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Maximum Coverage and Flexible Convergence based 3-D Localization Approach for Wireless Sensor Networks

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Abstract

Objectives: Sensor network consists of sensor nodes, which independently organize the network and used in various applications like medical services, fire detection, military operations etc. This paper presents the 3-Dimensional GA based DV-Hop localization algorithm, which identifies the position of hidden nodes and distance from anchor node to the hidden node. The proposed model utilizes the swarm intelligence to localize the network. **Methods:** The proposed model simulation is entirely based upon the topology design with the randomly deployed network topology. The variable number of nodes has been obtained and the random positions are calculated to define the x and y coordinates of the nodes in the given topology. The proposed model has been tested with the different transmission ranges in order to understand the performance of the proposed model. **Findings:** The planned technique for localization empowers the wireless network to correctly analyze the solutions for the specific problems associated with the localization errors or positioning coverage. The performance parameters which compared with existing technique are average error and average localization error. **Novelty of the Study:** The experimental observations obtained from the proposed model shows the significant difference than the existing model, which shows the enhanced performance of planned model.

Keywords: Genetic Algorithm, Localization Error Recovery, WSN Localization

1. Introduction

Wireless Sensor Network (WSN) is collection of multiple nodes and base stations. Sensor network divides sensor nodes to observe the environmental and physical properties like sound, pressure, temperature etc. Sensor nodes are self-governing little devices that consists four components are sensing, handling, power supply and translating. These sensors gather information from the surroundings or forwards data to base station. It maintains the link to the outer world in which the data is managed, evaluated, granted to the effective approaches. The numerous applications involve Security, surveillance of battlefield, Monitoring Environmental aspects, Industrial applications etc. Presently, wireless sensor network has become vital technology for different kinds of smart environments and an intensive research effort is carried out for several industrial applications. Specific examples includes in case of natural disaster detection and preventing, nodes are installed over the environment to sense and detect the environment and predict natural disaster before their occurrence. In Medical applications sensors are implanted in patients' body with surgery that helps to check the health of Patients. In sensing of seismic areas, sensors are deployed in randomly manner over volcanic area for detection of the development of volcanic eruptions and earthquakes. In wireless network various number of nodes are installed in random manner for observing the structure while calculating its parameters. Different number of new protocols is proposed in the current research of sensor network. The factors like coverage space, power consumption, mobility are considered for design of the

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network. A survey is given relating to the design related problems and classification of protocols[1]. In WSN, node localization is an vital issue for several location dependent applications, like device tracking, traffic management. Because sensor network can be deployed in disaster relief operations or unreachable terrains and nodes location does not identified. Global Positioning System gives the accurate positioning value to this issue. Due to its high cost and equipment, it is not possible. Genetic Algorithm was initial developed by Holland and more improved by Goldberg and Mitchell etc. GA is that approach which is derived from fundamentals of organic process methodology. This algorithm is applicable to the multiple optimization issues, like wireless network optimization and also travelling salesman problem. The generation of chromosomes starts the deployment of genetic algorithm. The growth of chromosomes depends upon the rules of natural selection method as well as recombination of genetic knowledge in the whole generation. Every member of the generation is equipped with the fitness value by employing the fitness function which provides the dimension for solution nature. The fitted individuals chosen to producing the child for coming generation which individuals performs best result and have high chances to reproducing than the individuals which executes poor results. The operators like selection, mutation, cross over provide every chromosome to be optimization chance. The cross over operator easily merges the two individual parents to produce the 2 unique child having distinct chromosome strings which inherit the characteristics through the two individual parents. Though, it may not produce the knowledge which does not given previously. The mutation overcomes it through inserting the data in the new string of chromosomes[2].

