ISSN 2250-3153

Genetic Algorithm for Wireless Sensor Network With Localization Based Techniques

*** Kapil Uraiya , ** Dilip Kumar Gandhi**

*M.Tech (EC), TIT, Bhopal
** Department of EC, TIT , Bhopal

Abstract-In wireless sensor network nodes position estimation in space is known as localization. Node localization in wireless sensor network is important for many applications and to find the position with Received Signal Strength Indicator requires a number of anchor nodes. However the estimation of distance from signal strength decay in not very accurate especially in time varying environmental conditions and the estimation of exact direction required highly directive antenna but, may still affected by multipath fading. A Genetic Algorithm for wireless sensor network localization is proposed in this paper to solve the issue that the positioning accuracy is low with minimum anchor nodes. Hence in this paper we are presenting a Genetic algorithm for optimization approach which tries to find the optimal location by satisfying both the criteria with minimal error. The simulation results also shows effectively outperform both the techniques.

Index Terms- WSN, Localization, Optimization, Genetic Algorithm (GA).

I. INTRODUCTION

WSN Sensor network node location information is important for numerous reasons. In many cases the sensed data has no value without the location information. The location information can be used by routing and other protocols, algorithms and services. The straightforward solution to the localization problem of equipping nodes with GPS receivers is not a suitable option because GPS receivers require line of sight to GPS satellites. Moreover GPS is costly and power hungry. Therefore for the randomly deployed sensor networks various localization algorithms has been introduced where only a small number of sensor nodes are equipped with GPS receivers and other sensor nodes derive their locations by using the localizations techniques [1]. Though localization is not a recent topic it still has issues and challenges to handle because some solutions are not cheap and some have unexpected level of errors. WSN Localization techniques are largely categorized into range-based and range-free localizations. The range-based technique involves in deriving absolute distances or angles whereas the range free technique involves in deriving distances from non-anchor nodes to anchor nodes. Well known range-based localization techniques are receive signal strength indicator (RSSI), angle-of-arrival (AoA), time of arrival (ToA) or time difference of arrival (TDoA) etc. Ideally distance can be measured from transmit and receive signal strengths of radios. If transmit and receive signal strengths are pi and pj than the distance can be measured as $d_{ij} = \beta \sqrt{pi/pj}$. Where β is known as path loss exponent and can be calculated by measuring power at unit distance.

Since the estimation of distance on the basis of received signal strength (RSS) in not very accurate because of the fading characteristics of the path greatly varies with time and weather also the angle of arrival (AOA) estimation either required a highly directional antenna or array antenna structure with complex processing algorithm but still error cannot be neglected. The other problem is with localization is it required higher numbers of anchor points to exactly estimate the position in three dimensional space of node. The methods discusses above are fall in the range based techniques however there exist another approach which uses only the connectivity information between unknown nodes and landmarks. These techniques can be further divided into two categories: local techniques and hop counting technique. In hop counting technique node estimates the distances to its neighbor anchor nodes by the hop counts and the hop size for the closest anchor node and then estimate its own position, while the local technique node collects the position information of its neighbor anchor nodes to estimate its position. In this paper we are focusing on the range based technique because of its accuracy and adaptability to any protocol and presented a combine RSS and AOA based optimization approach to accurately estimate the location of node.

This rest of paper is organized as follow, section II presents a brief review of the related literature work while the III and IV section explains the General localization method using RSS and AOA techniques respectively for location estimation. The section V explains the genetic algorithm and section VI explains the proposed algorithm follower by the simulation results and conclusion with future scope in VII and VIII respectively.

II. RELATED WORK

A survey on different localization techniques available is presented by Guangjie Han et al [2], they also reclassify the localization algorithms on the mobility state of landmarks and unknown nodes point of view with a detailed analysis. Distributed Angle Estimation based approach is presented in [3]. In the literature two antenna anchor are used to transmit linear chirp waves simultaneously, and the angle of departure (AOD) of the emitted waves at each receiving node is estimated via frequency measurement of the local received signal strength indication (RSSI) signal. Estimation method is also improved with the adaption of multiple parallel arrays to provide the space diversity. The other advantage of the technique is relying only on radio transceivers and synchronization is needed. Zero-configuration indoor localization to estimate a relationships between RSSI samples and the distance between nodes is presented in [4]. A localization approach specifically for the mine environments proposed in [5].

