

Enhancement of sensor deployment Using Interactive Artificial bee colony algorithm

^[1]Diana Anto, ^[2]Amrutha V Nair

Communication Engineering Department, Mahatma Gandhi University
Sree Buddha College of Engineering for Women, Ayathil, Elavumthitta

^[1]diana.anto2@gmail.com, ^[2]amrutha.vnair@gmail.com

Abstract: IABC(Interactive artificial bee colony algorithm) is used for sensor deployment.IABC algorithm will perform better than that of artificial bee colony algorithm(ABC) and particle swarm optimization(PSO).In this paper,compare the IABC and ABC algorithm.IABC algorithm improve the network lifetime of node by finding the best position for the nodes.There are three bees in IABC which are employed bee and onlooker bee.Employed bee provides the neighborhood of the source in its memory.The onlooker bee select the food source.A heuristic is used for the scheduling of sensor nodes which will maximizes the network lifetime.IABC outperforms than that of ABC algorithm.IABC algorithm mainly used for solving optimization problems.

Index Terms— Sensor deployment,sensor scheduling ,network lifetime

I. INTRODUCTION

Wireless sensor network is a collection of sensing devices that can communicate wirelessly.Each device can sense, process, and talk to its peers.In this case embed numerous distributed sensor nodes into the physical world.So that they can coordinate to perform higher-level identification and tasks.Wireless Sensor Networks (WSNs) are important for many applications such as environment monitoring, building and structural monitoring traffic surveillance, video surveillance and manufacturing automation.Any kind of sensor,interfaced through an ADC.The nodes are normally battery powered.The sensor node has On-board storage it may have actuators.In this mainly aimed to deploy the sensor nodes in the optimal location.That will maximizes the network lifetime.The scheduling of the sensor nodes will also maximizes the network lifetime[1].The artificial bee colony algorithm and particle swarm optimization are used for the deployment of the sensor nodes[1]. So as to achieve the theoretical upper bound of network lifetime[1].A heuristic for scheduling will also achieve the theoretical upper bound of network lifetime[1]. The artificial bee colony algorithm will perform more than that of particle swarm optimization[1].But the network lifetime is a main problem.

The coverage in a WSN needs to guarantee that the region is monitored with the required degree of reliability[1].For the algorithms that examine coverage of the network,Locations of sensor nodes constitute the basic input.There are mainly two types of problems that are area coverage problem and target coverage problem.The area coverage is that monitors the entire region and Target coverage is monitoring the specific point in that region.The

target coverage categorized as simple coverage,Q-coverage, and k coverage.

Simple coverage is that the target is monitored by atleast one sensor node.K-coverage is that the target is monitored by K sensor nodes.Q-coverage is that the target $T = T_1, T_2, \dots, T_m$ monitored by the $Q = q_1, q_2, \dots, q_m$ number of sensor nodes.m is the number of targets. In sensor deployment,the upper bound of the network lifetime is calculated as mathematically.Then find the deployment locations such that the network lifetime is maximum.First uses heuristic[1] to compute the deployment locations and then uses ABC and PSO algorithms to compute the locations.The sensor node is placed on the middle of all targets.The next nearest target is identified and the sensor is placed on the middle of the all targets.If it can cover this new target along with targets it was already monitoring,allow this move, else discard the move[1].

In earlier days,ABC and PSO are used for sensor deployment[1].Artificial Bee Colony (ABC) Algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm[1].This colony contain mainly three groups that are employed bees, onlookers and scouts[1].The employed bee takes a load of nectar from the source and reched to the hive[1].A special dance is performed by the employed bee called waggle dance which contains information about the direction in which the food will be found.Onlooker bee observe all the dances and choose to employ itself at the most qualitative source[1].The scout is a bee that carries out random searches.In particle swarm optimization consist of swarm of particles[1].Every particle contain position vector representing a candidate solution to the problem and a velocity vector[1].Each particles contains its own best position and global best position which is obtained by the communication with its neighbor

particles[1].In each particle contain a small memory that stores its own best position and global best position. Another aim of this paper is to schedule the sensor nodes such that the theoretical upper bound of network lifetime can be achieved.To achieve this,propose a weight-based method for determining the cover sets.In this paper,to improve the network lifetime of sensor nodes chooses IABC algorithm.

