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Energy Efficient Clustering Algorithm for Data Collection Path Planning in Wireless Sensor Networks

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***Abstract*— In sparse wireless sensor networks, a mobile robot is usually exploited to collect the sensing data. Each sensor has a limited transmission range and the mobile robot must get into the coverage of each sensor node to obtain the sensing data. To minimize the energy consumption on the traveling of the mobile robot, it is significant to plan a data collection path with the minimum length to complete the data collection task. In this paper, we observe that this problem can be formulated as traveling salesman problem with neighbourhoods, which is known to be NP-hard. To address this problem, we apply the concept of artificial bee colony (ABC) and design an ABC-based path planning algorithm. Simulation results validate the correctness and high efficiency of our proposal.**

Keywords: Sparse wireless sensor network Artificial bee colony algorithm, Traveling salesman problem with neighbourhoods.

I. INTRODUCTION

Wireless sensor networks (WSNs) play an important role in the cyber physical system as they allow us to get the physical world information, e.g., temperature, sound, pressure, etc. A special kind of WSN is characterized by nodes geographical sparsity and therefore are usually referred as sparse WSN , where the sensor nodes cannot directly communicate with each other or with the sink node. In this case, we usually explore a mobile robot to collect the sensing data.

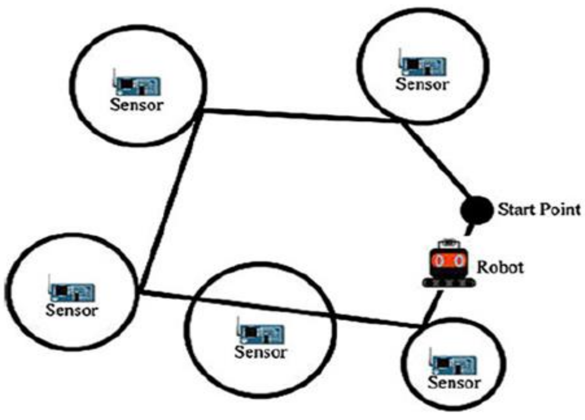

Figure 1. Example of robot routing in a network with five sensors.

The robot must be within a sensor's communication range before it starts to collect the desired sensing data. The coverage of a sensor can be specified by a disk with radius equal to the sensor's transmission range. Therefore, the mobile robot must reach all the disks in the WSN to complete the sensing task. Figure 1.1 shows a sparse WSN instance with five sensor nodes and a mobile robot. Beginning at the starting point, the mobile robot must visit each disk at least once before it gets back to the starting point. Motivated by the high efficiency of artificial bee colony (ABC) algorithm [10] in solving combinatorial optimization problem, we apply the concept of ABC and propose an ABC-based TSP algorithm. However, DCPP is not a pure combinatorial optimization problem since it also includes the decision on meeting points. We carefully design a meeting point selection strategy d integrate it into different phases of our ABC-based TSP algorithm. Through extensive simulation results, the high energy efficiency that can be achieved by our proposal is validated.

II. LITERATURE SURVEY

To lower the energy consumption of data collection in sparse WSN using mobile robot, considerable efforts have been devoted to finding the shortest robot travelling path. Yuan et al. [19] use an evolutionary algorithm which first constructs the path by sensors coordinates and then fix the meeting point in each sensor by a given angle to the coordinate. Comarela et al. [3] combine greedy and ant colony optimization (ACO) [6] algorithm to solve the traveling path planning problem. They first construct the initial solution by greedy algorithm and use ACO to shorten the path by adjusting meeting points' permutation. Tekdas et al. [17] consider a scenario where multi-robots are exploited to collect data from sensors. They split the network into different regions according to the number of robots and then find the travelling path for each region. Recently, Chiu et al. [2] consider situations involving sensors with overlapping communication ranges and propose a clustering-based parallel genetic algorithm to plan the traveling path. Many studies formulate the robot path planning into a TSPN problem, which also has attracted much attention in the literature. Elbassioni et al.[7] propose an approximate algorithm which first find a set of meeting points and then permutate them to produce a TSPN route by greedy algorithm. Gentilini et al. [9] formulate TSPN into a nonconvex mixed-integer nonlinear program (MINLP) and then transform it a convex nonlinear program by fixing all the integer variables. A special case of TSPN is known as TSP,which also has been widely studied in the literature. Many swarm intelligence algorithms (e.g., ABC) based solutions have been proposed. Li et al. [12] propose a discrete ABC algorithm combining the destruction and construction phases of iterated greedy algorithm to solve TSP with time windows. Karaboga et al. [11] recently show that ABC algorithm is suitable for the combinatorial optimization problems like TSP. However, how to apply ABC for more general TSPN that beyond pure combinatorial optimization is still under-investigated and therefore we are motivated to study this issue.