A. OVERVIEW OF LOCALIZATION ALGORITHMS

The various positioning algorithms that are reported in the literature can be categorized as follows:

• **Centralized schemes** [6] in which every node sends its neighborhood table to a base station. This may cause congestion in a large-scale network.
• **Multi-hop progress schemes** [7] in which horizontal data flow is required. This is not feasible because of the first constraint. Also, most of these algorithms are not scalable.
• **Recursive Localization Algorithms** [8] require that all nodes can function as anchors and send their own beacons after estimating their position. In EMMON the architecture anchors are predetermined and are the only nodes that can broadcast beacon signals (constraint A), therefore the implementation of this scheme is not feasible.
• **Range-based algorithms** include distance estimation between communicating nodes by taking advantage of some characteristic of the signals exchanged such as Time of Arrival (TOA), Time Difference of Arrival (TDoA), Angle of Arrival (AoA), Received Signal Strength Indicator (RSSI) or Link Quality Indicator(LQI),Generally they require the use of extra hardware such as ultrasound hardware, sophisticated synchronization mechanisms or special antenna equipment [9].

III. LOCALIZATION BASED ALGORITHMS

A. General Localization Method Using Received Signal Strength

By definition, the received signal strength is the voltage or power measured at the receiver end using signal strength indicator (RSSI) circuit. Many algorithms take advantage of the power level at the receivers to infer their distance from the sender. In a wireless sensor network, where nodes apply this mechanism to self-localize, anchors include their power level in the transmitted packet and receivers subtract it from the received power. This approach is very attractive in terms of device complexity and cost, but the achieved accuracy is its major drawback; accuracy decreases when the distance increases.

Following derivation are used for finding distance from signal strength:

$Let\ the\ transmission\ power\ of\ anchor\ node\ = P_{tx}$

$The\ strength\ estimated\ at\ receiver\ node\ = P_{rx}$

$Assuming\ that\ path - loss\ model\ is\ known$

$The\ path - loss\ coefficient\ = \alpha$

Then the following equation can be used for estimation of distance between anchor node and the receiver nodes:

$$P_{rx} = c * \frac{P_{tx}}{d^{\alpha}}$$

$$d = \sqrt[\alpha]{c * \frac{P_{tx}}{P_{rx}}} \ldots\ldots\ldots\ldots\ldots (1)$$

$Where$

$c = constant\ dependent\ on\ the\ path - loss.$

$\alpha = 2, since\ received\ power\ is\ inversaly\ proportonal\ to\ distance.$

$2 \leq \alpha \leq 4 = for\ the\ multipath\ fading\ channel\ and\ spreadi\ spectrum\ transmistion\ technique$

Ones the node estimates the distance from different anchor nodes it utilizes the following algorithm to estimate its location

$Let\ the\ total\ number\ of\ anchor\ nodes = n$

$$let\ the\ coordinates\ of\ these\ nodes = (x_i, y_i, z_i), i \in n$$

$$let\ the\ coordinates\ of\ the\ node\ to\ be\ estimated = (x_u, y_u, z_u)$$

$$Estimated\ distances\ from\ each\ anchor\ node\ using\ RSS = d_{i,est}, i \in n$$

Writing the equalities

$$\sqrt{(x_i - x_u)^2 + (y_i - y_u)^2 + (z_i - z_u)^2} = d_{i,est} \quad for\ each\ i \in n \quad \ldots\ldots\ldots\ldots(2)$$

$$obj_{fun} = \sum_{i=1}^{n} \left| \sqrt{(x_i - x_u)^2 + (y_i - y_u)^2 + (z_i - z_u)^2} - d_{i,est} \right| \quad \ldots\ldots\ldots\ldots(3)$$

Hence the location of node can be estimated by searching the values of (x_u, y_u, z_u)which satisfies the equation (2) or minimizing the value of objective function (equation (3)).