A. Introduction to interactive artificial bee colony algorithm

Artificial bee colony algorithm is a new swarm based optimization technique.It has many problems such as lower convergence speed and then the second problem is when complex multimodal problems handles,esily trapped in local optima.This is because search pattern is good at exploration but poor at exploitation.So to overcome this problem IABC is used.The main steps are initialization,movement of onlookers,update the Best Food Source Found,termination checking.IABC accelerate the convergence speed and also improves the solution's accuracy.Therefore IABC is more effective for global optimization problems.

B. The organization of the paper is as follows

Introduction is presented in section I,Related work is described in section II ,Proposed method is presented in section III, Simulation output and its description is in section IV,The paper is concluded in Chapter V.

II. RELATED WORK

Artificial bee colony algorithm and particle swarm optimization are used for the deployment of sensor nodes in optimal location[1].Calculating the upper bound of the network lifetime for a given network mathematically.By using that compute the optimal location for the deployment of the sensor nodes such that the network lifetime is maximum.The scheduling of sensor nodes will achieve the upper bound of the network lifetime. A heuristic is used for the scheduling of the sensor nodes.A comparative study shows that artificial bee colony algorithm is better for sensor deployment problem than PSO[1].In this method,at the base station the optimal deployment locations and the schedule are decided.Two phases are there for the proposed method.That are sensor deployment and sensor scheduling.The nodes are initially deployed randomly.Then the optimal deployment locations computed using ABC algorithm based on the upper bound of the network lifetime which calculated mathematically and scheduling of sensor node by heuristic because of this the network lifetime will be maximum.

A. Sensor Deployment Description

1)Sensor Deployment using Heuristic: In this case uses the heuristic for the deployment of sensor nodes[1].The node is moved to the least monitored targets location when the node

is idle.If a next nearest node ID identified then the sensor node is situated in the middle of the all targets.If it can cover this new target.Then allow this move, else discard the move[1].The upper bound is calculated at the end.It has some drawbacks.

2) Sensor Deployment using ABC: ABC Algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm[1].In the colony of the group there are three main groups mainly that are employed bees, onlookers and scouts. The employed bee takes a load of nectar from the source and returns to the hive[1] and unloads the nectar to a food store.After unloading the nectar they perform a waggle dance which indicates the direction of food.An onlooker bee watch all dances and choose to employ itself at the most qualitative source.The Scout bees search for a random feasible solution.Let B is the solution population.

$B_a = (x_1, y_1), (x_2, y_2), \dots, (x_m, y_m)$ is the each solution.Where $a = 1, 2, \dots, nb[1]$ where nb and m represents total number of bees and total number of nodes.All the targets are covered when The initial solution is generated and each sensor node covers at least one target.

3)In this case define a sphere just like a honey comb structure.

- Certain random points in sphere are selected as the foods nectar blocks(sensing tagets in our case).
- Then use the algorithm to locate quality food.
- From one point here perform a fitness(Network life time in our case) test based on the probability to select that particular fitness is saved and neighboring points are analysed for fitness.
- If it have better fitness, then forgets previous location and new location of food is saved.
- Similarly computes selected random points in no.of cycles to find optimum fitness food locations.
- Probability of error (to select unfit location) was also calculated at each point.As fitness of a location increases, probability of error get reduced and is plotted as a graph at the end.

