Radial Basis Localization Technique for Internet of Things

Ajay Kumar
Department of CSE,
College of Engineering and Technology,
Mody University of Science and Technology,
Lakshmangarh, India.
ajaykr0088@gmail.com

V. K. Jain
Department of CSE,
College of Engineering and Technology,
Mody University of Science and Technology,
Lakshmangarh, India.
drvkjain72@gmail.com

Abstract— Internets of Things and Wireless Sensor Networks have pulled in all researchers due to their provisions for example, doctor's facility surveillance, advanced mobile home, Ecological monitoring, and so forth. The location of sensor node is a critical issue in localization. It may be profoundly alluring to plan scalable, minimal effort, furthermore effective mechanism for node localization. This paper provides and compares a sensor node positioning techniques named gradient algorithm which is a range free techniques for node localization. This algorithm uses multi hop technique to estimate the position of node in a wireless network and also the techniques is compared with the radial basis neural network based technique, which have been implemented to improve the accuracy. A correlation for gradient, centroid algorithm and radial basis neural network technique has been done and found that neural system guarantees superior comes about to higher accuracy.

Keywords—*Internet of Things, Wireless Sensor Networks, Gradient Algorithm, Centroid Algorithm, Radial Basis.*

*****

1. INTRODUCTION

Many of the applications being used would have not been possible without the process of localization[1][2]. Internet of Things has received a great response from various fields with new and recent technologies being used in numerous fields. Few of the promising applications involve monitoring forests and/or fields, rescue operations, patient monitoring, smart home, etc. A proficient localization process[3] can find out the exact coordinates of the unknown sensor node using the information available from sensor nodes with their position known. In addition, the locality based routing protocol can effectively save and utilize a considerable amount of energy by removing the need for route finding and improve the position for purpose. The advancement in technologies helps in designing the sensors that are smaller, cheaper and consumes less power with the capabilities of storage, communication and data sensing. In almost every application using wireless sensors, the nodes are deployed randomly in the specified region. Hence, it is mandatory to determine the location of the nodes. The possible solution to the problem of localization[4] is by manual configuration which is not a feasible one, another is to use Global Positioning System (GPS) two sensors, which is again not a feasible solution due to its large power consumption and higher cost. In the different papers number of localization process[4][5] have been discussed which are mainly classified as range based and range free algorithms. In this paper the classification of localization process is discussed in section 2, followed by proposing a methodology based on Neural network and comparison with the range based process in section 3. Finally the result of the comparison is discussed and shown graphically in section 4 followed by a conclusion.

2. CLASSIFICATION OF LOCALIZATION

Localization[6] can be achieved using any of the following methods based on :

- Anchors
- Network and
- Range

2.1 Anchor Free v/s Anchor Based[6][7]

The sensor nodes which have their position already and other nodes use this information received via messages to estimate their location in the global positioning system. Such nodes obtain their location with the help of some extra device called Global Positioning System (GPA). The node identifies their position through GPS and helps other nodes too for the same. The obtained location is accurate and requires less processing as compared to other processes. The localization process without using anchor nodes or GPA is Anchor free and in this method the sensor nodes identifies their position by utilizing extent estimations amid them.

2.2 Centralized v/s Distributed[6][7]

In Centralized localization all the information is collected at the central position, where the information is processed and the results are forwarded to the nodes in the network. The advantage of such method is that it keeps all sensor nodes free from computations and inappropriate access, scaling and the delay due to transmission. In comparison to Centralized process, sensor nodes in distributed localization do the required computations and coordinates with all other nodes to get their position identified in the network. On the basis of range measurement localization process can be classified as range based and range free localization.

2.2.1 Range Based Localization[7]

This localization process uses distance or angle between the sensor nodes for approximating the position of the node. Such process applies distance estimation techniques to obtain the gap between receiver and transmitter, to localize the node using the principles of geometry. The techniques used in range based approximation are received signal strength indication (RSSI), angle of arrival (AOA), time difference of arrival (TDOA), and time of arrival (TOA).

2.2.2 Range Free Localization

In range-free[7][11] localization algorithms the radio connectivity between nodes and the sensing capabilities of the sensors are used to identify the position of the node. In range free localization techniques some reference sensor nodes may be used. The methods under this category are distance vector (DV) hop, hop terrain, centroid system, APIT, and Gradient algorithm.

Centroid Techniques: Centroid technique[8][9][10] is applicable in the greater density anchor node scenario, so that every unknown node can hear from several known nodes. Here each unknown sensor node obtain their position through by estimating the centre of all the reference nodes, the node receives. The localization error can be reduced by proper arrangements of anchor nodes. In Ad hoc networks proper arrangement of nodes is not possible. To enhance the efficiency of the process weighted algorithm can be used. After the information is received by the unknown node, the location is estimated as :

$$(X_{est}, Y_{est}) = \left(\frac{X_i + \ldots.. + X_n}{N}, \frac{Y_i + \ldots.. + Y_n}{N} \right)$$

Where, X_i,Y_i is the position of anchor node and (X_{est},Y_{est}) is the estimate of unknown node position

In gradient algorithm, multilateration process and hop count, is used to obtain the location of the unknown nodes. Gradient algorithm follows the following steps:

In the first step, the nodes with known positions broadcast their coordinates and hop count value in a message.

