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Optimized Node Deployment using Enhanced Particle Swarm Optimization for WSN

Mr.Arvind M Jagtap[#1], Prof.Mrs.M.A.Shukla[*2]

[1]Smt.Kashibai Navale COE Pune, University of Pune, India
arvindjagtap_it@yahoo.co.in,

[2]Smt.Kashibai Navale COE Pune, University of Pune, India
meenashukla@yahoo.com

***Abstract*—** Sensor nodes deployment is critical for wireless sensor networks (WSNs). Current methods are apt to enlarge the coverage by achieving a nearly even deployment with similar density in the wireless sensor network. Virtual force (VF) directed enhance d particle swarm optimization (EPSO) algorithm, which uses a combined objective function to achieve the tradeoffs of coverage and energy consumption. By assuming deployment as an optimization problem, EPSO is more reliable and flexible for WSNs than VF-style algorithms in terms of computation time, coverage, connectivity and efficient moving energy consumption. EPSO has good global searching ability and scalability, and it can quickly and efficiently get the sensor nodes deployment in WSNs.

***Keywords*—** **WSN (Wireless Sensor Networks), VF (Virtual Force), EPSO (Enhanced Particle Swarm Optimization).**

I. Introduction

Wireless sensor networks (WSNs) are networks of self healing nodes used for observing an environment. WSNs are defined as multiple direction optimization problems. For analyzing the performance of different schemes like virtual force (VF), Distance limited VF(DVFA),simple particle swarm optimization(PSO) is extended to Enhanced particle swarm optimization(EPSO) and the solution of preferential deployment in interested region is analysed. Simulation report shows that EPSO has the better performance that is more efficient than other three schemes in terms of coverage, connectivity and efficient moving energy consumption. EPSO has good global searching capability and scalability, and it can quickly and efficiently get the sensor nodes deployment in WSNs.

Without loss of generality, this paper aims at the deployment problem of the hybrid WSNs consisting of static and mobile sensor nodes. All sensor nodes are randomly scattered into sensing field. Then deployment is executed to direct the movement of mobile sensor nodes to complete the coverage with minimum cost. In this process, it is assumed that the locations of sensor nodes can be acquired by some methods, such as signal strength and angle of arrival. Here, sensor nodes deployment is considered as an optimization problem, where the locations of mobile sensor nodes are variables and the critical objectives of WSNs are combined in the objective function. Essentially, sensor nodes deployment concerns not only the coverage but also the sensing performance. In some applications, such as target tracking, some interested regions require preferentially dense deployment.

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II. Related work

WSN issues such as node deployment, localization, energy-aware clustering and data-aggregation are often formulated as optimization problems in [1], [2], [3], [4]. Traditional analytical optimization techniques require enormous computational efforts, which grow exponentially as the problem size increases. An optimization method that requires moderate memory and computational resources and yet produces good results is desirable, especially for implementation on an individual sensor node in [5], [6], [7]. Bio-inspired optimization methods are computationally efficient alternatives to analytical methods.

Particle swarm optimization (PSO) in [10] is a popular multidimensional optimization technique. Ease of implementation, high quality of solutions, computational efficiency and speed of convergence are strengths of PSO. Literature is replete with applications of PSO in WSNs. In [8], [9] the work presented in explores the idea of exploiting the node deployment for the purpose of increasing the lifetime of a wireless sensor network with minimum energy-constrained nodes. A novel linear programming formulation for the joint problems of determining the movement of the node and the connectivity, coverage in the network that induces the maximum network lifetime is proposed.

