.21	6(369.54,477.09,15.96)	7(355.56,312.29,295.30)	29.52/19.96
Ring Radius reduced to 16						
8.5	91.68	19.74	25.26	2(195.00,463.68,458.75)	5(378.25,206.95,246.17)	19.96/19.96
Average RSSI By ROC-RSSI:23.95						
Average RSSI:21.54						
Average Improvement:10.07%						

Figure3: Online phase

Figure 4 shows five different results. First the node position vary with seconds (time), second is signal strength is coming from two ROCRSSI and RSSI, third, fourth, fifth shows variation in temperature, humidity and light.

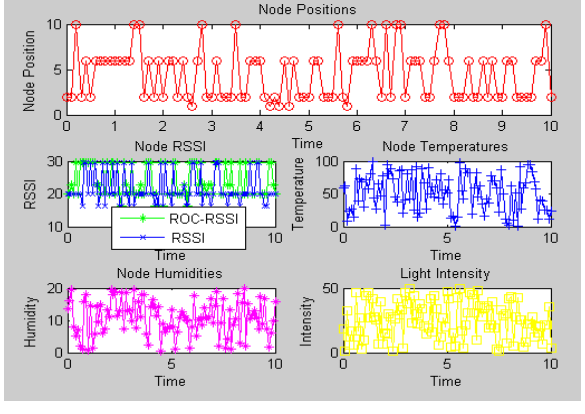

Figure 4: results in online phase

Figure 5 show the distance location error with time between ROCRSSI and RSSI. ROCRSSI give better result when nodes are far in distance.

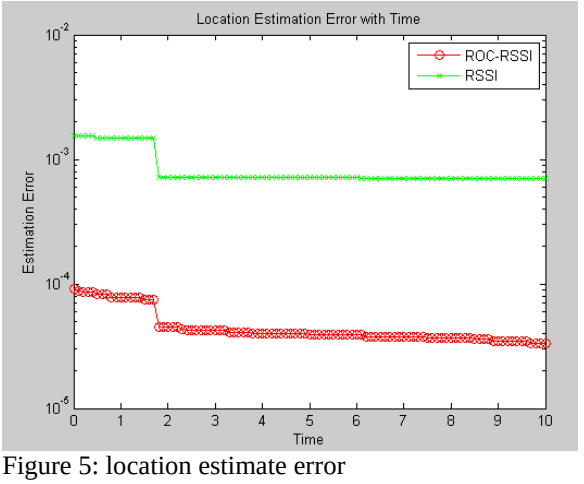

Figure 5: location estimate error

Last figure is shows the position of anchor and unknown node in three dimension location.

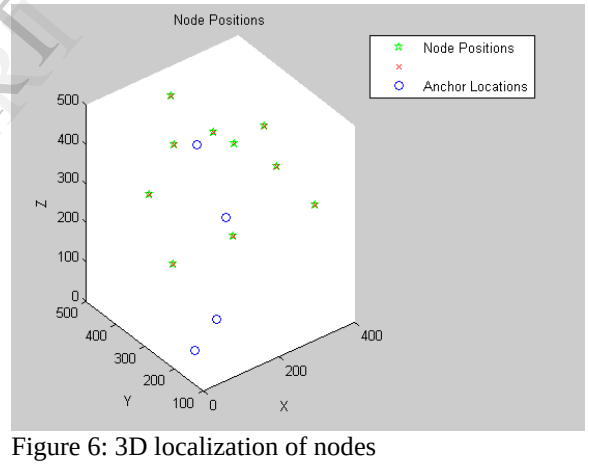

Figure 6: 3D localization of nodes

7. Conclusions

We have studied the sensor node position information in three dimensions, where we studied the ROCRSSI algorithm in 3d which provides range-fee localization that achieves accuracy in location estimation process. The three dimension localization nodes can estimate their position with more accurately. This paper provides result on fixed sensor nodes, further process to implement in mobile node in three dimensions. In finger print localization need more algorithms in three dimensions which provides real world view.

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