Efficient Two Dimensional Node Localization using Genetic Algorithm in Wireless Sensor Network

Preety Saini[1] Rajiv Bansal[2]
[1]Research Scholar [2]Assistant Professor
[1,2]Department of Computer Science Engineering
[1,2]JMIT, Radaur, Haryana, India

Abstract— Node localization that to be aware of the position of nodes is an essential part of wireless sensor network. One of the major requirement of localization in WSN is accuracy of location. The aim of this paper is to reduce error in location estimation and convergence speed in two dimensional coordinate system. The proposed 2DL-RAGA in this paper is range based and anchor based algorithm. Initial step of algorithm is optimal placement of anchor nodes by using k-means and then encodes the sensor node in real coding. Fitness function is designed based on distances between anchor and non-anchor nodes. The Uniform crossover and improved neighborhood mutation operator are applied. Simulation result shows that the two dimensional (2DL-RAGA) algorithm shows less average error than previous algorithm and algorithm shows faster convergence.

Key words: WSN, Localization, Range based, Optimization, Genetic Algorithm (GA)

I. INTRODUCTION

A wireless sensor network has a number of different configuration sensors. Sensors are capable of sensing physical things like temperature, pressure of sound, humidity level, leakage of gas, light as in [1] and also can detect land mines. The job of each sensor is to identify the change which happens in its surrounding area according to range of sensor as in [2] and make notification of these changes at the base station. Now the job of base station is to find the location of that node. The recent technological development in wireless sensor network made feasible the development of low power, low cost, small size sensors which communicate over short distances.

Localization as in [3] is the major research area under wireless sensor network which identify the current location of sensor nodes. Localization means to calculate physical coordinates of a sensor node (or a group of sensor nodes) as in [4] and the spatial relationship among nodes. Sensor node do this either automatically or with the help of GPS device attached to it as in [5] or it is done manually. Manual estimation of the location may not be feasible in the context of large network and in inaccessible area.

To provide GPS with each sensor node is very costly, so the alternative is to use the concept of anchor node. Some nodes have GPS as in [6] called anchor nodes and other node identify location with the help of nearby anchor nodes. While the GPS is undoubtedly the well-known location sensing system, it is not accessible in all environments as in [7] (for example indoor environment) and may incur resource cost unacceptable for resource constrained wireless sensor network.

Localization covers a set of techniques as in [8] and methods that allow a sensor to estimate its own location based on information gathered from sensor's environment. These technique include range based or range free, anchor based or anchor free, centralized or distributed. Range base technique (high accuracy, high cost) as in [9] include RSSI, TOA, TDOA, Range free technique (less accuracy, low cost) include hop count etc. Other methods are trilateration, multilateration, bounding box, probability based.

The requirement of location information in wireless sensor network is realized in these major areas as in [10], [22] for example, Navigation (To understand movement of objects and to guide path of the mobile objects to their destination), Track (It means understanding of the location of devices), Real time location (Virtual / Real time location and also orientation of sensor node), Optimize routing (Routing needs location information of each node in such a way that it optimized the routing).

In this paper efficient two dimensional (2DL-RAGA) node localization algorithm based on genetic algorithm is purposed. It work on the basis of uniform crossover and improved neighborhood mutation operator. This paper also highlights the future research areas of localization in wireless sensor network.

1) Organization of The Paper:

Section 2 covers Review on localization algorithm based on GA. Section 3 Problem Statement. Section 4 Purposed algorithm. Section 5 present Simulation and Results. Section 6 present the Discussion and Future events. Section 7 Concludes the paper.

II. RELATED WORK

There are various algorithm in two dimensional network. As in the paper [11] author propose an improved DV-Hop (GADV-Hop) algorithm which was based on genetic system. In order to increase position accurateness or convergence rate, they restrain a population viable region.

A combination of RSS and AOA based optimization which use genetic algorithm is introduced in paper [12] to accurately estimate the position of node.

A Genetic Algorithm in paper [13] for wireless sensor network localization with level-based reliability pattern is proposed to resolve the matter that the positioning correctness. Their proposed LRS-GA is made up of two stages. The node with excessive consistency is elected by level-based reliability pattern at the first stage and then acquires the measure distance by RSSI. At the second stage, GA localization procedure is used to approximation of the position of the unknown node.

An efficient algorithm in paper [14] that targets at minimizing the number of anchor nodes in a WSN, without threatening the job of locating all left behind nodes in the network.

The GA in paper [15], [16], [32] worked on the Euclidean distance objective function to discover the correct position of the sensor nodes. The objective function is predominant to minimize the difference between the actual and projected distance between the anchor node and the mobile sensor node.