B. General Localization Method Using Angle-Of-Arrival

Range-based system refers to the Angle of Arrival of a signal to a receiver. This method usually provides corresponding information to ToA and RSS by signifying the direction of adjacent sensors. There are two ways to obtain AoA measurements and both require multiple antenna rudiments: the first one is to use a sensor array and array signal processing techniques and the second one is to use the RSS ratio between two directional antennas located on the sensor. AOA (Angle-of-Arrival) measures local angle information to neighboring nodes, which can either be used as corresponding to other distance measurements (such as RSSI) , or be used to compute the locations of nodes with the help of connectivity information, which can be achieved in any WSNs.

At the moment two different techniques are used for the estimation of AOA.

AT first technique receiver utilizes the array antenna parameter and the received signal from each elements of the array is then processed to estimate the AOA utilizing the array antenna properties.

The second technique for measuring the source signal's AOA, utilizes the rotating, directional antennas, and the angle is estimated by observing the peaks. The rotational angle between two peaks represents the relative angle between for the receiver's point of view.

The relation between relative angles and the coordinates is given as follows

$$\theta = 2 * \mathrm{atan}\left(\frac{norm(v_u * norm(v_i) - norm(v_u) * v_i)}{norm(v_u * norm(v_i) + norm(v_u) * v_i)}\right) \quad \ldots\ldots\ldots\ldots(4)$$

Now ones the angle is estimated from all anchor points the location vector can be calculated by minimizing the equation (5)

$$obj_{fun} = \sum_{i=1}^{n} \left| 2 * \mathrm{atan}\left(\frac{norm(v_u * norm(v_i) - norm(v_u) * v_i)}{norm(v_u * norm(v_i) + norm(v_u) * v_i)}\right) - \theta_{i,est} \right| \quad \ldots\ldots\ldots\ldots(6)$$

$$where\ \theta_{i,est} = estimated\ angles\ with\ the\ i^{th}\ anchor\ node$$

IV. GENETIC ALGORITHM

Genetic algorithms (GA) are search algorithms based on the mechanics of natural selection and natural genetics, which maintains a invariable size population P of candidate solutions. During each iteration step (generation) three genetic operators (reproduction, crossover, and mutation) are performing to generate new populations (offspring), and the chromosomes of the new populations are evaluated via the value of the fitness which is related to cost function. Based on these genetic operators and the evaluations, the better new populations of candidate solution are formed. With the above description, a simple genetic algorithm is given as follow [14]:
The algorithm flowchart is shown as figure 1 and implementation steps are as follows:

Step 1 Initialize the network, nodes obtain the information of their neighbor nodes.

Step 2. Create arbitrarily a population of binary string.

Step 3. Use arithmetic crossover in formula as crossover operator.

ISSN 2250-3153

Step 4. Use uniform mutation in formula as mutation operator.

Step 5. If all nodes are localized, output the localization result and end the program. Otherwise turn to Step 2, positioning the next unknown node.