III. System overview

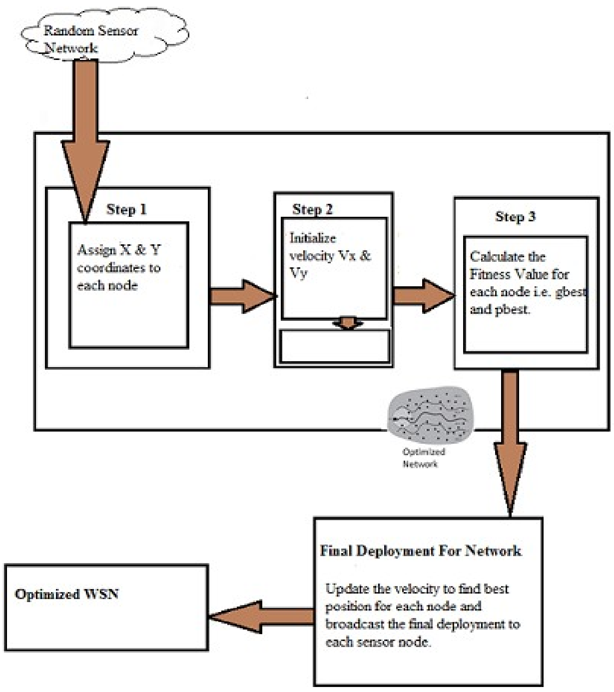

Figure 1 EPSO System Architecture

Step 1:

In this Step 1, Coordinate value of Xi and Yi are assigned to each node in the network. In first step it will calculate the initial random velocities using random function which is varies between 0 and 1.Each node in the network broadcast their own position to the wireless channel.

Step 2:

In this step, Coordinate value of Vx and Vy is initialize which is assigned to each node in the network. In this step it will calculate the initial random velocities using random function which is varies between 0 and 1.Each node in the network broadcast their own position to the wireless channel.

Step 3:

In this step, it will calculate the Fitness function value for each node in the wireless sensor network. Fitness function will give gbest(global best) pbest(local best) position for the node. This position will be broadcast for each node in the wireless sensor network.

IV. Mathematical model

In our proposed approach i.e. EPSO best position of node is calculated as follows:

Initial coordinates of node i are calculated as

x_i= random(0, maxX) for i=0 to n (1)

Where n is total number of nodes in network,

maxX is maximum value of x axis in network

Similarly,

yi= random(0, maxY) for each i=0 to n (2)

Where maxY is maximum value of y axis in network

Initial velocity along x axis V_x and along y axis V_y is calculated as

V_x= random (0, 1) for i=0 to n (3)

V_y= random (0, 1) for i=0 to n (4)

Global best node is selected as

Gbest = { n | f(n) = Max(f(i))} for i=0 to n (5)

Where f(i) is fitness function as

$$f(i) = \begin{cases} 0 & \text{if } dist(node(i), node(j)) > Nr \\ \sum_{j=0}^{n} dist(node(i), node(j) & \text{if } dist(node(i), node(j)) =< Nr \end{cases} \quad (6)$$

Where Nr is communication range of node

Similarly Pbest is calculated according to eq. 5 for each node

Velocity of node i is updated as follows

$$V_{xnew}(i) = V_{xold} + c1 (pbest_x - x_i) + c2 (gbestx - x_i) \quad (7)$$

$$V_{ynew}(i) = Vy_{old} + c1 (pbest_y - y_i) + c2 (gbesty - y_i) \quad (8)$$

Where c1 and c2 are constants,

$pbest_x$ is x coordinate of local best,

$pbest_y$ is y coordinate of local best,

$gbest_x$ is x coordinate of global best,

$gbest_y$ is y coordinate of global best,

Eq. 7 and 8 are used is number of iterations and in every iteration updated pbest and gbest are used.

V. Conclusion and Future Work

In this work, an optimal deployment scheme called as EPSO has been proposed. In EPSO, the mapping between sensor nodes and Coordinator is optimized in order to maximize coverage, connectivity and less energy consumption. EPSO has a potential to support sensor networks with low and high density and with coordinator. A Fitness function is presented to solve the general sensor node deployment optimization problem. To reduce the computational complexity, Node deployment is very important in the view of coverage and connectivity to implement EPSO scheme. Simulation experiments are carried out by considering the scenarios for varying the number of sensor nodes for both EPSO and PSO schemes under Omnet++ interfacing with C++.

The EPSO and PSO schemes are validated by considering one coordinator and one preferential area. The graphs in a, b and c shows that EPSO outperforms by minimizing the energy consumption while maximizing connectivity and coverage in the network.

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