The nodes in paper [17] of sensor system is two dimensional. (xi, yi) as anchor node coordinates. Initially, the algorithm implement the decimal coding scheme of sensor. Agreeing to communication between nodes compute the distance between nodes.

The elementary idea of the algorithm PGA in paper [18] is that algorithm present pattern search algorithm to the selection segment of genetic algorithm, so as to preserve a diversity of current population. In concept, PGA algorithm can reserve the best and the neighboring individuals of each generation.

The author propose an enhanced genetic algorithm in paper [19] with a filter and replenishment approach FRGA, this algorithm can successfully evade the problems that the localization correctness of some nodes is not strict because of premature convergence.

Algorithm in paper [20] avoid the impact of environmental aspects by pre-establishing the pattern. Likewise, the offered algorithm does not necessity of too much statistics about anchor nodes to pre-establish the pattern.

The algorithm in paper [8] is distributed into two stages, use sampling routine to gain initial location and polishes the initial location centered on genetic set of operation.

A real-coded form of the generally used genetic process is presented in paper [31] in order to calculate the correctness of node localization problem in wireless sensor setups, in the meantime, the analogous fitness function and genetic operation are planned.

Their work in paper [23] targets at determining the location of the sensor nodes with great correctness. The initial part of their work is supported out by localizing the nodes by means of Mobile Anchor Positioning (MAP), a range-free localization technique. Root Mean Square (RMSE) error has been used by them as a performance measure to compare between the two methodologies.

III. Problem Statement

WSN localization problem can be defined as follows:
There are m anchor nodes and n non-anchor nodes in three and two dimensional network. And initial coordinates of all the sensor nodes (m + n) are stored in a base station at the time of deployment. The coordinates of anchor nodes are known to us. The problem is to find coordinates of n non-anchor node based on the position of anchor node and distance between non-anchor node and anchor node.
Therefore, the WSN localization problem can be formulated as:

(x, y) = F (X_i, Y_i, D_i), where x, y is the position of non-anchor node and X, Y is the position of anchor node, D is the distance between anchor and non-anchor node.

The assumptions of wireless sensor network are as follows, Nodes present in 2D space. Nodes are static. Two types of nodes anchor or non-anchor and nodes are homogeneous.

IV. Proposed Algorithm

This algorithm is based on Darwin's evolution of natural methods. Genetic Algorithm in [24], [25] is categorized as a global search technique. In order to get and obtain a global optimum solution, genetic algorithm is an evolutionary algorithm, that has advantage of simple conditions, strong ability as in [26], [27] to search, and it is appropriate for single and multi-objective, so it is suitable for wireless sensor network. Genetic Algorithm work on the random space as in [30] and real value encoding is used as in [31] through tournament selection as in [33], crossover and neighborhood mutation as in [21], [34] operations. One step in Genetic Algorithm is elitism. Its job is to keep the best chromosome for the next generation so that it cannot be lost. Genetic Algorithm is implemented using simulations and localization problem is converted into an optimization problem.

Propose localization algorithm used genetic algorithm as optimization tool. In the algorithm anchors are distributed uniformly as in [28], [29] and for this k-means is applied. Two major stage of algorithm are
Stage 1) Network Formation or distance estimation which include step 1 and step 2.
Stage 2) Genetic Algorithm or position estimation which include step 3 to 10.

1) Step 1. INITIALIZATION

Initialize all the sensor node with random coordinates in 2D network. Now calculate Euclidian distance between all sensor nodes in an n x n matrix, n is total number of nodes. For distance estimation RSSI method is used in the field where sensors are placed. (x1, y1), (x2, y2) are coordinates of different node.

$$d=\sqrt{y2 - y1) * 2 + (x2 - x1) * 2}$$

2) Step 2. Optimal Placement of Anchor Node

There are two types of nodes anchor node and non-anchor node. Anchor nodes are equipped with GPS and know their position. The position of non-anchor node is calculated with the help of anchor node. So uniform distribution of anchor node is must so that all non-anchor node must come in communication range of one of the anchor node. For this K-means algorithm is applied to make clusters. K-means provide node id with cluster number and center positions. It calculate distance between anchor and its neighbor. Then return center of cluster which has minimum distance.

3) Step 3. Population Generation

Population contains individuals according to the population size. One individual contains randomly generated coordinates (x, y) in 2DL-RAGA as the number of non-anchor.