In[3] examined the background of sensor network. The sensor nodes can also be equipped with GPS device for observing the position of node. In this paper networking standards IEEE 802.15.4 and Zigbee are described. The Zigbee standard was formed with the aim of developing, monitoring and handling the components which are reliable, low cost, limited power. The standard defines two Direct Sequence Spread Spectrum (DSSS) and the three license free frequency bands are used. The different type of IEEE 802.15.4 frequency bands and characteristics are discussed. In[4] discussed about the localization techniques in WSN. Using localization techniques, knowledge about the position of node or collected data are obtained and then sensor network forwards the data to destination. Localization is a method to calculate the location or position of sensor nodes. In this paper, architecture of sensor nodes and its applications, different type of localization techniques are discussed. Sensor node localization plans have different features and it used for distinct applications. The different type of localization algorithms are used for dynamic and static nodes. WSN components and applications, overview of localization in WSN, localization techniques are also described in this paper.In[5] presented a three-dimensional localization technique based on DV-HOP. The positioning deviation of DV-HOP algorithm is simply too large to identify the hidden nodes, and intensity of coverage is too limited to discover the all sensor nodes. Due to drawbacks, novel 3-Dlocalization DV-Hop algorithm designed. The newly developed algorithm updates per hop distance to increase the efficiency of distance estimation among the hidden and known nodes, Total Least Square technique is used to correct the localization error of known node. In this paper analysis results presents that proposed algorithm enhances the accuracy of localization. In[6] proposes WSN that is used for numerous pervasive and universal applications like security, health-care, trade automation, agriculture, atmosphere and surroundings observation. As hierarchical clusters lower the energy consumption needs for WSNs. In this paper the intelligent techniques for cluster formation and management are examined. A Genetic Algorithm (GA) is employed to make energy efficient clusters for data circulation in the network. The analysis result shows that the proposed inventive hierarchical clustering technique will expand the network lifetime for various network deployment environments. In[7] presented a protocol based on block level retransmission and network coding which is designed to optimize error recovery in sensor networks. This protocol takes reliability and energy consumption parameters and this procedure reduces the number of transfer and reception in the nodes.

2. Proposed Work

The first phase clustering has been performed using the genetic algorithm without mentioning the anchoring nodes across the given sensor network. The application of the genetic algorithm requires the inputs divided into the two primary groups of the chromosomes, which has been controlled by the dimension arrays. The dimension arrays has been defined from the node locations given in the X and Y coordinates, where the array A is constructed from the X coordinate information and array B is decided from the Y coordinate information. The genetic algorithm computes the decision by computing the fittest among the given set of population (population size), which is the decision making algorithm to add one node to the given particular cluster. The implementation detail of the proposed model is as below:

Algorithm 1: First Level Genetic Algorithm

Input: Sensor Node Position Arrays (X and Y)
Output: Cluster Information Array

Step 1: Generate the initial set of population.
Step 2: Fitness of chromosomes is evaluated and determine probability and cost of every chromosomal entity for new population generation.
Step 3: If the fitness value meets the maximum convergence point, the condition is satisfied
(i) And perform the following steps [step 4-8]
Step 4: perform the chromosomal selection from P(t) to P(t+1), where P(t) is the current chromosome and P(t+1) is the next chromosome inside the list.
Step 5: Implement the mutation and crossover phases.
Step 6: Revaluate the fitness of the chromosomes
Step 7: Update the counter t and increment by 1
Step 8: GOTO step 3

Next level genetic algorithm is responsible for the various calculations between sensor network to cluster data across the anchor nodes. Anchor nodes are more powerful nodes due to the degree of connectivity. Anchor nodes are estimated and pointed with black circles in the topology. The proposed model utilizes the genetic algorithm to compute the fitness function of known nodes for finding the best anchor nodes in terms of balanced position, energy and degree of connectivity. The algorithmic behavior has been discussed in detail in the following section:

