ISSN: 2321-7782 (Online)
Volume 3, Issue 10, October 2015
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Localization in Wireless Sensor Network using Moderate Random Particle Swarm Optimization (MRPSO)

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Abstract: In Wireless Sensor Network localization is one of the main problem because the data collected by the network without location information is not useful. This paper proposes a PSO with a MRS strategy called Moderate Random Particle Swarm Optimization (MRPSO) algorithm for distributed node localization in wireless sensor network. Every node which is not localized gets localized under the measurement of distance from three or more neighbouring anchor nodes. The node which is localized, used as an anchor for remaining unlocalized nodes. A comparison between the performances of PSO and MRPSO is presented using simulation in Matlab.

Keywords: Moderate random particle swarm optimization (MRPSO), Particle swarm optimization (PSO), Wireless sensor network (WSN), Localization

I. INTRODUCTION

WSN is a wireless network consisting of many sensor nodes that are spatially distributed over certain area to monitor the physical and environment conditions. There are many applications of wireless sensor network including target tracking, event detection, vehicle tracking, people monitoring, forest fire detection etc. For all these applications location information of the sensor nodes is required. [1] Localization is one of the process to find out the position of the sensor nodes. To localize the sensor network many algorithms was used and all the algorithms share a common feature that they find out the location of sensor nodes i.e unknown nodes by measure the distance from some other sensor nodes which knew their positions. [7] Localization in WSN has characteristics like better accuracy, less power consumption, reduced collisions and less localization time, so it is best choice for wireless sensor node but with some advantages localization face some challenges that arise from communication failures, memory & computational constraints. In this paper we propose distributed localization algorithm based on MRPSO and a comparison of localization algorithm for wireless sensor network between PSO & MRPSO (moderate random particle swarm optimization).

Rest paper is organised as follows Section II show the related work. The problem formulation was discussed in Section III & Section IV represents the proposed work in which PSO & MRPSO are discussed. Finally section IV discuss the simulation results of the proposed algorithm and Section V presents the conclusion of this paper.

II. RELATED WORK

Jialing Lv et al. [3] proposed the localization problem in WSN and to solve this problem PSO was used. To improve the algorithm efficiency and localization precision, author presented an objective function based on the normally distribution of ranging error, and a method of obtaining the search space of particles.

Ifa et al. [1] was proposed an approach to reduce the localization error using BPSO algorithm for distributed node localization in WSN. Each unknown node performed localization under the measurement of distances from three or more neighbouring anchors which was calculated using Euclidean distance. The node that get localized using iteration would be used as a reference for other remaining unknown nodes. Comparison of the localization techniques i.e PSO, basic BPSO and modified BPSO in terms of localization error was presented.

Singh. N et al. [6] was proposed solution for ELD (Economic Load Dispatch) problem which was used in real-time energy management power system. ELD was the process of allocating generation among the committed units such that the constraints imposed were satisfied & fuel cost was minimized. The Economic load dispatch problem with valve point loading effect and generator lamp limits was solved by PSO with moderate random search technique to enhance its global search ability.

Kulkarni. R.V et al. [10] was proposed segmentation of terrain images for autonomous deployment of WSN nodes from a UAV and for localization of deployed nodes in a distributed and iterative manner which was performed by bio-inspired algorithms PSO (particle swarm optimization) & BFA (bacterial foraging algorithm) and comparison between the PSO & BFA was discussed in terms of deployment of nodes.

Sharma. N et al. [8] was proposed IOT algorithm that placed a major role to send the information on time to all nodes in the network due to which QoS was improved. Comparison of two localization techniques i.e centroid algorithm & IOT algorithm was presented.

III. PROBLEM FORMULATION

Localization is one of the main problem in WSN. To solve this problem many localization techniques are used. In WSN localization method can be explained in two phase which are Ranging phase & Position phase. In ranging phase, node measure their distances from the anchors using many algorithms as Received signal strength, AOA (angle of arrival), TOA (time of arrival) etc. In estimation phase the node estimate their position using the ranging information. This is done either by using geometric approach which gives the exact solution or by using the optimization approach which minimized the error in locating the coordinates of the sensor node (unknown node). Many researchers had approached the localization problem from different perspective. Here we focus on the localization method based on distance measurements and reduced the localization error between the estimated location & exact location of the sensor node.

