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Wireless Sensor Network Path Optimization Based on Hybrid Algorithm

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Abstract

One merit of genetic algorithm is fast overall searching, but this algorithm usually results in low efficiency because of large quantities of redundant codes. The advantages of ant colony algorithm are strong suitability and good robustness while its disadvantages are tendency to stagnation, slow speed of convergence. Put forward based on improved ant colony algorithm for wireless sensor network path optimization approach will first need to pass the data in the shortest path for transmission, assuming that transmission path jam, it will clog information sent to the initial position, so the follow-up need to pass data can choose other reasonable path so as to avoid the defects of the traditional method. Genetic ant colony is proposed to avoid the faults of both algorithms above. The proposed algorithm determines distribution of pheromones on path through fast searching and changing the operation of selection operator, crossover operator and mutation operator of genetic ant colony, and then solves the problems efficiently through parallelism, positive feedback and iteration of ant colony algorithm. Therefore, the faults of both algorithms are conquered and the aim of combinational optimization is achieved. At last, the validity and feasibility is demonstrated by means of simulation experiment of traveling salesman problem.

Keywords*: ant colony algorithm (ACA), combinatorial optimization, traveling salesman problem (TSP), wireless sensor network (WSN)*

1. Introduction

In the 1990 of the 20th century, Italy scholar M.Dorig, who was inspired from the mechanism of biological evolution, Ant routing behaviour by simulating the natural world, proposing a new simulated evolution of Ant Colony algorithm (Ant Colony algorithm ACA). Early was widely used in the travelling salesman problem (Travelling Salesman Problem, TSP) solution. Travelling salesman problem is a typical combinatorial optimization problem, but also a NP hard problem. As the problem grows, ant colony algorithm in a limited number of cycles is difficult to find the exact solution of the problem, and can easily fall into local optimal solution, causing the system to run the cycle is too long, slow convergence and the emergence of stagnation. University of Michigan in 1975, Professor John H. Holland proposed genetic algorithm (Genetic Algorithm, GA) can be initialized from a start node traversal, to avoid initialization from a single node caused the most easy to fall into local optimal solution of the iterative process that converges to a greater probability of the optimal solution, which has a better ability to solve the global optimal solution. However, in solving complex nonlinear problems there too premature, convergence is slow, resulting in a lot of redundant code and other shortcomings, thus making the solution accuracy is too low [1-3]. Wireless sensor network coverage problem in the field of wireless sensor network (WSN) is one of the focuses of research problems. Wireless sensor network characteristics can be summarized as: small size, low cost, low energy consumption, has a certain calculation, processing and communication capabilities. In the process of wireless sensor network coverage, needs to solve two problems: first, the coverage, how to reasonably and effectively reduce the node energy consumption, and try our best to prolong the network life cycle; Second: using mobile node scheduling strategy and parameter dynamic change, reduce the mobile node to cover the amount of work area, to achieve the goal of local area cover effectively, enhanced the topology of the network, reducing redundant data generated at the same time improve the quality of network service. Covered,

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therefore, how to meet certain conditions, the use of minimum sensor node to specify the local area covered and effectively inhibit the node energy consumption of too fast is a challenging topic.

2. Description of the Ant Colony Algorithm and Genetic Algorithm

2.1. Description of the Ant Colony Algorithm

Ants in nature after one's prey during the shortest path from the food source to Ant nests can be found mainly rely on a called pheromone chemicals. Ants in the foraging process will release a certain amount of pheromone, in motion perception in pheromone of ants and strength, and to guide their own direction [4, 5]. When a path message when the concentration of higher, indicating that the path adopted by the ants, the more the number, which select the path, the greater the probability of so that they formed made up of a large number of Ant Colony collective behaviours of a positive feedback mechanism of information . When the path of the pheromone more and for a long time, while other pheromone on a path with the passage of time has gradually declined, the colony will eventually find an optimal path.