Algorithm 2: Second Level Genetic Algorithm

Input: Sensor Node Position Arrays (X and Y)
Output: Cluster Information Array

Step 1: Start the for loop for every sensor node
Step 2: Initialize the node information
Step 3: End
Step 4: Do (for all clusters)
Step 5: Do (for each node across the network)
Step 6: Evaluate the fitness of input nodes.
Step 7: If the present fitness value (pBest) is better than the global best (gBest)
Step 7a: Update the current node as the anchor position
Step 8: Update the gBest with the current pBest
Step 9: End
Step 10: Elect the node with the gBest values as the final anchor node.
Step 11: Obtain the X and Y of the nearest node to estimated position coordinates.
Step 12: Mark anchor node
Step 13: End

After the iteration, the optimization algorithm handles the global best and personal best values for the computed solution with the following equations:

$$g[i] = g[i] + C1 * rand() * (gB[i] - gR[i]) + C2 * rand() * (gB[i] - pB[i]).... \quad (1)$$

$$pR[i] = pR[i] + q[i]......... \quad (2)$$

Where g[i] denotes the solution computed for each cluster i, pR[i] gives the cost of the current solution, gB[i] gives the global best value for the current solution, pB[i] gives the cost for the current iteration, C1 and C2 are the environment factors for the genetic algorithm learning and rand() is the random function used to compute the random weights between 0 and 1.

3. Results

Average localization error is defined as the ratio between the total localization error of hidden nodes to the total number of hidden nodes. Figure 1 represents the changes in localization error due to the variation of communication radius. X axis represents the communication radius

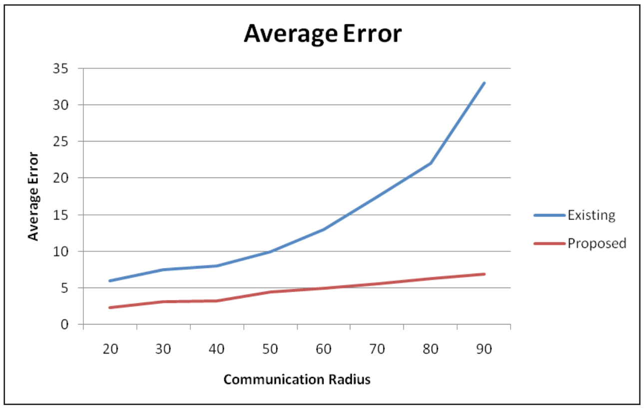

Figure 1. Average error.

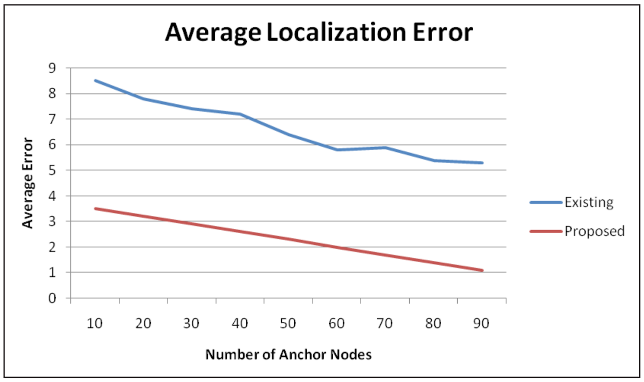

Figure 2. Average localization error.

and Y axis represents the average error. 3-D GA based DV-Hop localization mechanism shows the less localization error as compared to the other algorithm and error increases with more communication radius.

Figure 2 shows the variation of average error with the number of anchor nodes. When anchor nodes increase then the average error of localization is decreases. With the increment of anchor nodes the minimum hop count value decreases. Due to less hop count value, estimated distance between anchor node and unknown node is close to actual distance.

4. Conclusion

The main aim of localization is to minimize the estimation error while calculating the location of node in WSN. There is significant usage of WSN due to its size and cost. Localization helps reducing deployment cost of dense networks. Various algorithms use multiple numbers of mathematical methods to improve the positioning accuracy. 3-D localization algorithm is proposed for the calculation of hidden sensor nodes and minimizes localization error of nodes. The GA based localization technique is better in performance than the existing technique for the identical applications while comparing in multiple topologies and altering communication radius.

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