

# Localization Algorithm Based on Genetic Algorithm for Wireless Sensor Networks

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*Abstract*— Localization accuracy is very important in WSN. As localization of sensor nodes is required to know the location of origin of events. Because of cost-effectiveness, energy efficiency and no need of additional hardware for localization, Range-free localization algorithms are important research topic. This paper presents an improved localization algorithm based on genetic algorithm. MATLAB simulations are done for comparisons with previous Range-free algorithms.

**Key words:** WSN, localization, anchor nodes, RSS, hop count, Genetic algorithm

## I. INTRODUCTION

Wireless sensors networks consists of several sensor nodes that are deployed in some geographical area for monitoring and event detection purpose. The number of nodes in a WSN could be from few hundreds to millions of nodes depending upon the application for which these sensor nodes are deployed[1]. Sensor nodes sense the physical quantities in the real world like pressure, humidity, temperature, vibrations, and chemical level. A sensor network is composed of a large number of sensors nodes that are densely deployed. A sensor node has embedded processing capabilities and on-board storage. A node can have a single sensor or array of sensors that operate in acoustic, seismic, radio, infrared or optical domains. Communication links between the sensor nodes are wireless. The sensor node also has location and positioning knowledge that is acquired by global positioning system or localization algorithm[2]. Each of the distributed sensor nodes collects and analyses data and route them to a sink point for appropriate processing

WSN is used in various fields such as surveillance, military affairs, medical field, target tracking, environmental and habitat monitoring, disaster management and many more applications where data gathering is done at proximity of origin of data. In all the WSN applications sensor nodes detect events or gather data from particular locations. Therefore event gathering without the knowledge of locations is meaningless. Therefore sensor nodes localization is very important issue in WSN. In WSN node localization is also essential for proper operation of a sensor network.

The easiest way to know the position of sensor nodes is global positioning system (GPS). But GPS equipped sensor nodes become very costly and consume large energy. Line-of-sight with satellite is also a problem of GPS. Therefore for large scale wireless sensor networks GPS is not a good solution. As energy efficiency and cost are constraints of large scale wireless sensor networks, Localization algorithms are used to localize the sensor nodes in WSN. The nodes with knowledge of their position are known as anchor nodes. Anchor nodes are equipped with GPS or are manually configured. Other nodes those do not

have position knowledge are called unknown nodes or normal nodes. Normal nodes make reference of anchor nodes to know their position. For localization, energy efficient, cost-effective, robust and scalable localization algorithms are required. Broadly localization algorithms are classified as Range-free and Range based.

The Improved Range-free algorithm in this paper is based on Genetic algorithm. Genetic algorithms are nature inspired algorithm based on genetics. The paper is organised as follow: section 1 provides a brief review of Range-free algorithms; section 2 describes the proposed algorithm; section 3 gives simulation work and the paper is concluded in section 4.

## II. RELATED WORK

On the base of technique used to estimate distance between the sensor nodes, localization algorithms are classified as Range based and Range-free. Several Range-free localization algorithms are proposed in recent years. Advanced DV-hop [3], APIT [4] and centroid are some typical Range-free localization algorithms. Basically Range-free algorithms are based on connectivity information between sensor nodes and no additional hardware is required for localization. In Range based techniques distance between the sensor nodes is estimated using ranging techniques [5] like AOA (angle of arrival), TOA (Time of arrival), TDOA (Time difference of arrival) and RSS (Received signal strength) are used. These techniques use additional hardware like directional antenna, therefore these techniques are expensive and require additional energy for localization but give more accurate results as compared to Range-free techniques.

Some Hybrid localization [6] algorithms are also proposed. Hybrid algorithms provide advantages of both the Range based and Range-free techniques. In [7] an anchor free localization algorithm is proposed. In anchor free technique, localization is done on the base of neighbourhood relation, distance, direction and connectivity between neighbouring nodes. In anchor free technique no extra infrastructure is required for localization.

For optimization of localization, several optimization algorithm based localization algorithms are proposed in literature. [8] Presented an artificial neural network (ANN) approach to localization in wireless sensor network through the adjustment of the ANN structures using genetic algorithm. The population of ANNs containing their structure in a genetic code is evolved during twenty generations in order to select the best parameters for a particular simulated WSN. The method was tested in an indoor simulation environment of 26×26 meters with eight anchor nodes.