2.2. Genetic Algorithm Description

Genetic algorithm is a kind of Bionic optimization algorithm, is a natural biological natural selection and genetic mechanism of natural of random adaptive search algorithm. Act genes on the chromosome to find the best solution of chromosomes. In genetic algorithms, mutation and crossover operator on the solution space search, cross operator is through a combination of the parents of individual characteristics, produces a new individual. After combining it with selection operator, is the primary method of accelerating genetic algorithm for information exchange, enhanced genetic algorithm of global search. Fitness function can then be used for numerical evaluation of each individual, on the evolution of new species for the next round. Each and every individual that we ask a potential implicit solution of problems, from generation to generation in the genetic manipulation evolve an optimal solution.

2.3. WSN Description

Radio problem existing sensor network nodes are the constraint conditions at the distance, section Point of energy, the nodes of wireless power, environmental factors, etc. Different network application needs Constraint conditions are different, but the minimum energy consumption constraint is one of the main and most important Constraints, and the constraint condition mainly depends on propagation distance constraints and section Point where environmental factors constraints and other constraints are related to these two conditions, the important link, A wireless sensor network model can be a figure G(V,E), V=(v1,v2,v3…vn), According to the network ,E=(e1,e2,e3…em) Said in the network communication between the nodes[4]. Each edge (i, j)$\in$E have link metrics $C_{ij}\in R$, at the same time Each node i$\in$V has a node energy variable Pi. In order to transmit power p Started for wireless transmission, variable set to $p_0\in P$, V_i said adjacent node IR. If the node in the node j the maximum transmission range, I will call node j and i neighbour nodes, the maximum transmission range depends on p0. All meet C_{ij} <P or less node j$\in V_i$, that can be covered by node I. Therefore, such as Fruit node I can spread with maximum energy p_0, all belong to the V_i of nodes can be In order to be covered.

3. Algorithm For TSP Problem Definition and Establishment

3.1. Definition of TSP Problem

Given D a directed graph of triples (V, E, f), which V is a non-empty set, the element is a directed graph of nodes; E is a collection whose elements for directed graph edges; E from to $V\times V$ mapping function on f .TSP problem refers to the given distance between the cities and cities, travelling salesman to determine through the city if and only if one of the shortest route. Purpose of the TSP is shown in the picture; find the length of the shortest Hamilton circuit, in the set of points on $V=\{v_1, v_2, v_3\cdots v_n\}$ urban traverse and n minimal closed curve that traverses only once.

3.2. Establishment of Ant Colony Algorithm

Only m Ant random to placed in n on city, set initial moments city each edge $\tau_{\mathrm{ij}}(0)=\mathrm{const}$ had information pigment, const is a constants, $b_i=(t)$ said t moments is located in elements of i Ant number, $m=\sum_{i=1}^{n}b_i(t)$, $\mathrm{tabu_k}$ is taboo table, used to records k Ant by Traverse City knot points, v initial moments $\mathrm{tabu_k}$ is first a city knot points, collection is as evolution for dynamic adjustment, who writes taboo table in the city knot points, Ant is does not allows then traverse the city knot points. When the cycle is completed, $\mathrm{tabu_k}$ taboo table is empty, the ants also can choose freely again. In path during the search, Ant based on the path heuristic information and ways to calculate the amount of State transition probability [5,6]. At the t moment, ants k in i urban transition j probabilities in select cities $P_{ij}^{k}(t)$:

$$P_{ij}^{k}(t)=\begin{cases}\dfrac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{s\in allowed_k}\tau_{is}^{\alpha}(t)\eta_{is}^{\beta}(t)} & j\in allowed_k\\ 0 & \text{otherwise}\end{cases} \tag{1}$$

