VOL. 10, NO. 5, MARCH 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

GROUP SEARCH OPTIMIZER ALGORITHM FOR LOCALIZATION IN WIRELESS SENSOR NETWORKS

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ABSTRACT

In wireless sensor network, sensor nodes are deployed randomly depending on the application. The sensor node location is very much important to make a meaningful sense of the data gathered by the sensor network. The intelligence of the environment is assisted by wireless sensor network by using the location information of the sensor nodes. In this paper a novel algorithm named group search optimizer localization algorithm is proposed for sensor node location information detection. This algorithm is based on producer scrounger model of animal behavior. The location information detection is required to increase the performance and reliability of wireless sensor networks (WSN). It also increases the lifetime of the network by guiding the network without unwanted routing.

Keywords: wireless sensor networks, group search optimization, anchor nodes, producer, scrounger, localization, sensor nodes.

1. INTRODUCTION

Wireless sensor networks are self organized network and deployed randomly according to the application requirement. Due to the low cost and technology advancement like MEMS, integrated circuits and communication antennas WSN are widely used. For example environment monitoring, military application, agriculture, vehicle tracking, traffic management control of hazardous region, forest fire detection and controlling. In all these application the sensor node location is essential for making the data meaningful as well as intelligent. For location detection, global positioning system (GPS) can be used, but it requires more power. The WSN is resource constrained. So GPS may not be feasible and cost effective. In event based application the data is embedded with the location information and this is send to the base station [1]. Location information is vital for reliable functioning of WSN and also it improves the performance and efficiency. Moreover it reduces the energy required.

Localization algorithms in general are categorized as range based localization algorithm and range free localization algorithm. Range based requires the detection of the distance or orientation of the sensor nodes. Range based algorithm depends on the hop of communication between nodes. But they are accurate than the range free localization algorithm [2]. In range based the distance can be calculated by angle of arrival, time of arrival and radio signal strength indicator (RSSI). The RSSI based system does not require any additional hardware for distance calculation [2]. So RSSI is better compared to angle of arrival and time of arrival. Range free based algorithm does not require distance calculation; it needs the presence of the beacon signals in the network.

This RSSI based method uses trilateration technique which uses anchor nodes and sensor nodes. The anchor node or Beacon node knows its location information. The sensor node does not know the location information and whose position has to be detected. For anchor nodes GPS can be used to determine the location. According to the computation process the algorithm can be distributed or centralized. The centralized computation algorithm requires all the range information to be transmitted to the centralized base station for processing. This computation technique requires frequent communication that leads to more energy consumption [3]. In the distributed algorithm all the nodes is responsible for node localization calculation by using the local information. The distributed algorithm is energy efficient. Since computation is done by the individual sensor nodes, and the computation is distributed the lifetime of the wireless sensor networks is increased. The group search optimizer localization algorithm discussed in this paper is a range based distributed algorithm.

2. NODE LOCALIZATION SCENARIO

Localization scenarios of 40 sensor nodes are considered. In this 8 anchor nodes with known location information and 32sensor nodes with unknown location is considered. The aim is to find the location of these 32 unknown sensor nodes with the location knowledge of anchor nodes. Range based method is used which implies trilateration method. Three known anchor nodes which are nearer to the selected unknown node are chosen. With the help of these anchor nodes, its location information, the distance of these anchor nodes with the chosen unknown node, the location of unknown node is found.

The location information estimation involves distance calculation and minimization of the localization error estimated by the localization objective function. The distance between the 3 anchor nodes and unknown nodes are calculated by using the equation (1).

$$d_{ist} = \sqrt{((x_{est} - x_{anchor})^2 + (y_{est} - y_{anchor})^2)} \quad (1)$$

VOL. 10, NO. 5, MARCH 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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The localization objective function is calculated by using the equation (2)

$$f(X_u, Y_u) = \left[\sqrt{(X_{est} - X_{anc})^2 + (Y_{est} - Y_{anc})^2} - d_{est}\right]^2 \quad (2)$$

3. GROUP SEARCH OPTIMIZER LOCALIZATION ALGORITHM DESIGN

This algorithm is referred from the paper [4].It is a population based optimization algorithm. It is based upon the animal foraging search behavior. Searching behavior is the animal movement to find or attempt to find the resources like food, water and nests. Success of the animal foraging depends on the efficiency in locating the resources. And also how an animal respond to the environment and respond to the availability of the resources in environment [5].