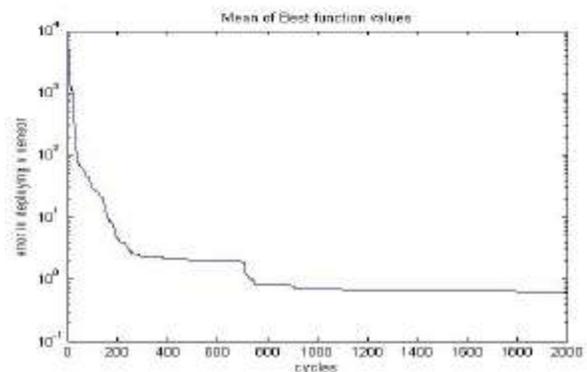


Figure 1. ABC algorithm output

3) Sensor Deployment using PSO:

Particle Swarm Optimization (PSO) consists of a swarm of particles[1]. They are moving in a search space of possible solutions for a problem. Every particle has a position vector. This represents a candidate solution to the problem and it consists of a velocity vector. Moreover, each particle contains a small memory. In that memory stores its own best position and a global best position. A global best position obtained through Communication with its neighbor particles.

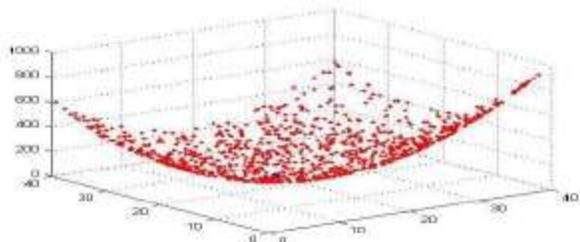


Figure 2. PSO algorithm output

B Sensor Scheduling Description

A heuristic is used for the sensor scheduling[1]. A weight-based method is proposed here for determining the cover sets. It includes Weight assignment, Cover formation, Cover optimization, Cover activation and Energy reduction.

1) *Weight Assignment:* It is based on the the priority of sensor nodes. Weight of a sensor node is more, then this node has higher priority. Cover sets are decided based on this priority. The base station calculates weight for each sensor node by considering two factors. The initial weight deciding factor is weight due to remaining energy and the next is weight due to targets that the node covers.

3) *Cover Formation:* The nodes which make all the targets k/Q covered then cover is generated. This approach uses a priority based method. If any new sensor node contributes to k/Q coverage requirement, it will be added to the cover set.

In the next section, compare ABC algorithm and IABC algorithm.

III. PROPOSED METHOD, IABC

Quality of the solutions improves by more effective usage of the information. Employed bees was sharing the information. Then the onlooker bee focus on this information. Balance is kept by randomization. The population has showed stagnation behavior and get stuck a local minimum when all bees concentrate on only one employed

bee or global best. In ABC, The neighbor selection based on memory board method was added then more quality solutions obtained. The solutions will stay on the memory board in waiting time is very essential for IABC algorithm. IABC algorithm consider the characteristics of optimization problems. ABC find the better solution for object function. ABC algorithm is new swarm intelligence

based method. It has some difficulties in solving optimization problem. In this paper some modification is added on the original ABC iteration equation.

In this paper, to deploy sensors according to a new algorithm called Interactive Bee Colony Algorithm which is an enhancement of older ABC algorithm. The Interactive Artificial Bee Colony algorithm is proposed based on the structure ABC algorithm. By employing the Newtonian law of universal gravitation, universal gravitations between the onlooker bee and the selected employed bees are exploited. IABC algorithm which increases the convergence speed and also improves the network life time of the nodes. So IABC is the best method for the sensor deployment. Population initialization affect the quality of the solution. It can search the whole solution space eventually. There is no information about the location of the solution before an optimization problem solved. An orthogonal array consist of small number of combinations. That are uniformly scattered over the space. The initial population be scattered evenly over the solution space by the orthogonal design. So orthogonal initialization generate the initial population[12]. In IABC, initialize the food source by orthogonal initialization. Then evaluate the population after that memorize the best food sources. Next step is the new search mechanism can search the new food source for employed bee and then evaluate its quality. A greedy selection process can select the better solution between the new food source and the old one. Afterwards calculate the probability. Then apply roulette wheel selection scheme to choose a food source for onlooker bees. After that replace this food source with a new food source produced. Afterwards memorize the best solution achieved so far.