Where $\mathrm{allowed}=\{0,1,2,\cdots \mathrm{n}-1\}-\mathrm{tabu_k}$, α is information on inspiration factor, the relative importance of the path. β Are expectations inspired by factor, represents a relatively important visibility. d_{ij} Represents the distance of the city, which $\eta_{ij}(t)$ inspired function is inversely proportional:

$$\eta_{ij}(t)=1/d_{ij} \tag{2}$$

When the ants after t a moment, after completed a traverse to n a city, left on a path of pheromone concentrations will gradually reduce, this requires make adjustments to the pheromone on each path, its expression:

$$\tau_{ij}(t+1)=\rho\tau_{ij}(t)+\Delta\tau_{ij}(t,t+1) \tag{3}$$

$$\Delta\tau_{ij}(t,t+1)=\sum_{k=1}^{m}\Delta\tau_{ij}^{k}(t,t+1) \tag{4}$$

$\Delta\tau_{ij}^{k}(t,t+1)$ On behalf of k the Ant remained (i,j) on the path of the strength of information $(t,t+1)$ at all times. ρ is volatile factor pheromone, $(1-\rho)$ is the prime factors of residual information. The size of ρ the direct impact on the global search capabilities of Ant Colony algorithm and its convergence rate $(1-\rho)$ reflects the ability of Ant interaction between individuals.

3.3. Establishment of Genetic Algorithms

Length of L binary n string s_i formed a group $i=(1,2,3\cdots n)$ at the beginning of the genetic algorithm, also known as the initial group. In each series, each binary digit is the individual genes of the chromosome. The actions of the group there are three: the first option, which were selected from a group representing individuals to adapt. These select individuals for breeding the next generation. It is also sometimes called the operation regeneration. Fitness proportional selection is selection of the most basic method, where each individual is selected with its value and the number of expected group average proportion of fitness. $P=\{a_1,a_2,a_3\cdots a_n\}$ Groups sue for a given n size, the individual $a_j\in P$ the fitness function is $f(a_j)$, its selection probability as:

$$p_s(a_j) = f(a_j) \Big/ \sum_{i=1}^{n} f(a_i) \quad (5)$$

A second crossover, which are selected for breeding the next generation of the individual, individuals of two different genes are exchanged at the same location, which results in a new individual. Crossover operator may generally be divided into three types, respectively, is a one-point crossover operator, multiple point crossover operator, and consistent cross-operating [3]. Consistent cross operation is the core cross-cutting operations in the most current research one of the cross. Consistent cross-operation is that every of chromosomes on the bit string according to the same probability for random uniform cross.

3.4. A Network Model

Under normal circumstances, the coverage directly reflect the goal by the degree of attention, attention of the target node areas with high coverage, at the same time to consider sensor node is located in the covered area function relationship between expectations and area covered, in order to study the problem of convenient, Figure 1 shows the cover with unilateral square area as the research object of the region, which contains six eight sensor node and destination node, sensor node and the relationship between the target node is shown in Figure 1.

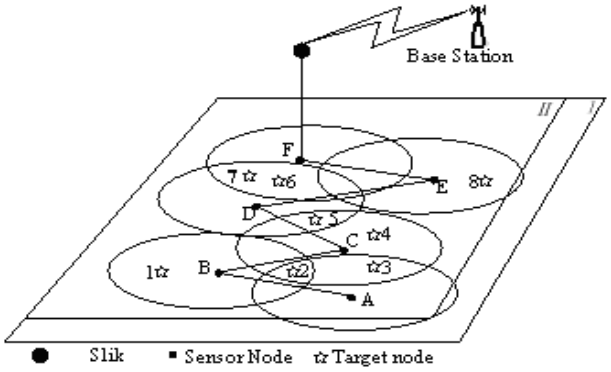

Figure 1. The Model of the Monitoring Area Network Coverage

In process for single square area coverage, information collected by sensor nodes by gathering nodes to base station, the base station after processing the data is transmitted to the central control terminal [7, 8]. Can be seen from Figure 1 between each sensor and the relationship between the target node, sensor node as the research object, given that A (2, 3); B (1, 2); C (2, 5); D (5, 6); E (8); F (6, 7), on the other hand, with the target node is given as the research object is: 1 (B); 2 (A, B, C); 3 (A, C); 4 (C); 5 (C, D); 6 (D, F); 7 (D, F); (E). It can be seen between the sensor node and destination node maximum correlation for 3.