1	2	....	Non-anchor
(x, y) For 2D	(x, y) For 2D		(x, y) For 2D

Fig. 1: Individual 1

4) Step 4: Encoding

As individual stores all coordinates of non-anchor nodes. Therefore Positions of sensor nodes are encoded with double values. It is called Value encoding.

Individual	17.34	50.45	98.23	78.45	....

Fig. 2: Value Encoding

5) Step 5: Fitness Function:

The previously generated matrix (m X n) of distances which was stored in base station. Formulate a matrix (m X n) of distance of all nodes for each individual of population. Now calculate the difference of both the matrix. Here X_i, Y_i is coordinates of anchor node and X, Y are coordinates of unknown node and d_i is estimated distance by our algorithm.

$$F(x, y)= \sum_{i=1\ldots n} |\sqrt{((X-X_i) *2+(Y-Yi) *2)}- d_i|$$

6) Step 6: Elitism:

It store best individual value from each generation in an array.

7) Step 7: Selection:

For selecting best individuals from population Tournament selection is used. Tournament size is set to 4. It select 4 individual at a time, sort them. Then select top two parent for crossover and mutation.

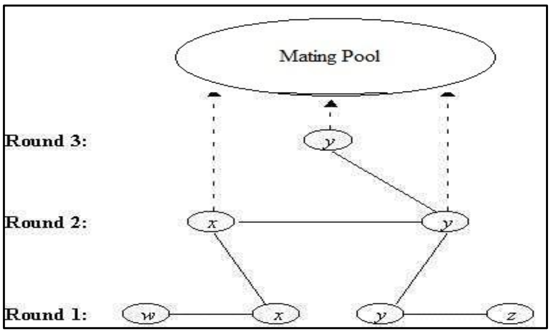

Fig. 3: Tournament Selection

8) Step 8: Crossover

For this uniform crossover gives best result. It is rate based crossover. Rate can be changed to see the different result. Uniform crossover takes values from both of the parent.

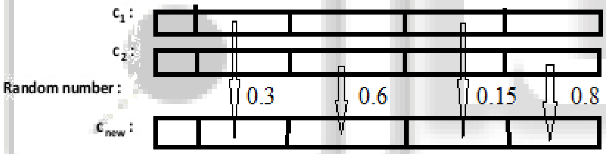

Fig. 4: Uniform Crossover

9) Step 9: Mutation

For this improved neighborhood mutation with some changes of boundary checking is applied on each coordinate of a node for example on x, y. It is rate based operator. Mutation operator take a random move around the single point with a specified radius and ϴ ε [0, 2∏].

```
rth= rand * ϴ
C= cos (rth)
S= sin (rth)
v1=v2=0
Ideal distance =sqrt (area Dimension/n)
Radius = ideal distance *(1-iter/max iteration)
Rotation in Two dimensional Area
v1=radius * C
v2=radius * S
xd = x+v1
yd = y+v2
Boundary Checking
If (xd < 0)
   xd = x+ abs(v1)
else if (xd>area Dimension)
   xd = x-abs(v1)
End

If (yd<0)
   yd =y+ abs(v2)
else if (yd>area Dimension)
   yd =y-abs(v2)
End
```

Here xd, yd are new mutated coordinates of sensor node.

10) Step 10: Termination Criteria

The stopping condition for proposed algorithm is maximum number of iteration.

– Advantage of Proposed 2DL-RAGA

For first step of localization algorithm: Distance estimation, when position of non-anchor node is calculated there is no need for requirement of three or more anchor node, proposed algorithm can predict location when non-anchor node come under communication range of at least one anchor node.

Second advantage is that GADV-Hop [5] require to calculate minimum of three distances between one non-anchor node and three anchor node predicted by algorithm. But the proposed algorithm place anchor node in such a optimize way by using k-means which already choose anchor node as a center of cluster with minimum distance of neighbor nodes.

For second step of localization algorithm: coordinate estimation Third advantage is that the second step to calculate coordinates of nodes by using distances from first step, this coordinate calculation is done by random generation method, which is the benefit of genetic algorithm, it reduce complexity of logic formation for localization algorithm.