Inspiring foraging and dance behaviour of honey bee colonies develop the swarm based metaheuristic optimization technique which is called ABC algorithm. Initialization, employed bee, onlooker bee and scout bee are the four phases of ABC. The solution is improved by the employed bees in employed bee phase. Self solution is cannot improved by the employed bees. So scout bee improve the self solution which is done in scout bee phase. Information sharing is done in onlooker bee phase. The onlooker improve the candidate solution among employed bee population according to fitness value of the employed bees. In ABC, propose a selection mechanism. In the onlooker bee phase, onlooker bee select the neighborhood of candidate solution. Then calculate the average fitness value of employed bees and those having better average fitness value of employed bees are written to the memory board. Then from the memory board the onlooker bees select the neighbor. In this paper shows that IABC algorithm is better than ABC algorithm.

A. ABC algorithm

A population based optimization algorithm is ABC and global minimum or maximum is acquired by this algorithm. Maximum cycle number or acceptable error value is the termination condition for ABC. There are three kind of bee in the ABC hive. They are employed bees, onlooker bees and scout bees. Scout bee found the solution space. Employed bees and onlooker bees found the nectar sources around the hive. Number of employed bees equals the number of nectar sources. Number of employed bees also equal to the number of onlooker bees.

1) *Initialization*: For employed bees initial solution are employed $Y_{i,j} = Y_{jmin} + (Y_{jmax} - Y_{jmin}) \cdot r_{21}$, $i = 1 \dots N$, $j = 1 \dots D$. j is the j th dimension of j th employed bee. Lower and upper bound of j th parameters are represented as Y_{jmin} and Y_{jmax} . Random number is within this [0,1] range, number of employed bee is N , the dimensionality of optimization is D . In each employed bee the abandonment counter is reset in this phase.

2) *Phase of employed bee*: Dimension of i th candidate solution is v_{ij} , j th dimension of i th employed bee is Y_{ij} , j th dimension of k th employed bee is Y_{kj} , number of employed bee is N , dimensionality of optimization problem is D , neighbor of candidate solution is K , dimension of the problem is j . Then find the fitness value of employed bee. Employed bee is put back with the candidate solution. Then reset the abandonment counter of employed bees. Otherwise abandonment counter is increased bees by 1.

3) *Phase of onlooker bee*: In ABC, every employed bee selected by onlooker bee which will improve its solution. This selection is according to the fitness value of the employed bees. The onlooker bee watch the dance of employed bee and then randomly neighborhood selection occurs. The onlooker bee get a new solution which has better fitness value than that of fitness value of the solution of employed bee. The onlooker bee is changed to employed bee and employed bee's abandonment counter is resets. Otherwise abandonment counter is increased by 1.

4) *Phase of scout bee*: An employed bee who cannot improve the self solution until the abandonment counter reaches to limit becomes scout bee. Afterwards the scout bee produced the solution and resets the abandonment counter. The scout bee produced the solution itself and scout bee become converted to employed bee.

A. Universal gravitation

Universal Gravitation is an invisible force between objects.

$$F_{12} = G \frac{m_1 m_2}{r_{21}^2}$$

F_{12} is the gravitational force heads from object 1 to 2, G is the universal gravitational constant, m is the mass of the object, r_{21} is the separation between the objects 2 to 1. The unit vector in the form of equation

C. An optimization algorithm IABC

In Interactive Artificial Bee Colony (IABC), the mass in equation is

$$F_{12} = G \frac{F(\theta_i)}{r_{21}^2} \hat{r}_{21}$$

Euclidean distance is applied for calculating r_{21} . The normalization procedure is applied to the fitness values [10] used in the above equation and the normalized fitness values are given as F_{ik} .

$$x_{ij}(t+1) = \theta_{ij}(t) + F_{ik_j} \cdot [\theta_{ij}(t) - \theta_{ij}(t)]$$

Simultaneously considering the gravitation between the picked employed bee and n selected employed bees [10], it can be reformed again into this equation

$$x_{ij}(t+1) = \theta_{ij}(t) + \sum_{k=1}^n F_{ik_j} \cdot [\theta_{ij}(t) - \theta_{kj}(t)]$$

To apply IABC for solving problems related to optimization, the number of the considered employed bee n should be predetermined.