III. RESEARCH WORK

In this, an extensive study of challenges/issues in Routing for path calculation has been carried out. Path planning of mobile node to collect sensor node data with shortest path is an a major issue. In simple routing methods, the mobile robot crosses the region of the sensor node to collect the data. Due to this routing overhead is increased. An efficient mechanism is needed to reduce such problem by collecting the data of sensor nodes at border of the sensor node. By traditional routing algorithms the mobile robot crosses the region of the sensor nodes. The central thrust of this dissertation is to study, implement and analyze Artificial Bee Colony(ABC) based Travelling Salesman Problem(TSP) for calculating the best routing path for mobile node to collect data in Wireless Sensor Network(WSN).

a. Motivation of the Research Work

Wireless Sensor networks contains a base station and the sensor nodes, where we assume that the sensor nodes are not able to communicate with each other. In terms, it specifies that the Wireless Sensor network is a Sparse Wireless Sensor Network. In such situation we have to implement a mobile node which is going to collect the data from such sensor nodes in Sparse Wireless Sensor Network. Such conditions of Sparse Wireless Sensor network may occur in military application. The motivation of this dissertation work is to discover the minimum or best routing path for mobile node to collect the data from sensor nodes. Idea of this dissertation is performance analysis and performance improvement. A new routing protocol with ABC based TSP algorithm is implemented.

Designing a efficient algorithm with the help of Artificial Bee Colony algorithm and Travelling salesman problem to calculate the best routing path for mobile robot. The major issue of mobile robot is to collect data from sensor node in its path with shortest path. We are going to collect the data as soon as mobile robot enters the region of the sensor node and would travel for further path.

b. Objectives

1. To minimize energy consumption

The main problem in Wireless Sensor Networks (WSNs) is energy consumptions by the sensor nodes. The energy resource provided to WSN's are limited. Thus the main objective is to save the energy usage and thus to minimize energy consumption.

2. Find a path of minimum length for sensing data collection by using ABC algorithm

The next problem goes with the collection of sensing data from nodes. As per the assumptions the sensor nodes are not able to communicate with each other or any sink node to transfer or share the sensing information. Motivated by the high efficiency of artificial bee colony (ABC) algorithm in solving combinatorial optimization problem, we apply the concept of ABC and propose an ABC-based TSP algorithm.

3. To minimize network traffic

The objective of our project is to minimize the network traffic in Wireless Sensor Networks (WSNs). As the sensor network goes on increasing network traffic becomes a bottleneck for data transfer. It becomes necessary to remove this bottleneck as to improve the performance of our project.

4. To maximize sensor network lifetime

Sensor network lifetime depends upon the battery usage of sensor. Thus to maximize sensor network lifetime it becomes necessary to minimize the battery usage. Minimizing the energy consumption of sensor node reflects in maximizing the network lifetime.

c. Scope of Research Work

Path finding is the effective mechanism but causes problem when it collects data from sensor nodes. The main purpose of the proposed system is to overcome the problem i.e routing of mobile node. Artificial Bee Colony(ABC) based Travelling Salesman Problem(TSP) is used to improve the performance in terms of finding the shortest path of mobile node.The proposed system is compared with Greedy Approach to compare its feasibility and accuracy of path finding.

d. Major constraints

1. Mobile node

The mobile nodes is assigned to collect the data from the sensor nodes in the field. It has to collect the data from the shortest path as to save the energy of the mobile node. If the path is not the shortest path then it degrades the system performance.

2. Sensor Nodes

It is assumed that the sensor nodes are not able to communicate with each other to pass the data for base station. Mobile nodes is going to collect the data from sensor nodes. Sensor nodes must be plotted in between the sensor field other wise the mobile node may not be able

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to reach the sensor node.