– Design Module:

The flow chart represents the proposed algorithm as shown:

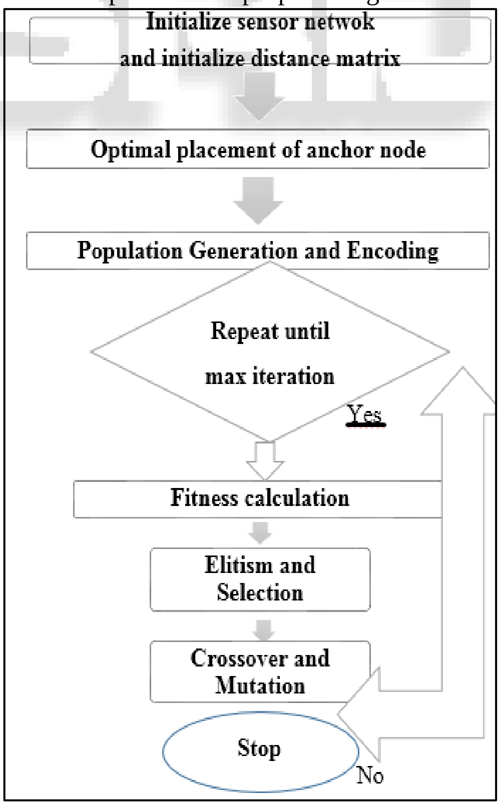

Fig. 5: Flow Chart of Proposed Algorithm

V. Simulation and Result

In order to evaluate location performance of the proposed algorithm, the simulations are achieved by MATLAB

7.10.0, window 7, i3 processor. The sensor nodes are considered to be placed on a 100 X 100 square for two dimensional network. The number of nodes are considered to be 100. Each node has transmission range of 30m.

S. No.	Parameters	Values
1.	Network Size	100 X 100
2.	No. of nodes	100
3.	Population Size	120
4.	No. of Generation	180
5.	Transmission Range	30
6.	Crossover Probability	0.5
7.	Mutation Probability	0.5
8.	Distance Estimation Method	RSSI
9.	Position Estimation Method	Random Generation
10.	Localization Algorithm	Genetic Algorithm
11.	Classification of Proposed Algorithm	Ranged Based, Anchor Based
12.	Observation Parameter	Error, Average Error, Complexity
13.	Tournament Size	4

Table 1: Simulation Parameters for 2DL-RAGA

In order to compare location algorithm average error are defined as

Error: Error of single node,

$$Error=\sqrt{((Xest-Xi)*2+(Yest-Yi)*2)}.$$

Average Error: Average error are calculated as by given formula, for 2DL-RAGA,

$$\text{Average Error}=\frac{\sum_{i=1}^{n}\sqrt{((Xest-Xi)*2+(Yest-Yi)*2)}}{n}$$

Here (Xest, Yest) are estimated coordinates of sensor node given by genetic algorithm and (Xi,Yi) are actual coordinates of sensor node, here n is the number of sensor node.

General indicators [10] of localization method are Location accuracy (It is primary evaluation of localization algorithm and it is used to determine the proportion of error and the node's wireless range) and Anchor node density (It is another sign for evaluation of localization algorithm. It should be least possible in order to decrease deployment cost).

The figure 6 shows placement of sensor node. Here blue dots represent actual position of sensor node, red circle represent position of anchor node and red dots represent position of sensor nodes predicted by proposed 2DL-RAGA when number of sensor= 100, transmission range =30, area dimension= 100 X 100., anchor node=20. More Red dot represent overlapping of actual position.

The figure 7 shows the fitness of best individual in one population size during all iteration of genetic algorithm when number of sensor= 100, transmission range =30, anchor node=20, area dimension= 100 X 100.

The figure 8 shows error of each node, when number of node=100, transmission range=30, area dimension=100 X 100, number of anchor=20 and it shows average error=5.3.

The graph 9 shows the comparison of proposed 2DL-RAGA and GADV-Hop [5] when number of sensor= 100, transmission range =30, area dimension= 100 X 100. Graph shows the average error when number of anchor node vary from 20 to 90. It shows that error are decreasing with increase in number of anchor node.

The graph 10 shows the comparison of proposed 2DL-RAGA and GADV-Hop [5] when number of sensor= 100, anchor percentage =20, area dimension= 100 X 100. Graph shows the average error when transmission range of node vary from 30 to 90. It shows that error are increasing with increase in communication range.