The algorithm follows a producer scrounger (PS) model. Producer means finding opportunities for resources. Scrounging means joining opportunities for resources unknown by other animals [6].Successful animal that find the resources will become producer and would expose the resources to less successful animals that is the scrounger [7].

In Group search optimizer localization algorithm population is called a group and each individual in the population is called a member. The steps followed in the algorithm are given below.

Step-1: Create initial population of members
Step-2: Find the localization error value of individual members
Step-3: Member which has minimum error becomes producer
Step-4: Update producer to find global position of nodes using equations 2 to 11
Step-5: Scrounger are selected from population which has more fitness value as compared to producer
Step-6: Update scrounger based on producer position using equation 12
Step-7: Exploration of search space using rangers from population using equation 13 and 14
Step-8: Update population by new position of producer, scrounger and ranger
Step-9: Repeat step 2 to 8 till convergence criterion.
Step-10: Print estimated position of nodes after convergence

The flowchart of the Group search optimizer localization algorithm that is used for finding the location information of the sensor nodes is shown in the Figure-1.

The localization optimization problem is solved by group search localization algorithm with 100 iterations for a space size of 100.Total group population of 20 is taken. Among the group one become producer which has minimum error. This is joined by the scrounger.

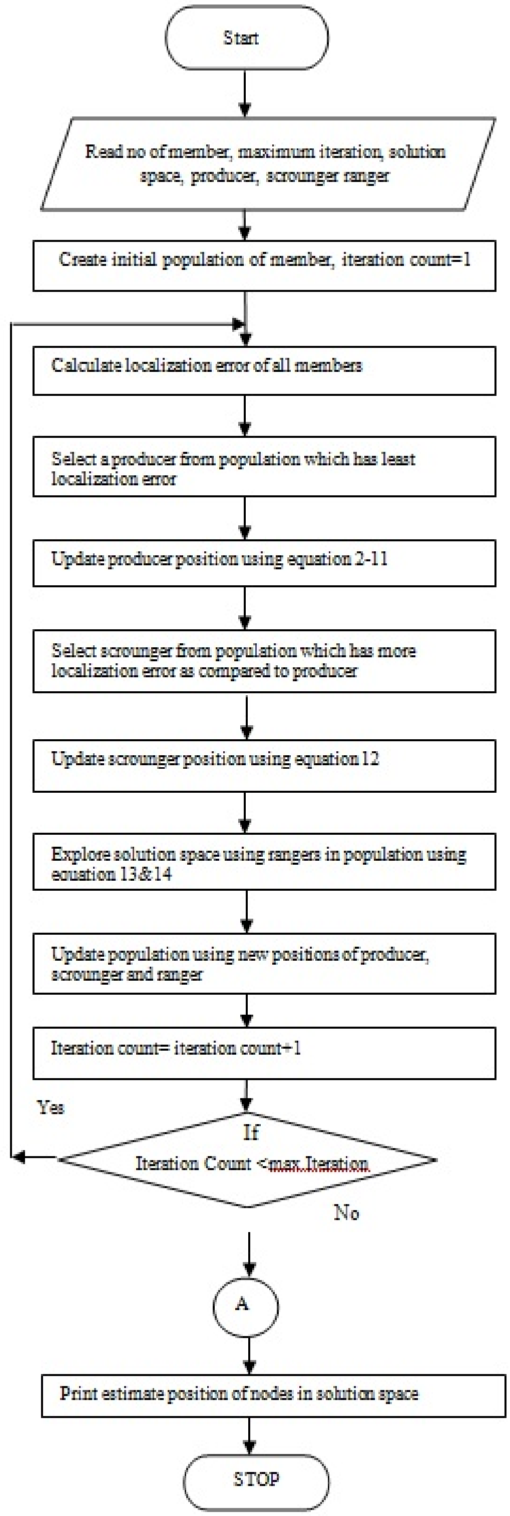

Figure-1. Flowchart of GSO localization algorithm.

The search direction of member head angle is taken as

$$\phi=(\pi/3,\pi/4) \quad (3)$$

The search direction of the member is

$$D_{vec}= [\cos (\phi(1)) \sin (\phi(2)] \quad (4)$$

In Group search optimizer localization algorithm three types of members are used Producer, Scrounger and Rangers [7].In this paper number of producer is taken one. Number of scrounger as 16 and number of rangers as 3.For each iteration there is only one producer, 16 scroungers and 3 rangers. The producer and scrounger move in the space environment and they can interchange the roles as producer, scrounger or ranger. Producer can become scrounger and vice versa depending on the localization error. The localization error calculated by the equation (2) and the member which has the minimum error leads to producer in each iteration.