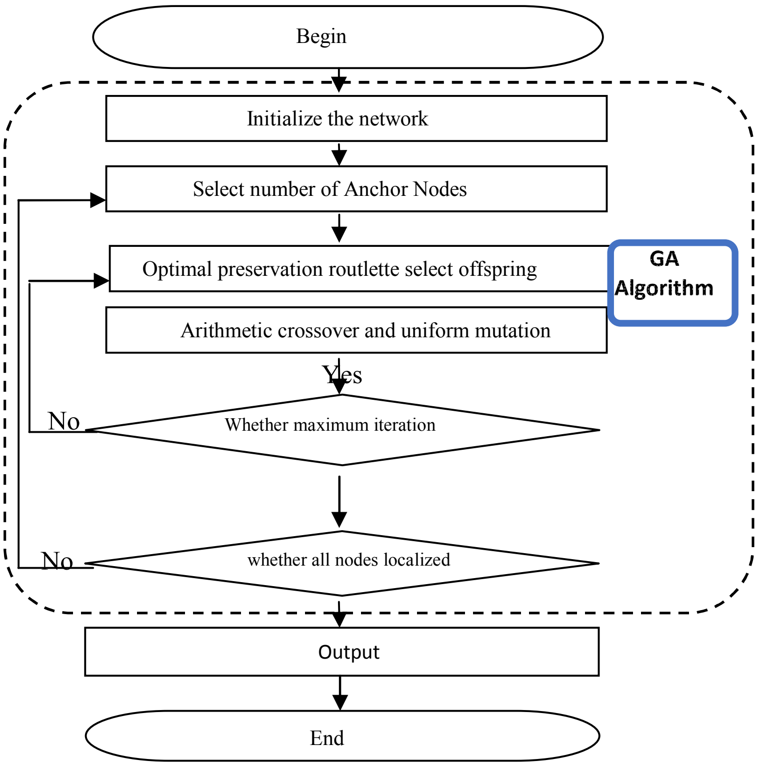

Fig 1: GA Algorithm Flow chart

V. PROPOSED METHOD

The proposed system estimates the optimal location of node from the existing anchor nodes by using RSS and AOA and finding the optimal solution for both at the same time. The proposed algorithm can be described in following steps

Step 1: let in the present topology of the network N-anchor nodes with their known location are present and all of them are transmitting their locations and the power and if they are not transmitting these information it is assumed that the nodes already have these information.

Step 2: know the node wants to locate estimates the signal strength of the signal received form each anchor nodes separately and uses the equation (1) to estimate the approximate distance from each of the anchor nodes.

Step 3: Ones the node estimates the distance from all the anchor nodes it starts finding the angle of arrival from each nodes by either using array antenna processing or by simple directional rotating antenna.

Step 4: After calculating the information of distance and angles the node uses the genetic algorithm to find its coordinates such that in minimizes the objective function given in equation (7

$$obj_{fun} = \sum_{i=1}^{n}\left|\sqrt{(x_i-x_u)^2+(y_i-y_u)^2+(z_i-z_u)^2}-d_{i,est}\right| + \left|2 * \text{atan}\left(\frac{norm(v_u * norm(v_i) - norm(v_u) * v_i)}{norm(v_u * norm(v_i) + norm(v_u) * v_i)}\right) - \theta_{i,est}\right| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Step 5: if the genetic algorithm finds a solution for the equation 8 it terminates and the returns the solution otherwise it gives the best fitted solution achieved within the given iterations.

VI. SIMULATION ANALYSIS RESULTS

The evaluation of the proposed work is done by simulating it for different scenarios and configurations

Scenario 1: Table 1: Configuration used for scenario 1 to assessment of the proposed algorithm.

Properties	Value
Width	100 m
Height	100 m
Length	100 m
Number of Anchor Nodes	2
Error in Distance Calc. (%)	5
Error in Angle Calc. (%)	5
GA Population Size	64
Maximum Iterations	100

Technique	X	y	z	% Error	Time (Sec.)
Original	38.6947	6.9457	69.6513	0	0
RSS	12.2719	19.4490	78.3378	26.6736	32.3487
AOA	63.2834	1.9821	58.1087	27.9844	34.8704
Proposed	38.1291	15.9873	85.3985	16.7894	52.5912

Scenario 2: **Table 2: Configuration used for scenario 2 to assessment of the proposed algorithm**.

Properties	Value
Width	100 m
Height	100 m
Length	100 m
Number of Anchor Nodes	3
Error in Distance Calc. (%)	5
Error in Angle Calc. (%)	5
GA Population Size	64
Maximum Iterations	100

Technique	X	y	z	% Error	Time (Sec.)
Original	58.9748	31.7321	31.754	0	0
RSS	54.4659	33.3654	34.857	4.7573	29.6546
AOA	58.7548	30.8644	31.54375	1.5703	28.7545
Proposed	58.3621	31.4743	31.53695	1.5357	46.8429

Scenario 3:
Table 3: Configuration used for scenario 3 to assessment of the proposed algorithm.