In the second step, the shortest path between unknown and known (anchor) node from where it receives the message is calculated using the equation:

$$d_{ji}=h_{j,Ai} * d_{hop}$$

In the third step, minimum position error is computed by following equation:

$$E_j=\sum d_{ji}-d^{ji}$$

where i varies from 0 to n and d^{ji} is gradient propagation based estimated distance.

Neural Networks is also an efficient option for localization. Traditionally, a network of biological neurons is referred as Neural Networks[13]. The recent description for the term is an artificial construct whose activities are based on a network of simulated neurons [14]. Neural Networks are the interconnections of neurons with activation functions. Neural Networks are trained so that a particular input yields a specific output[13]. Implementing neural networks in wireless sensor networks is a promising area for more accurate and faster localization[12]. Various classes of neural networks whose performance has been compared in this paper are Feed Forward Networks, Radial Basis Networks and Recurrent Networks.

3. PROPOSED METHODOLOGY

Another technique to obtain the accurate localization is neural networks based localization. These networks are the interconnection of nodes called neurons with their activation functions. Various classes of neural networks can be obtained by using different activation functions and the structure of weighted interconnections between the neurons. Three classes of neural networks whose performance for localization are: *Feed Forward Networks, Radial Basis Networks and Recurrent Networks.*

The centroid algorithm is used as a reference for the performance verification of the created neural network. Using the recorded values of unknown nodes, a neural network can be trained. Real positions of unknown nodes are provided to the input layer of neural network. The output layer uses the input transformed by hidden layer. Output layer yields the output as the estimated positions of unknown nodes.

The accuracy of the localization between the real and the estimated (calculated) values is measured using mean square error (mse) formula mentioned in equation 4.

$$mse = \frac{\sqrt{\sum_{i=1}^{n}[(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2]}}{R}$$

Where,

x_i and y_i = real node coordinates

$\hat{x}_i$ and $\hat{y}_i$ = estimated node coordinates

R = communication range

i = node index

By initializing the number of layers and neurons to each layer the neural network is trained and transfer function to each layer is initialized. The output generated from neural network is the estimated position of unknown nodes. From real and estimated positions mean square error can be measured. The process is repeated with updated weights and biases till mean square error is less than that of mean square error of centroid method.

4. RESULTS

4.1 Centroid Algorithm Based Approaches

Centroid algorithm is implemented and executed using the MATLAB R2013a simulator. In this algorithm, we have taken 100 anchor nodes and performance has been done by taking 10 unknown nodes. We have deployed these nodes in the network area of 100x100 meters with the communication range of 20 meters between them. The network was generated using the parameters as in Table 1.

Table 1: Recreation parameters for Centroid Algorithm

PARAMETERS	VALUES
Number of anchor	100
Number of unknown	10
Communication range	20 m
Deployment area	100*100 m

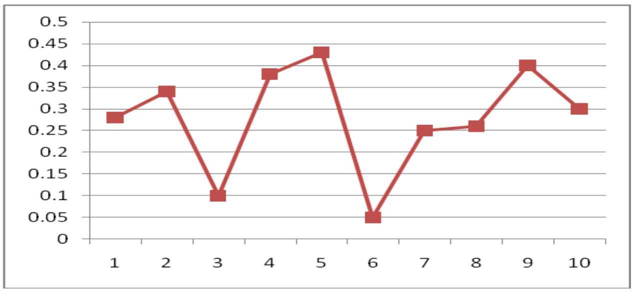

Fig. 1. Error distribution for 10 unknown nodes using centroid algorithm

In above Fig. 1, bars represent the estimated error of individual 10 unknown nodes. Error has been defined as the variation between real and estimated positions of unknown nodes. We observed that node 5 gives the maximum error as it is displaced maximum from its real position after implementing centroid algorithm. Similarly, node 6 gives the minimum error as it is displaced minimum. The average error of all 10 unknown nodes comes out to be 0.2807 meter.

4.2 Neural Network Based Approach

In case of neural networks, real coordinates of unknown nodes are provided as the input to the network and with the help of neural networks output data is achieved. This output is the estimated coordinate location of unknown nodes achieved by neural networks. Now the output data is compared with the target data and the variation between output data and target data becomes the error. Here to obtain the higher accuracy of localization *Radial Basis Network is used.* For performing these neural networks, we need to train the networks. Therefore, these networks can be trained by taking 10 neurons, 50 epochs, training function as Levenberg-Marquardt (TRAINLM), adaption learning function as LEARNGDM and performance function as mean squared error (MSE).These neural networks are trained and generated by using the parameters given in Table 2.