This producer does the visual search and scans the environment. In this algorithm the producer does the scanning randomly with three different locations or degrees. Zero degree location, right hand side location angle and left hand side location angle. These angles are defined as follows.

Zero degree scan

$$X_{pz} = X_p + r_{and} * l_{max} * D_{vec} \quad (5)$$

Right hand side direction

$$D_{vecr}= [\cos (\phi(1) + r_{and} * (\theta_{max}/2))\sin(\phi(2) + r_{and} * (\theta_{max}/2))] \quad (6)$$

Right hand side scan

$$X_{pr} = X_p + r_{and} * l_{max} * D_{vecr} \quad (7)$$

Left hand side direction

$$D_{vecl} = [\cos (\phi(1) - r_{and} * (\theta_{max}/2)) \sin (\phi(2) - r_{and} * (\theta_{max}/2))] \quad (8)$$

Left hand side scan

$$X_{pl} = X_p + r_{and} * l_{max} * D_{vecl} \quad (9)$$

If this localization error is not satisfied according to the tolerance limit and convergence then a new randomly generated location angle is considered.

New randomly generated angle

$$\phi^{t+1} = \phi^t + rand * (\theta_{max}/4) \quad (10)$$

Again if this fitness is not optimal producer goes back and does a new search. Turn back zero location degree

$$\phi^{t+a} = \phi^t \quad (11)$$

The scrounger joins or follows the producer. The scrounger location is given by

$$X_s= X_s + r_{and} (X_p-X_s) \quad (12)$$

The ranger new random distance is given by

$$L_{ranger} = 2* r_{and} * l_{max} \quad (13)$$

The ranger new location is given by

$$X^{R+1} = X^R + L_{ranger}* D_{vec} \quad (14)$$

The output of the group search optimizer localization algorithm is shown in the Figure-2.It shows the position of anchor nodes, actual position and estimated position.

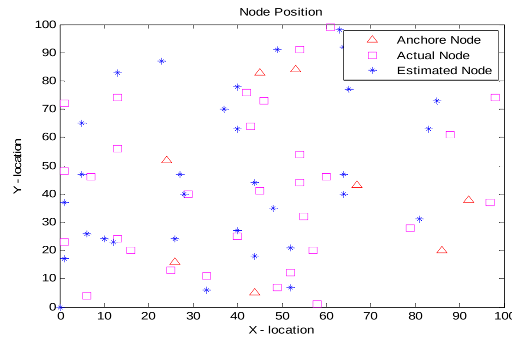

Figure-2. Group search optimizer localization algorithm simulation output.

The convergence curve for the designed group search optimizer localization algorithm is shown in the Figure-3.

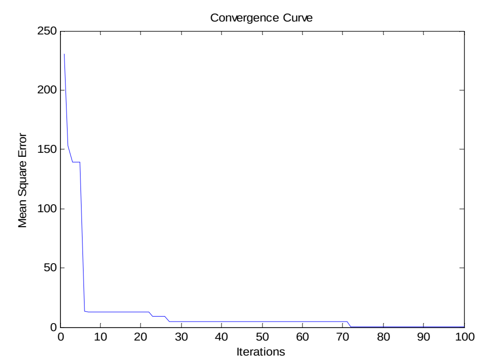

Figure-3. Group search optimizer localization algorithm convergence curve.

Table-1. Parameters of group search optimizer localization algorithm.

Parameters	Values
Iteration	100
Space size	100
Anchor node	8
Unknown node	32
Dimension, a	40
l_{max}	5
ϕ_{max}	$\pi/6$
Producer	1
Scrounger	16
Ranger	3

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4. CONCLUSIONS

Wireless sensor networks require localization of sensor nodes for network management and topology control. In this paper a novel group search optimizer localization algorithm is proposed, analyzed, and implemented for sensor node localization problem. The proposed algorithm provides the best location estimation nearer to the actual location. This algorithm provides better accuracy and convergence. The group search optimizer localization algorithm is range based and distributed and the individual node estimate the location information by collaboration with the neighbor nodes. So location information communication to the sink node in a multi hop environment is reduced. This increases the performance and lifetime of Wireless sensor networks. As a future scope of this algorithm the design parameters can be further fine tuned as well as hybrid with other intelligent algorithms for better estimation accuracy and convergence.

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