Properties	Value
Width	100 m
Height	100 m
Length	100 m
Number of Anchor Nodes	4
Error in Distance Calc. (%)	5
Error in Angle Calc. (%)	5
GA Population Size	64
Maximum Iterations	100

Technique	x	y	z	% Error	Time (Sec.)
Original	38.3916	43.7531	57.1443	0	0
RSS	35.9326	46.4714	64.7759	5.7643	38.3542
AOA	52.7825	43.1534	63.6359	3.9976	39.7214
Proposed	51.9804	45.1531	63.8629	2.1097	58.7863

Scenario 4:
Table 4: Configuration used for scenario 4 to assessment of the proposed algorithm.

Properties	Value
Width	100 m
Height	100 m
Length	100 m
Number of Anchor Nodes	5
Error in Distance Calc. (%)	5
Error in Angle Calc. (%)	5
GA Population Size	64
Maximum Iterations	100

Technique	x	y	z	% Error	Time (Sec.)
Original	26.6574	47.9974	44.7701	0	0
RSS	28.7584	43.2561	41.3302	3.226	38.8435
AOA	27.0584	48.0134	46.3366	2.2275	37.8841
Proposed	25.7897	48.0285	47.3343	2.226	55.6648

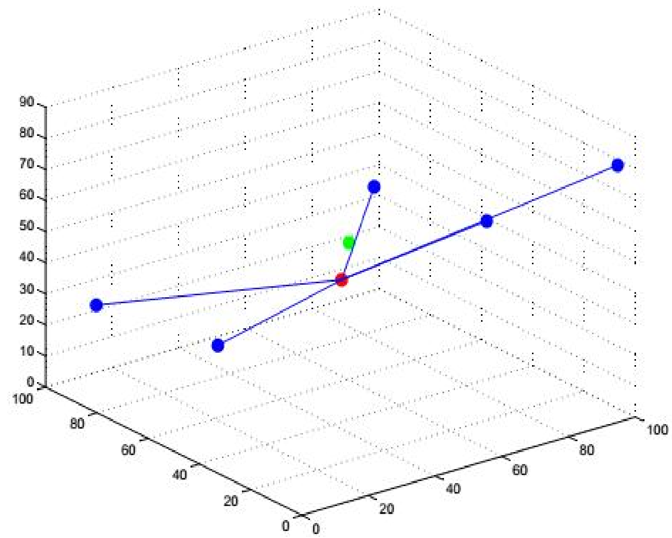

Fig 2 : Proposed Algorithm (RSS+AOA) With RSS And AOA For The Location Estimation For Anchor Node

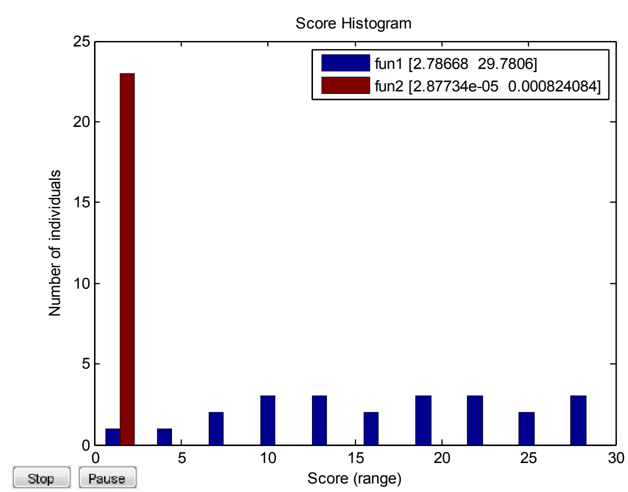

Fig 3 : Proposed Algorithms Score Histogram Graph Between Number of Individuals and Score (range) for Anchor Node

VII. CONCLUSION AND FUTURE ASPECTS

In this paper, a GA localization algorithm with Localization based algorithm which are at the same time optimized by the genetic algorithm to find the optimal solution of the location of the sensor node using some anchor nodes. GA localization algorithm is used to estimate the position with the measured by RSS + AoA . The simulation results with different scenario shows that the present algorithm gives the highest accuracy with a minimum error of 1% with is twice better than the closest competitor AOA. The result also indicates that only three anchor node are sufficient to provide best estimation the further increase in anchor node leads to increase in time but does not improves accuracy. The simulation results show that the algorithm in this paper can estimate the position of the unknown node with less anchor nodes and improve the positioning accuracy efficiently because standard genetic algorithm is used. In summary, we can say that sensor network localization continues to be an important research challenge. Despite, many methods and systems to estimate the location of nodes in WSN are proposed and optimization technique can be developed but right now its depart for future proposed work.