Table 2: Simulation parameters for neural networks

PARAMETERS	VALUES
Number of neurons	10
Number of epochs	50

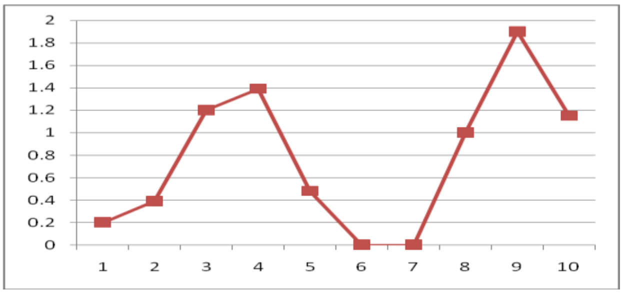

Fig. 2. Error estimation for 10 nodes using Radial Basis Networks

The above Fig 2 represents the estimated error for 10 individual unknown nodes using radial basis networks in which node 9 shows the maximum error. The average estimated error for 10 unknown nodes comes out to be 7.7297e-07 meters.

Table 3: Performance Comparison for 10 unknown nodes

METHOD	ERROR IN METERS
Centroid Algorithm	0.2228
Radial Basis N/ws	7.7297e-07

The above Table 3 shows the performance comparison of the experimental results. The average localization error have been used to evaluate the performance of different localization schemes for all unknown sensor nodes. After comparing the values, we can say that radial basis neural networks have best performance than the centroid and Gradient method on the basis of estimated error. Therefore, implementing radial basis neural network in localization is a better choice for higher localization accuracy.

ISSN: 2454-4248
80 – 83

5.CONCLUSION

In this paper, centroid algorithm and radial basis different neural networks have been discussed and their performances are evaluated on the basis of error estimation. Accurate localization of wireless devices is a crucial requirement for many applications. Therefore, neural networks based approached have been used to obtain better accuracy. It can be seen that radial basis neural networks give better results than the other networks when error is taken into consideration. Therefore, neural network implementation is a better option to obtain higher accuracy for localization in wireless sensor networks required for Internet of Things.

REFERENCES

[1]. Mohd Fauzi Othmana , Khairunnisa Shazalib,” Wireless Sensor Network Applications: A Study in Environment Monitoring System”, International S ymposium on R obotics and Intelligent S ensors 2012 (IR IS 2012).

[2]. Carlos F. García-Hernández, Pablo H. Ibargüengoytia-González, Joaquín García and Hernández, “Wireless Sensor Networks and Applications: a Survey,” International Journal of Computer Science and Network Security (IJCSNS), Vol. 7, No. 3, pp. 264-273, 2007.

[3]. Y. Shang, W. Rumi, Y. Zhang, and M. Fromherz, “Localization from connectivity in sensor networks,” IEEE Transactions on Parallel and Distributed Systems, Vol. 15, No. 11, pp. 961–974, 2004.

[4]. Shweta Singh, R. Shakya and Y. Singh, “Localization Techniques in Wireless Sensor Networks,” International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 6, No. 1, pp. 844-850, 2015.

[5]. P. K. Singh, B. Tripathi and N. P. Singh, "Node Localization in Wireless Sensor Networks," International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 2, No. 6, pp.2568-2572, 2011.

[6]. Nabil Ali Alrajeh, Maryam Bashir and Bilal Shams, “Localization Techniques in Wireless Sensor Networks,” International Journal of Distributed Sensor Networks, vol. 2013, Article ID 304628, 9 pages, 2013.

[7]. Amitangshu Pal, “Localization Algorithms in Wireless Sensor Networks: Current Approaches and Future Challenges”, Network Protocols and Algorithms ISSN 1943-3581, Vol. 2, 2010,.

[8]. Liu, Yu, Xiao Yi, and You He, "A novel centroid localization for wireless sensor networks," International Journal of Distributed Sensor Networks,vol. 2012, Article ID 829253, 8 pages, 2012.

[9]. G.-A. Lusilao Zodi, Gerhard P. Hancke, and Antoine B. Bagula, “Enhanced Centroid Localization of Wireless Sensor Nodes using Linear and Neighbour Weighting Mechanisms”, Proceedings of the 9th International Conference on Ubiquitous Information Management and Communication, ACM, 2015.

[10]. J. Blumenthal, R. Grossmann, F. Golatowski, and D. Timmermann, “Weighted Centroid Localization in Zigbee-based Sensor Networks,” Intelligent Signal Processing, IEEE, pp. 1-6, 2007.

[11]. Santar Pal Singh, S.C.Sharma, ”Range Free Localization Techniques in Wireless Sensor Networks: A Review” , 3rd International Conference on Recent Trends in Computing (ICRTC), 2015.

[12]. N. Bulusu, J. Heidemann, and D. Estri n, “GPS-less low-cost outdoor localization for very small devices”, Personal Communications, IEEE,Vol. 7, No. 5,pp. 28–34, 2000.

[13]. Ali Shareef, Yifeng Zhu, and Mohamad Musavi, “Localization using neural networks in wireless sensor networks”, Proceedings of the 1st international conference on MOBILe Wireless MiddleWARE, Operating Systems, and Applications. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), ACM, 2008.

[14]. Chen, Chien-Sheng, “Artificial neural network for location estimation in wireless communication systems,” Sensors, Vol. 12, No. 3, pp. 2798–2817, 2012.