1) *The process of the IABC can be described in 5 steps:*

Step 1. Initialization: Spray n_e percentage of the populations into the solution space randomly [11], and then calculate their fitness values, which are called the nectar amounts, where n_e represents the ratio of employed bees to the total population. Once these populations are positioned into the solution space, they are called the employed bees.

Step 2. Move the Onlookers: Calculate the probability of selecting a food source, select a food source to move to by roulette wheel selection for every onlooker bees and then determine the nectar amounts of them. The movement of the onlookers follows an equation.

Step 4. Update the Best Food Source Found So Far: First update the Best Food Source found So Far. Then Memorize the best fitness value and the position, which are found by the bees.

Step 5. Termination Checking: Check if the amount of the iterations satisfies the termination condition. If the termination condition is satisfied, then terminate the program and output the results; otherwise go back to the Step 2.

The advantage is that the IABC shows better exploration results than older ABC. So deployment of sensors would be more optimized. Then intend to carry out a procedure called pipelined realization of deployment and scheduling of sensors for maximum network lifetime. Scheduling algorithm will be the same as older heuristic algorithm. Experimental results show that, more effective usage of the information in the hive improves the quality of the solutions. While onlooker bees focus on the information that was shared by employed bees, randomization should be kept in balance. If all bees concentrate on only one employed bee or global best, the population has showed stagnation behavior and get stuck a local minimum. In order to increase exploitation ability of the basic ABC algorithm, the neighbor selection based on

memory board method was added to basic ABC and the more quality solution was herewith obtained. The waiting time, which solutions will stay on the memory board, is fairly important for IABC algorithm and should be tuned considering the characteristics of optimization problems.

2) Advantages of IABC algorithm

IABC algorithm provide better network lifetime for the sensor nodes by selecting best location. It accelerates the convergence speed and provides accurate solution. It has better performance than ABC algorithm. It increases the exploration ability. It solves problems of optimization. It also solve small to medium sized generalized assignment problems.

SIMULATION RESULTS

In this paper comparing IABC algorithm [11] with ABC algorithm. In ABC, nodes find the optimum position based on the network lifetime. When the nodes locate in optimum position, then nodes get enough network lifetime. In IABC, the nodes find the location based on network lifetime. The simulation results shows that IABC provide high network lifetime for nodes than that of ABC algorithm.

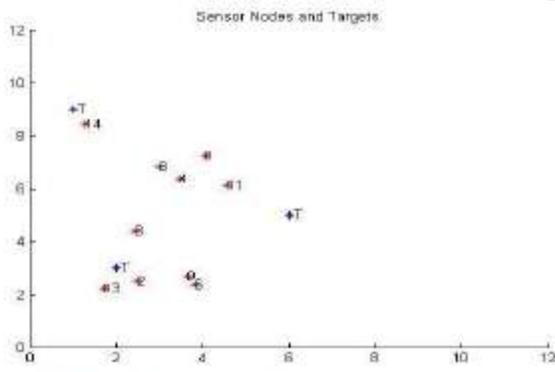


Figure 3. Output of ABC

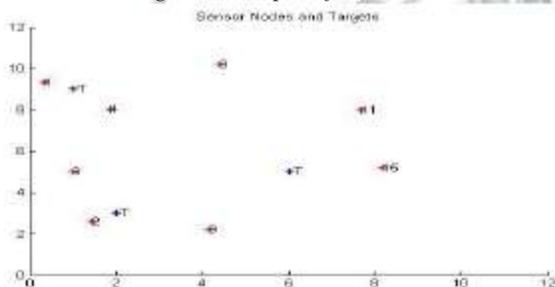


Figure 4. Output of IABC

CONCLUSION

The Artificial bee colony algorithm is used for finding the the deployment location of the sensor node that will maximizes the network lifetime. The ABC algorithm is performed more than that of PSO algorithm. The ABC Algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm. There are mainly