3. Artificial Bee colony(ABC) based Travelling Salesman Problem(TSP) algorithm. Artificial Bee colony(ABC) based Travelling Salesman Problem(TSP) algorithm is used to calculate the shortest path of mobile node. The Simulation result shows the accuracy of system to calculate the shortest path for mobile node.

e. Approaches for solving the problem and efficiency issues

ABC based TSP routing scheme is one of the approaches to solve the problem and efficiency issue. In Greedy approach, the minimum distance is calculated between all nodes and path is formed. It increases the routing overhead. So instead of using Greedy approach, ABC based TSP routing scheme is used. In ABC based TSP routing scheme the shortest path is calculated considering three nodes, the present node, previous node and next node. Thus the routing path is so optimized that we get the shortest path for mobile node.

f.Outcomes Research work

• The Best Routing path for mobile robot.
• Increase the network and mobile lifetime.

g. Solving Approach

Designing a efficient algorithm with the help of Artificial Bee Colony algorithm and Travelling salesman problem(TSP) to calculate the best routing path for mobile robot. In current scenario the major issue of mobile robot is to collect data from sensor node in its route with shortest path. We will going to collect the data as soon as mobile robot enters the region of the sensor node and would travel for further path.

IV. ARTIFICIAL BEE COLONY ALGORITHM

Routing problem is caused due to sensor nodes in wireless sensor networks are not able to communicate with each other. This routing problem thus degrades the mobile node performance. By implementing Artificial Bee Colony algorithm based on Travelling Salesman Problem, which reduces the routing path of mobile node, thus it helps to reduce routing overhead and increases routing performance.

According to the principle of ABC algorithm, our algorithm consists of four phases, the initialization phase, the employed bees phase, the onlooker bee's phase and scout bees phase. After the initialization phase, the employed bees phase, the onlooker bee's phase and the scout bee's phase are invoked iteratively for M cycles. The best solution after each cycle is registered after each iteration. The four phases are detailed as follows.

Advantages:

- It helps to minimize the energy consumption in WSN.
- It improves the efficiency in WSNs.
- It also reduces network traffic.

Disadvantage:

- Single Point of Failure may occur in the sensor network.

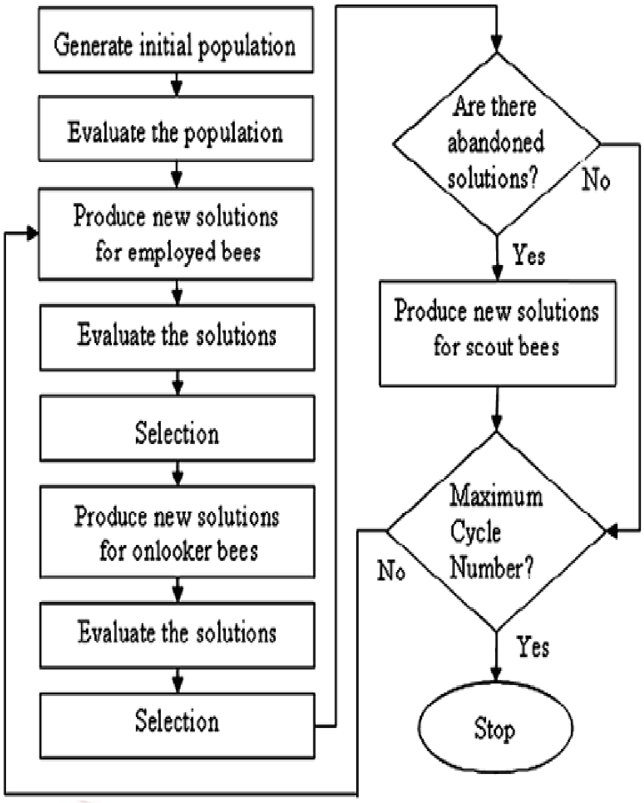
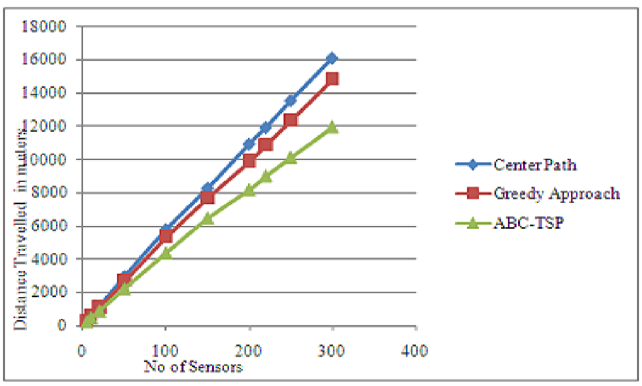