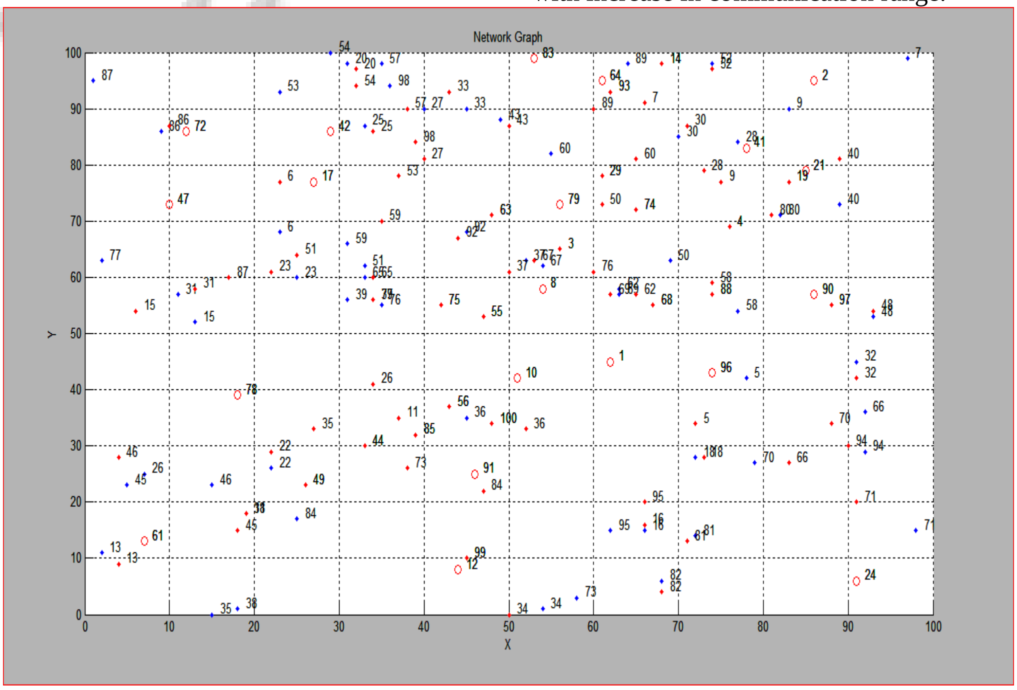

Fig. 6: Network Diagram for 2DL-RAGA

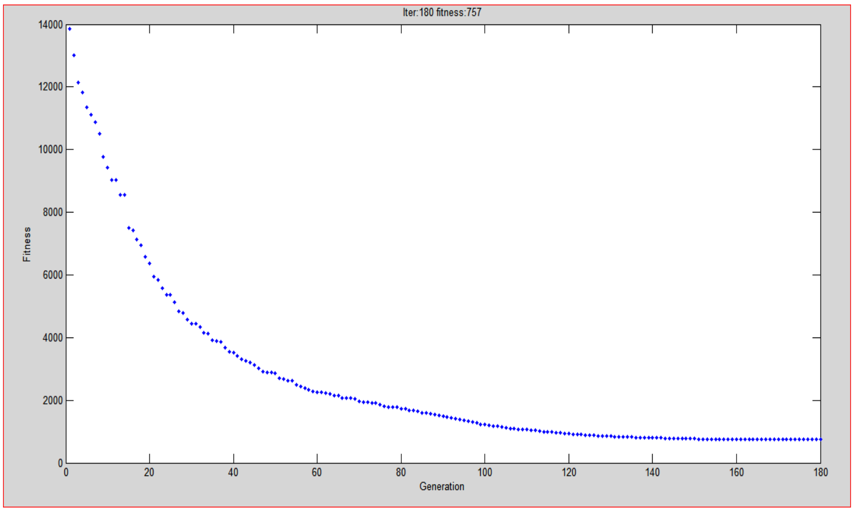

Fig. 7: Fitness Vs Number of generation for 2DL-RAGA

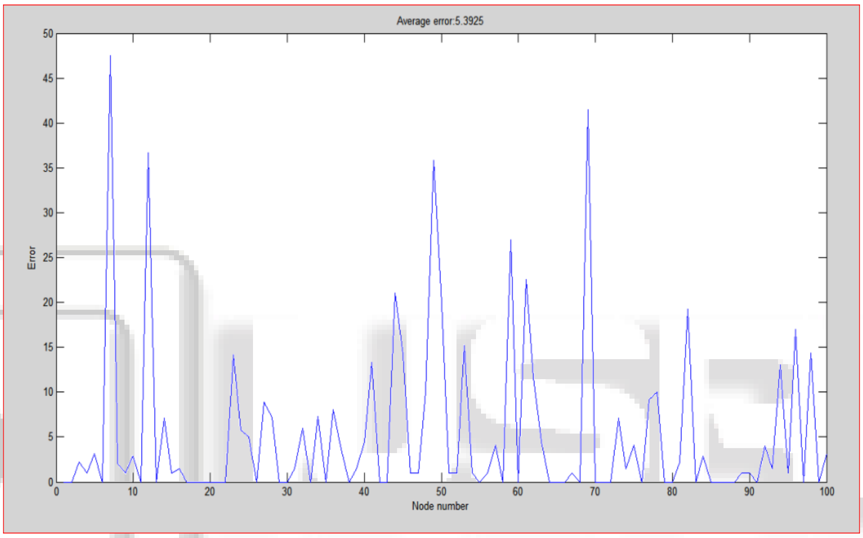

Fig. 8: Error of each node for 2DL-RAGA

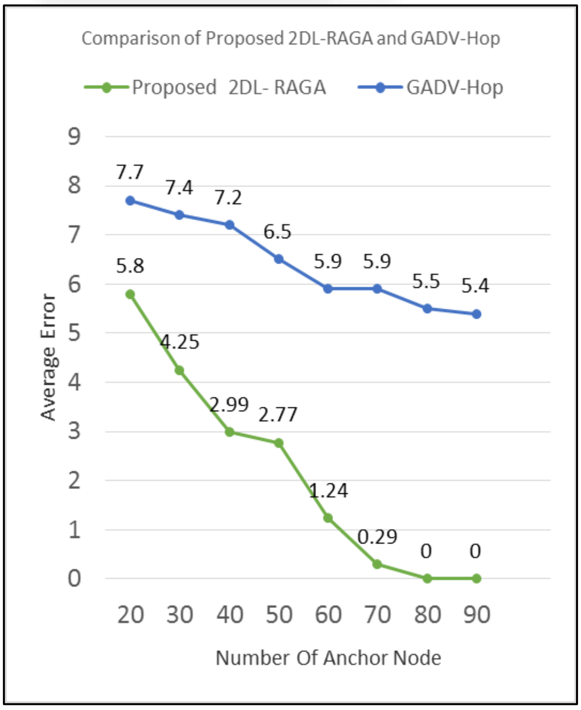

Fig. 9: Comparison of for 2D-RAGA and GADV-Hop

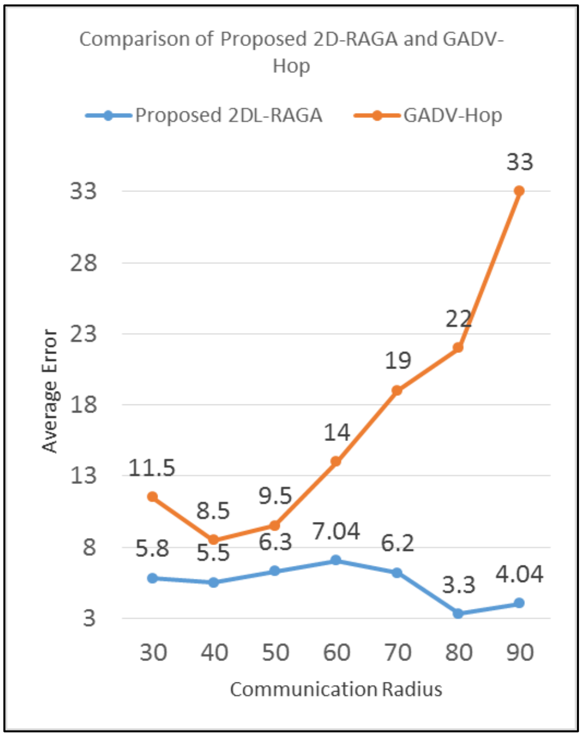

Fig. 10: Comparison of for 2DL-RAGA and GADV-Hop

VI. FUTURE EVENTS

The algorithm implement improved neighborhood mutation operator which mutate the coordinates of sensor node in circle. Here an improvement can be made by setting the direction of mutation. It will further reduce errors in coordinate estimation.

There are many other issues with localization of sensor nodes in WSN, such as deployment of [3] sensor node in three dimensional space by the use of aircraft.

In another case, when there is mobility in sensor nodes then location estimation is done each time an event occur. There is another issue when some nodes leave the WSN and some new node join the system. The localization problem is further complicated by the non-uniqueness of the sensor node in the network. Research may focus in area like accuracy, complexity, scalability, dependability, security, mobility [35] and energy conservation. As most of the localization method use neighboring nodes to identify their localization, there must be a confidence that position of nearby node is valid.

1) Anchor density Future work can be done to further reduce number of anchor node.
2) Resource constraint Energy concept can be applied while estimating the location.
3) Mobility Localization here consider static nodes. There exist a terrible fall in position accuracy, for mobile nodes.

VII. CONCLUSION

Node localization is an important issue in wireless sensor network as many applications depend on knowing the position of sensor node. Localization in WSN is an optimization problem whose aim is to minimize the total estimation error of localization problem in WSN. In recent years, there have been several optimization based localization algorithm. In the purposed algorithm 2DL-RAGA combine the optimization method to solve two dimensional localization problem and purposed algorithm is based on genetic algorithm.