IV. PROPOSED ALGORITHM

A. PSO

PSO is a population based stochastic optimization technique developed in 1995 by R.Eberhart and J. Kennedy, which simulates the social behaviour of bird flocking.[1] [3][10] It employs a set of feasible solutions called particles which explore the search place to find the global solutions. Suppose search space is d-dimensional and i^{th} particle can be represented by d-dimensional position vector $X_i = (X_{i1}, X_{i2} \dots\dots\dots X_{id})$. The velocity is represented by $V_i = (V_{i1}, V_{i2} \dots\dots\dots V_{id})$. The position vector of i^{th} particle personal best is shown as $pbest_i = p_{i1}, p_{i2}, \dots\dots\dots p_{id})$, $gbest = (p_{g1}, p_{g2}, \dots\dots\dots p_{gd})$ be the position vector of the best particle in the swarm. Now the position and velocity updated equation are as follows:

$$V_i(t+1) = wV_i(t) + c_1 r_1(P_{ibest} - X_i) + c_2 r_2\left(P_{gbest} - X_i\right) \quad (1)$$

$$X_i(t+1) = X_i(t) + V_i(t+1) \quad (2)$$

where w is the inertia weight show the effect of previous velocity vector on new vector.We also determine the objective function to measure the particle fitness to improve the localization precision and search space for increasing the convergence. The objective function is defined as:

$$f(x,y) = \frac{1}{M}\sum_{i=1}^{M} \frac{\left(\sqrt{(x-x_i)^2 + (y-y_i)^2} - \widehat{d_i}\ \right)^2}{(\widehat{d_i}\delta)^2} \quad (3)$$

where (x, y) are coordinates of unknown nodes (x_i, y_i) are the coordinates of i^{th}anchor nodes. $\hat{d_i}$ bethe measured distance between the unknown node and the neighbouring anchor node.

B. MRPSO

PSO with an MRS strategy is called MRPSO (moderate random particle swarm optimization). MRPSO is a new algorithm which increase global search ability & improve the convergence rate for particles. MRPSO is divided into two operator local operator & global operator. Global operator is used to improve the global search ability of MRPSO and local operator has ability to search particles in the local area. In this strategy only position is updated, velocity updation is not required.Position of the particle can be calculated as:

$$X(t+1) = (1 + w - \emptyset_1 - \emptyset_2)X(t) - wX(t-1) + \emptyset_1 P_p + \emptyset_2 P_g \quad (4)$$

The position $x_{id}(t+1)$ of the dth element of the i^{th} particle at the (t+1)th iteration can be calculated as:

$$x_{id}(t+1) = p_d + \alpha\gamma\big(mbest_{id} - x_{id}(t)\big) \quad (5)$$

Attractor p_d is used as the main moving direction of particles. Mean best position represented by mbest gives the step size for position of particles and makes the contributions of all pbest to the evolution of particles. It enhance the diversity and searching ability of particle. Equation for calculating mbest is

$$mbest = \sum_{i=1}^{S} \frac{P_{pi}}{S} \quad (6)$$

where S is the population size in MRPSO.The convergence rate α is the only parameter which acquire control in the MRPSO as its accurate value is important. If convergence rate has a larger value it enable particles to have a less exploitation ability and if convergence rate has a smaller value than particles enables a more exploitation ability. The convergence rate in MRPSO is same as the inertia weight in PSO.γ is a MRS operator because it enables the MRPSO to search more precisely than PSO.

C. Design of proposed work

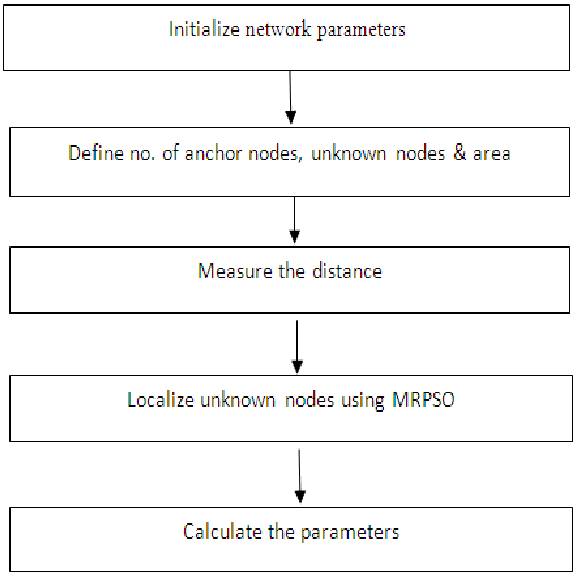

Fig. 1 Flow chart of proposed work

The implementation for MRPSO based localization is as follows:

Step 1: Define the number or anchor nodes, unknown nodes and area required.