Figure 2 ABC-TSP Architectural design

V. RESULT AND DISCUSSION

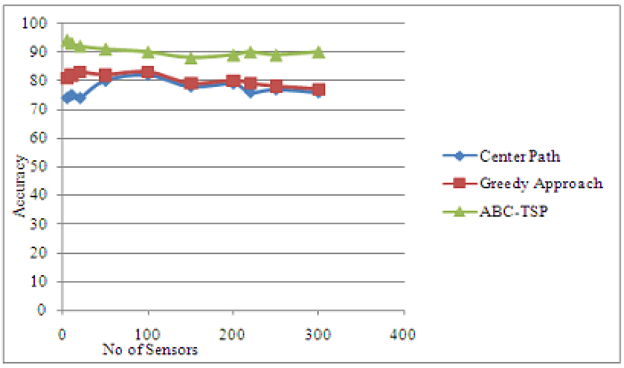
• Routing Distance of Mobile node

Center Path		Greedy Approach		ABC-TSP Based	
No.of Nodes	Distance Tavelled	No.of Nodes	Distance Tavelled	No.of Nodes	Distance Tavelled
5	328	5	305	5	243
10	640	10	615	10	486
20	1180	20	1100	20	890
50	2950	50	2700	50	2225
100	5784	100	5334	100	4378
150	8276	150	7689	150	6467
200	10945	200	9879	200	8204
220	11939	220	10866	220	9024
250	13563	250	12343	250	10151
300	16127	300	14811	300	11981



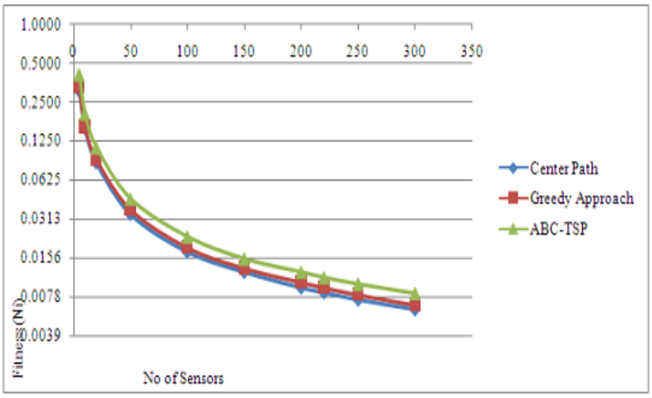
- Accuracy of the routing path finding algorithms.

Center Path		Greedy Approach		ABC-TSP Based	
No.of Nodes	Accuracy	No.of Nodes	Accuracy	No.of Nodes	Accuracy
5	74	5	81	5	94
10	75	10	82	10	93
20	74	20	83	20	92
50	80	50	82	50	91
100	82	100	83	100	90
150	78	150	79	150	88
200	79	200	80	200	89
220	76	220	79	220	90
250	77	250	78	250	89
300	76	300	77	300	90



- Fitness of the routing path finding algorithms.

Center Path		Greedy Approach		ABC-TSP Based	
No.of Nodes	Fitness (Ni)	No.of Nodes	Fitness (Ni)	No.of Nodes	Fitness (Ni)
5	0.3049	5	0.3279	5	0.4115
10	0.1563	10	0.1626	10	0.2058
20	0.0847	20	0.0909	20	0.1124
50	0.0339	50	0.0370	50	0.0449
100	0.0173	100	0.0187	100	0.0228
150	0.0121	150	0.0130	150	0.0155
200	0.0091	200	0.0101	200	0.0122
220	0.0084	220	0.0092	220	0.0111
250	0.0074	250	0.0081	250	0.0099
300	0.0062	300	0.0068	300	0.0083



VI. CONCLUSION

In WSNs with large number of nodes, a path of minimum length for sensing data collection by using ABC-TSP algorithm can be used. It helps to minimize the routing path of the mobile node in WSN and also improves the efficiency of the mobile node in terms of routing overhead, to collect data from sensor nodes in the wireless sensor network. In this paper, we present an ABC-based algorithm to solve DCPP problem in sparse WSNs. To suit ABC concept for the DCPP problem, we novelly design both the meeting point selection and the point permutation eneration strategies for different phases in our ABC-based algorithm. Through extensive simulations, the high efficiency of our proposal is validated. In the future, we will further extend our work to more general network model with multiple mobile robots. New algorithm with the joint consideration of mobile robots cooperation and travelling path planning will be proposed.

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