The purposed GA based algorithm first considered the two coordinate (x, y) for 2D to form individual of a population. Uniform crossover is applied on selected individual by tournament method. The algorithm implement improved neighborhood mutation with boundary checking to quickly converge the optimization problem and it maintain diversity of population. Simulation result shows that two dimensional (2DL-RAGA) algorithm shows less average error than previous algorithm. It shows error of 2.9 percent when anchor are 40 percent. The algorithm converges at iteration number 180.

VIII. ACKNOWLEDGEMENT

I would express my deep sense of regard to our Head of Department Mr. Vivek Sharma and to Mr. Rajiv Bansal, AP CSE Department for regular inputs and for constantly guiding. I am obliged to the staff members of CSE department, JMIT for the valuable information provided by them as and when necessary.

REFERENCES

[1] Waltenegus Dargie, Christian Poellabauer," Funndamentals of wireless sensor networks Theory and Practice", pp. 249-266, 2010 John Wiley & Sons Ltd.
[2] Saikiran Reddy Karedla, S.Anuradha, "Localization Error Minimization using GA in MWSN" Vol 2, Issue 4, pp.17-24, IJAEEE 2013.
[3] Vijay K. Chaurasiya , Neeraj Jain, G.C. Nandi, "A novel distance estimation approach for 3D localization in wireless sensor network using multidimensional scaling" Information Fusion 15, pp.5–18, 2014 Elsevier.
[4] Mamta Kanwa, Kanika Sharma," Localization Algorithm Based on Genetic Algorithm for Wireless Sensor Networks", IJSRD - International Journal for Scientific Research & Development| Vol. 2, Issue 11, pp.371-374, 2015.
[5] me.emu.edu.tr/majid/MENG584/Localization.ppt
[6] Yuehu Liu, Hao Yu, Bin Chen, Yubin Xu, Zhihui Li, Yu Fang," Improving Monte Carlo Localization Algorithm Using Genetic Algorithm in Mobile WSNs", pp.1-5, 2012 IEEE.
[7] N. Jiang, S. Jin, Y. Guo, Y. He," Localization of Wireless Sensor Network Based on Genetic Algorithm", International J Computer Communication, 8(6) pp.825-837, December, 2013.
[8] Lei Zhang and Binwei Deng," A New Range-based Localization Algorithm for Wireless Sensor Networks", ISECS International Colloquium on Computing, Communication, Control, and Management, 9 pp.111-114, 2009 IEEE.
[9] Azzedine Boukerche, Hooracio A. B. F. Oliveria, Eduardo F. Nakamura, Antonio A. F. Loureiro, "Localization System for Wireless Sensor Networks" Wireless Communications, pp.6-12, December 2007, IEEE.
[10] Bing Jiang, Wei Zhang, Pan Zhang" Research on an improved Genetic Algorithm which can improve the node positioning optimized solution of wireless sensor networks" International Conference on Computational Science and Engineering, pp.949-954, 2009 IEEE.
[11] Bo Peng Lei Li," An improved localization algorithm based on genetic algorithm in wireless sensor networks", 9, pp.249-256, Jan 2015 Springer.
[12] Kapil Uraiya, Dilip Kumar Gandhi," Genetic Algorithm for Wireless Sensor Network with Localization Based Techniques", International Journal of Scientific and Research Publications, Volume 4, Issue 9, pp.1-6, September 2014.
[13] Xinyu Wang, Ziwen Sun, Zhicheng JI," Genetic Algorithm for Wireless Sensor Network Localization With Level-based Reliability Scheme" Journal of Computational Information Systems, 9(16), pp.6479-6486, 2013.
[14] Angelo F. Assis, Luiz Filipe M. Vieira, Marco Tulio R. Rodrigues, Gisele L. Pappa," A Genetic Algorithm for the Minimum Cost Localization