Step 2: Measure distance between each pair of nodes. Each localized node calculate its distance from its neighbouring anchors.

$$d_i = \sqrt{(x - x_i)^2 + (y - y_i)^2}$$

where d_i is the Euclidean distance between two nodes. (x,y) is the location of unknown nodes & (x_i, y_i) is the location of i^{th} anchors.

Step 3: Find out search space of unknown node having 3 or more neighbouring anchors, and use MRPSO algorithm to estimate the position of unknown node,

Step 4: Localized the unknown nodes which are not localized in previous step having 3 or more neighbouring anchors.

Step 5: Repeat step 4 until no more unknown nodes are localized.

V. Simulation Results And Discussion

Simulation and performance of the proposed scheme carried out using Matlab. For localization in PSO & MRPSO suppose ten anchor nodes & fifty unknown nodes are randomly deployed in a sensor field size of 100*100m^2. The transmission range, of each node taken 30 m. Simulation parameters for PSO & MRPSO are shown in table I & table II.

TABLE I: Simulation Parameter for PSO

Parameter	Values
Iteration,k_{max}	150
Particle position	$x_{min} = 0, x_{max} = 100$
Acceleration constant c_1, c_2	2
Random numbersr_1, r_2	[0,1]

TABLE II: Simulation Parameter for MRPSO

Parameter	Value
Iteration k_{max}	150
γ	[-2,2]
α	0.4
Particle position	$x_{min} = 0, x_{max} = 100$

The location of anchor nodes, unknown nodes and the localized nodes are shown in Fig. 2 & Fig. 3. Theanchor and unknown nodes deployment is same for PSO & MRPSO algorithm. Simulation results show the unknown nodes which are localized is different for both algorithm.

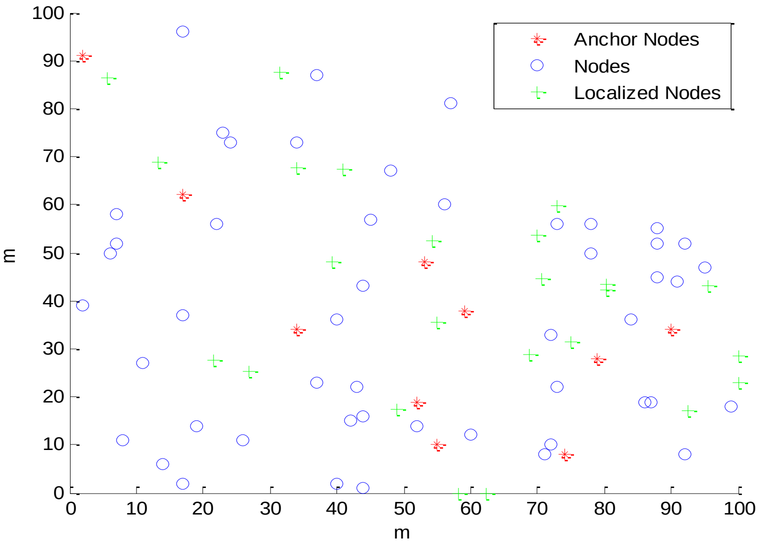

Fig. 2 Estimated locations by PSO

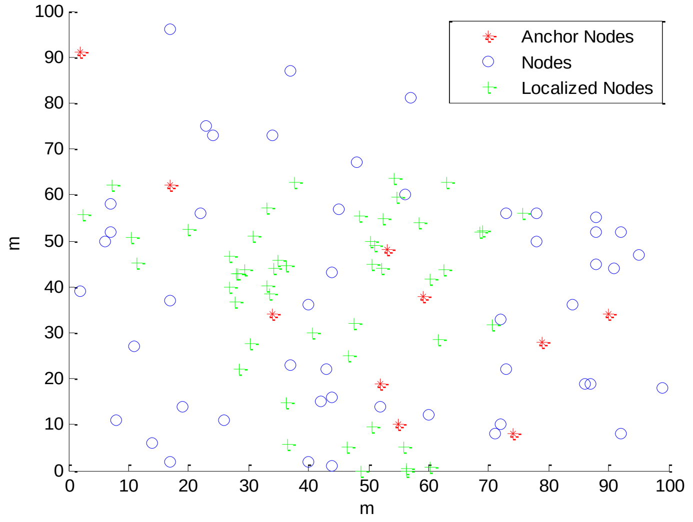

Fig. 3 Estimated locations by MRPSO

In order to compare the performance of both algorithms in terms of these parameters shown in Table III. This shows that MRPSO is better than PSO. Fig. 4 show the number of iteration required for localization of unknown nodes in MRPSO is less than PSO, which show that MRPSO is better than PSO as search space is as small as possible.In Fig. 5 it shows that the number of nodes which are localized in MRPSO are more than PSO & Fig. 6 shows the localization error.