In [9] localization algorithm based on HPSO and BBO algorithms was presented for distributed Range based localization. H-Best Particle Swarm Optimization (HPSO)

and Biogeography based Optimization (BBO) are nature inspired algorithm for optimization.

In [10] presented a centralized localization algorithm based on genetic and simulating annealing. GA and SAA are both optimization algorithms. The proposed algorithm GSAA is optimized algorithm is optimized algorithm that integrates both GA and SAA. The proposed algorithm is implemented in centralized architecture. All the nodes send measurements to central station for localization.

In [11] localization technique based on fuzzy logic and genetic algorithm is presented. The author briefly described the RSS model. Then RSS values are divided into linguistic constructs. The Sinc membership function is used to assign values to the input values. Sinc membership function is selected because of best performance in most of the cases. Genetic algorithm is used to optimize the knowledge of fuzzy system.

### III. PROPOSED ALGORITHM

Localization of sensor nodes is done in two phases. First the distance between the sensor nodes is estimated than the position of the sensor nodes is estimated. Distance estimation is done using connectivity information or based on absolute distance between the sensor nodes. Than the position of sensor nodes is estimated by set of simultaneous equations or optimization algorithm. In the proposed algorithm Genetic algorithm is used for optimal position estimation of unknown nodes.

Genetic algorithms are nature inspired algorithms based on genetics. GA are used for optimization of results. First of all some population is initialized. The number of individuals or chromosomes in a population depends upon the problem. The chromosomes are evolved toward the better chromosomes using the iterative process like mutation and crossover. Each iteration process to evolve the chromosomes is called generation. In each generation fitness of each chromosome is evaluated using a fitness function for the selection process. Then the selected chromosomes participate in next generation. In the proposed algorithm a set of individuals or chromosomes are initialized and a fitness function based on metrics, RSS and hop count is used for selection process.

Received signal strength is the simplest and inexpensive metric to estimate the distance between the sensor nodes for the purpose of localization. Many localization algorithms based on RSS are proposed. [12] – [14] are RSS based localization algorithms. The signal strength received at the sensor node is mapped into distances using some path loss model. The most popular channel model is path-loss model. The received power at sensor nodes using path-loss model is expressed as:

$$L = L_0 - 10\alpha \log_{10} \left( \frac{d}{d_0} \right) + n$$

Where L is power in dB received at sensor node,  $\alpha$  is path loss exponent,  $d_0$  is reference distance,  $L_0$  is received power at reference point and  $n$  is Gaussian random variable. But the reliability of RSS is affected by the environmental factors such as noise, obstacles and multipath.

In a wireless network Hop count metric between source node S and destination node D can be defined as number of intermediate nodes between source node S and destination node D including the source node. Localization

techniques which are based on hop count information need less number of anchor nodes because the position of anchor node is propagated in the network by packet forwarding.[15]-[21] algorithms are based on hop count metric. Hop count approaches are simple to implement.

### IV. SIMULATION RESULTS

In order to verify performance of the proposed algorithm with Advanced DV-Hop, and other DV-Hop based algorithms, simulations are conducted on MATLAB. In all the simulation experiments, the network region is assumed as square area of 100m×100m. The sensor nodes are randomly deployed in a square region. All the anchor nodes and unknown nodes have the same communication radius of 15m.

The localization error is calculated using the equation given below

$$LE = \frac{\sum_{i=M+1}^N \sqrt{(x_i - x_i')^2 + (y_i - y_i')^2}}{R \times (N - M)}$$

In the equation for node  $i$ ,  $(x_i, y_i)$  is the actual coordinate of the unknown node and  $(x_i', y_i')$  is the estimated coordinate of unknown node. R is the communication radius of sensor nodes. N is the total number of sensor nodes in the sensor field and M is the total number of anchor nodes. Lower localization error value shows the better performance. The performance of localization algorithm is affected by the number of unknown nodes, anchor nodes and communication radius of sensor nodes. In this paper simulation results are analysed for ratio of anchor nodes to the total number of nodes.

In real WSN networks, radio signals are affected by environment through which these radio signals propagate. Because of factors like environment, attenuation will result ranging error. Therefore performance of the proposed algorithm is compared and evaluated in three different scenarios of 0-10%, 0-20% and 0-30% communication ranging error. Total number of nodes is fixed to 300. In all the simulations ratio of the anchor nodes is varied from 0.05 to 0.3. Communication radius of all the nodes is same and equal to 15m.