VIII. REFERENCES

[1] Guangjie Han, Huihui Xu, Trung Q. Duong, Jinfang Jiang and Takahiro Hara "Localization algorithms of Wireless Sensor Networks: a survey", Telecommunication Systems Modelling, Analysis, Design and Management ISSN 1018-4864Telecommun System, DOI 10.1007/s11235-011-9564-7.

[2] Weile Zhang, Qinye Yin, Hongyang Chen, Feifei Gao, Member, and Nirwan Ansari "Distributed Angle Estimation for Localization inWireless Sensor Networks", IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 12, NO. 2, FEBRUARY 2013.

[3] Alessandro Redondi, Marco Chirico, Luca Borsani, Matteo Cesana, Marco Tagliasacchi "An integrated system based on wireless sensor networks for patientmonitoring, localization and tracking", Ad Hoc Networks 11 (2013) 39–53.

[4] Mohammad Abdul Azim, Zeyar Aung, Weidong Michael Xiao and Vinod Khadkikar "Localization in Wireless Sensor Networks by CrossEntropy Method", Data & Network Analytics Research Group (DNA).

[5] Chenshu Wu, Zheng Yang, Yunhao Liu, and Wei Xi, "WILL: Wireless Indoor Localization without Site Survey" IEEE Transactions On Parallel And Distributed Systems, Vol. 24, No. 4, April 2013

[6] Adel Youssef and Mustafa Youssef, A taxonomy of Localization schemes for WSN, The 2007 International Conference on Wireless Networks ICWN'07 pp. 444-450, Las Vegas, Nevada, June 25-28, 2007

[7] G. Mao, B. Fidan, and B. Anderson, Wireless sensor network localization techniques, in Computer Networks, vol. 51, no. 10, pp. 2529-2553,2007.

[8] Wang, C. and Xiao, L. (2007) 'Sensor localization under limited measurement capabilities', IEEE Networks, Vol. 21, No.3, pp.16-23

[9] Zheng Yang, Chenshu Wu, Tao Chen, , ,Yiyang Zhao, Wei Gong, and Yunhao Liu, "Detecting Outlier Measurements Based on Graph Rigidity for Wireless Sensor Network Localization" IEEE Transactions On Vehicular Technology, Vol. 62, No. 1, January 2013

[10] Jianbin Fu And Shilong Pan, "Uwb-Over-Fiber Sensor Network For Accurate Localization Based On Optical Time-Division Multiplexing" pans@ieee.org

[11] Shun Kawakami and Tomoaki Ohtsuki , "Localization using iterative angle of arrival method sharing snapshots of coherent subarrays" Kawakami and Ohtsuki EURASIP Journal on Advances in Signal Processing 2011, 2011:46http://asp.eurasipjournals.com/content/2011/1/46

[12] 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 (2013) 6479–6486.

[13] MATLAB 7 R14 Documentation: https://www.matlabworks com.

[14] M.L. Sun: Research on GA based Self-localization Algorithm in Wireless Sensor Networks. Beijing, China: China University of Petroleum, 2009.

[15] Theodoros Fronimos, Loukas Petrou, George Hassapis, "A Sensor Positioning Algorithm for the EMMON Large Scale Wireless Sensor Network Architecture",2012 IEEE

AUTHORS

First Author –Kapil Uraiya , pursuing M.Tech. degree From TIT Group Of Institutes, Bhopal (M.P) ,India
Email: kapiluraiya@gmail.com

Second Author – Dilip Kumar Gandhi, is working as Professor in the Department of Electronics & Communication, TIT Group of Institutes, Bhopal (M.P), India
Email: dilipgin23@gmail.com