Problem in Wireless Sensor Networks", 9(13) pp.797-804, 2013 IEEE.
[15] Olawale David Jegede, Ken Ferens," A Genetic Algorithm for Node Localization in Wireless Sensor Networks", pp.1-7, 2013.
[16] Shijun Zhao Meiling Sun Zhaohui Zhang," GASA-Hop Localization Algorithm for Wireless Sensor Networks", International Conference on Communications and Mobile Computing, pp.152-156, 2009 IEEE.
[17] Wenyuan Sun, Xiaolong Su," Wireless Sensor Network Node Localization Based on Genetic Algorithm", pp.316-319, 2011 IEEE.
[18] Haiping HUANG, Qiwang CAI, Ruchuan WANG, Baoyang SHE, Yujing MA," The Wireless Sensor Network Localization Algorithm Based on Improved Pattern Genetic Algorithm", 7: 9, pp.3031-3038, Journal of Computational Information Systems 2011.
[19] Gao Yang, Zhuang YI, NI Tianquan, YIn Keke, Xue longtong,"An Improved Genetic Algorithm for Wireless Sensor Networks Localization", pp.439-443, 2010 IEEE.
[20] Tin-Yu Wu, I-Ju Liao, Wei-Tsong Lee, Guan-Hsiung, Liaw, Jen-Wen Ding, Chung-Chi Wu," Enhancing Indoor Localization Accuracy of Sensor-based by Advance Genetic Algorithms", IWCMC 10, pp.1218-1222, 2010 ACM.
[21] Qingguo Zhang and Jingwei Huang Jinghua Wang, Cong Jin, Junmin Ye and Wei Zhang Jing Hu," A Two-Phase Localization Algorithm for Wireless Sensor Network", Proceedings of the International Conference on Information and Automation June 20 -23, 2008, Zhangjiajie, China, pp59-64, 2008 IEEE.
[22] http://en.wikipedia.org/wiki/Wireless_sensor_network.
[23] S.Sivakumar, Dr.R.Venkatesan, Error minimization in localization of wireless sensor using differential evolution with mobile anchor positioning (DE - MAP) Algorithm", 10th August 2014. Vol. 66 No.1, pp.330-339, JATIT & LLS.
[24] Raghavendra V. Kulkarni, Anna Förster, and Ganesh Kumar Venayagamoorthy," Computational Intelligence in Wireless Sensor Networks: A Survey", Communication Surveys and Tutorials, Vol. 13, No. 1, First Quarter, pp.68-96, 2011 IEEE.
[25] [Book] S. N. Sivanandam, S. N. Deepa,"Introduction to genetic algorithm", Verlag Berlin Heidelberg pp.1-5 2008 Springer.
[26] Hongliang Ren, Max Q.-H. Meng," Biologically Inspired Approaches for Wireless Sensor Networks", Proceedings of the International Conference on Mechatronics and Automation June 25 - 28, Luoyang, China, pp.762-768, 2006 IEEE.
[27] Wenwen Li, Wuneng Zhou1," Genetic Algorithm-Base Localization Algorithm for Wireless Sensor Networks", Seventh International Conference on Natural Computation, 3(11) pp.2096-2099, 2011 IEEE.
[28] Rui Zhang, Weiwei Xia, Ziyan Jia, Lianfeng Shen and Jinghong Guo," The Optimal Placement Method of Anchor Nodes toward RSS-based Localization Systems" 6th International conference on WCSP, pp.1-6, 2014 IEEE.
[29] Panya Sunantasaengtong and Sorawat Chivapreecha," Mixed K-means and GA-based Weighted Distance Fingerprint Algorithm for Indoor Localization System", pp.1-5, 2014 IEEE.
[30] S A kazarlis, V. Petridis,"A genetic algorithm solution to unit commitment problem", Transaction on power system, Vol 11, No.1, pp.83-92, Feb 1996 IEEE.
[31] Guo-Fang Nan, Min-Qiang Li, Jie Li," Estimation of Node Localization with a Real-Coded Genetic Algorithm in Wsn", Proceedings of the Sixth International Conference on Machine Learning and Cybernetics, Hong Kong, pp.873-878, 19-22 August 2007 IEEE.
[32] Qingguo Zhang and Jingwei Huang Jinghua Wang, Cong Jin, Junmin Ye and Wei Zhang," A New Centralized localization Algorithm for Wireless Sensor Network" pp.1-5, 2007 IEEE.
[33] HongyuShi, Jianzhong Cao," A New Hybrid Algorithm on TDOA Localization in Wireless SensorNetwork", Proceeding of the IEEE International Conference on Information and Automation Shenzhen, China, pp.606-610, June 2011 IEEE.
[34] Qingguo Zhang, Jinghua Wang, Cong Jin, Junmin Ye, Changlin Ma, and Wei Zhang," Genetic Algorithm based Wireless Sensor Network Localization", Fourth International Conference on Natural Computation, 8 pp.608-613, 2008 IEEE.
[35] Jia Huanxiang, Wang Yoni, Tao Xiaolinl," Localization Algorithm for Mobile Anchor Node Based on Genetic Algorithm in Wireless Sensor Network", 9(10) pp.40-44, 2010 IEEE.