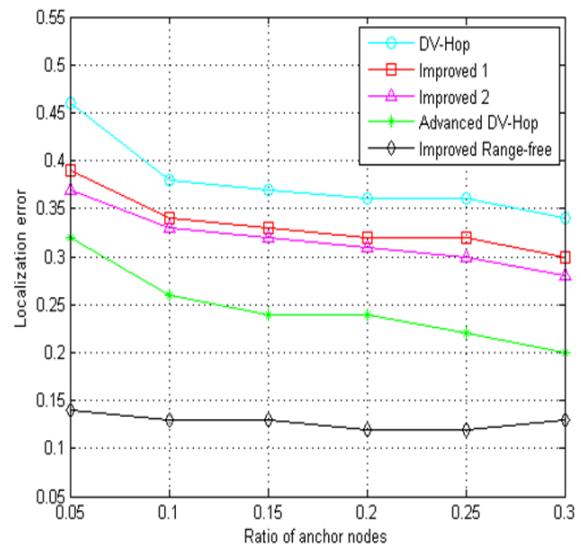


Fig. 1:

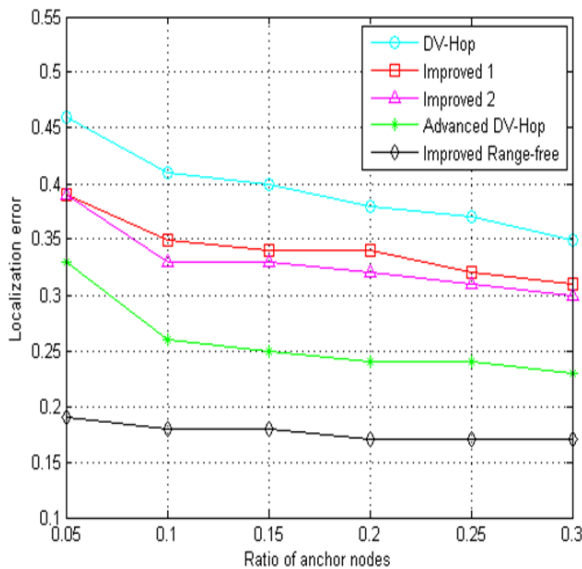


Fig. 2:

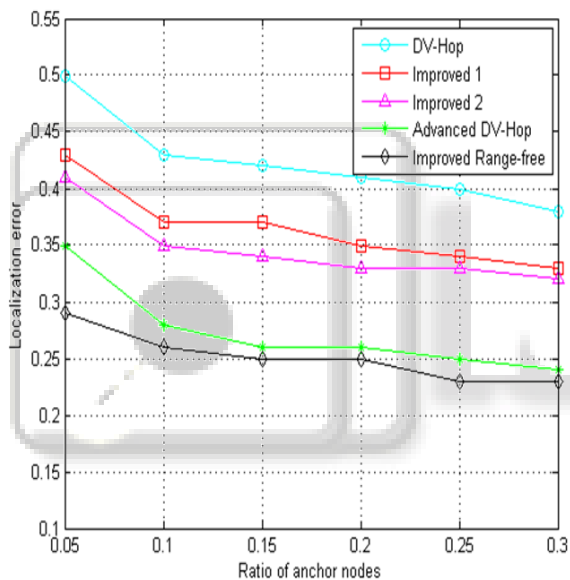


Fig. 3:

Simulation results show that the improved Range-free localization algorithm reduced error in all the three scenarios. Figs 1, 2, and 3 show the localization error results in three different scenarios. In all the three simulation results it is found that localization error is reduced as compared with previous DV-hop based algorithms. It is observed that the localization error is affected by varying the ratio of anchor nodes. Localization error of sensor nodes is reducing with increase in anchor nodes.

## V. CONCLUSION

Localization is the process to know the location of sensor nodes in WSN. Range-free localization has become an important research topic because of its advantages like cost-effectiveness and no need of extra hardware requirement for localization purpose. But the accuracy of Range-free algorithms is less as compared to Range based algorithms. The proposed improved Range-free algorithm is based on genetic algorithm for optimal results of localization. The

simulation results show that the improved range-free localization algorithm has reduced the localization error as compared to DV-Hop, Improved DV-Hop 1, Improved DV-Hop 2 and Advanced DV-Hop algorithms.

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