three groups mainly employed bees, onlooker bees and scout. The employed bees takes a load of nectar from the source and return to the hive and unloads the nectar to a food store. After that it perform a waggle dance which indicates the direction of the food source. To avoid battery drain of the sensor nodes uses the scheduling of sensor node is conducted. This will minimizes the number of sensor nodes to be turn on for satisfying coverage requirement. This method will maximizes the network lifetime. A heuristic algorithm is used for scheduling the sensor nodes which will maximizes the network lifetime. The deployment of the sensor node also maximizes the network lifetime. So that it can achieve the theoretical upper bound of the network lifetime. Then extend this method of deployment for probabilistic coverage in wireless sensor networks using the Interactive Artificial Bee Colony (IABC). IABC use the concept of universal gravitation for the movement of employed bee. IABC increased the exploration ability. Introducing the essence of the universal gravitation for the calculation of new position. Simulation results shows that IABC algorithm provide better network lifetime than that of ABC algorithm.

REFERENCES

- [1] S. Mini, Siba K. Udgata, and Samrat L. Sabat, "Sensor Deployment and Scheduling for Target Coverage Problem in Wireless Sensor Networks", IEEE Sensors Journal, vol. 14, no. 3, march 2014
- [2] D. Karaboga, S. Okdem, and C. Ozturk, "Cluster based wireless sensor network routing using artificial bee colony algorithm", Wireless Netw., vol. 18, no. 7, pp. 847860, 2012.
- [3] C. Ozturk, D. Karaboga, and B. Gorkemli, "Artificial bee colony algorithm for dynamic deployment of wireless sensor networks", Turkish J. Electr. Eng. Comput. Sci., vol. 20, no. 2, pp. 255262, 2012.
- [4] D. Karaboga, B. Gorkemli, C. Ozturk, and N. Karaboga, "A comprehensive survey: Artificial bee colony (ABC) algorithm and applications", Artif. Intell. Rev., 2012, pp.137.
- [5] D. Karaboga, C. Ozturk, N. Karaboga, and B. Gorkemli, "Artificial bee colony programming for symbolic regression", Inf. Sci., vol. 209, pp. 115, Nov. 2012.
- [6] Y. Gu, B.-H. Zhao, Y.-S. Ji, and J. Li, "Theoretical treatment of target coverage in wireless sensor networks", J. Comput. Sci. Technol., vol. 26, no. 1, pp. 117129, 2011.
- [7] C. Ozturk, D. Karaboga, and B. Gorkemli, "Probabilistic dynamic deployment of wireless sensor networks by artificial bee colony algorithm", Sensors, vol. 11, no. 6, pp.60566065, 2011.
- [8] L.-H. Yen and Y.-M. Cheng, "Range-based sleep scheduling (RBSS) for wireless sensor networks", Wireless Pers. Commun., vol. 48, pp. 411423, Feb. 2009.
- [9] G. Tan, S. Jarvis, and A.-M. Kermarrec, "Connectivity-guaranteed and obstacle-adaptive deployment schemes for

mobile sensor networks”, in Proc. 28th Int. Conf. Distrib. Comput. Syst., Jun. 2008, pp. 429437.

[10] J. Kennedy and R. Eberhart, “Particle swarm optimization”, in Proc. IEEE Int. Conf. Neural Netw., vol. 4, Nov./Dec. 1995, pp. 19421948.

[11] Pei-Wei TSai¹, Jeng-Shyang Pan¹, Bin-Yih Liao¹, and Shu-Chuan Chu²,” Enhanced artificial bee colony algorithm”, Volume 5, Number 12, December 2009.

[12] Xiangyu Kong,¹Sanyang Liu¹ and Zhen Wang²,”An Improved Artificial Bee Colony Algorithm and Its Application”.