TABLE III: Comparison of MRPSO and PSO

Parameter	Localization error		Number of Iterations		Number of localized unknown nodes	
Anchor nodes / Algorithm	MRPSO	PSO	MRPSO	PSO	MRPSO	PSO
10	0.0106	0.0522	149	149	22	1
20	0.0132	0.0143	29	149	49	45
30	0.0129	0.0147	103	149	50	50
40	0.0136	0.0138	22	149	50	50
50	0.0132	0.0138	149	149	50	50

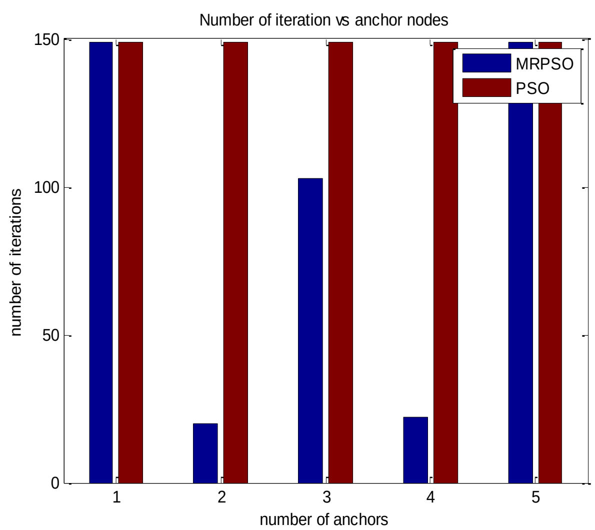

Fig. 4 Number of iterations

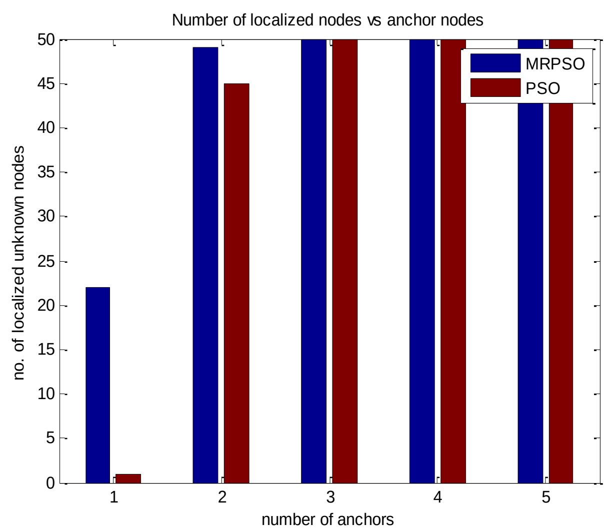

Fig. 5 Number of localized unknown nodes

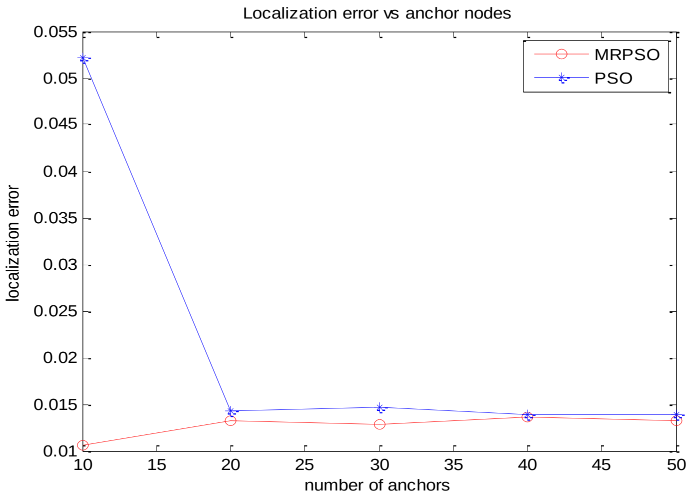

Fig. 6 Localization error

VI. Conclusion

MRPSO algorithm is proposed for distributed node localization in Wireless Sensor Network. Every unknown node perform localization under the measurement of distance from three or more neighbouring anchors. The localized node is used as an anchor for remaining unknown nodes. Distance between the anchor & unknown is calculated using the objective function. Performance of proposed algorithm is compared with Particle Swarm Optimization. Simulation results shows that MRPSO is better than PSO as MRPSO can localize more unknown nodes in higher precision with less number of iteration & the localization error is also reduced.

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