4. An Improved Algorithm

Ants are to complete the calculations after this time through the loop circuit distance. L_{best} is the shortest circuit, L_{worst} is the longest circuit. Update policy of their shortest and longest circuit press formulas to update:

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij} + \sum_{k=1}^{m} \varphi_k \Delta \tau_{ij}^{k}(t) \quad (6)$$

Fitness is the individual groups the opportunity to choose the only certainty of life indicator. Adaptive function is directly determines the evolution of group behaviour. For minimizing issues, to establish function $f(x)$ and $g(x)$ objective function of mapping relations:

$$f(x)=\begin{cases} c_{\max}-g(x) & g(x)<c_{\max} \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

$c_{\max}$ is an input or a theoretical maximum value. By adapting function on target selection and some kind of evolutionary process control function transformation in order to formulate an appropriate selection policy, evolution of hybrid Ant Colony algorithm for maximum capacity and the best search results [4].

To better evaluate network performance and simulated using MATLAB6.5 simulation experiment. By changing the coverage range, realize the different network coverage and connectivity, and to better assess the performance of the model under different scale, mainly reflected in the realization of network under the condition of different coverage and connectivity rate needs to be deployed at least the number of nodes, and each time simulation results are the average of 100 times, set up the simulation area is 100 m * 100 m, the node's perception of radius 2 m, node communication radius is 2 times the radius of perception. Figure 2 shows the initial moments of the random node local diagram, as shown in Figure 2:

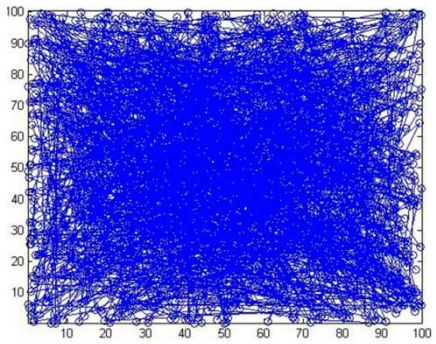

Figure 2. The Random Node Local Coverage Map

Take lower left here, by 1:2 to zoom in, each node in different time mobile map, as shown in Figure 3:

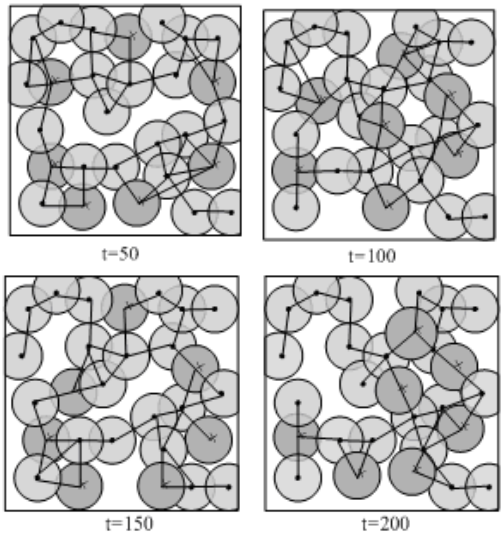

Figure 3. Different Time Nodes for Monitoring the Efficacy of Regional Coverage

5. Simulation Experiment

This shows that algorithm has good capability global search for optimal solutions, accelerate the convergence rate of the system, avoiding the early emergence of iterative processes, suppression of redundant code, makes the solution more accurate precision, which enables dynamic optimization of the solution process. In Table 1 and Table 2 in the parameter of the same three groups basic Ant Colony algorithm for symmetric TSP algorithms comparison with this article. in order to verify the effectiveness of this algorithm, using Ant Colony algorithm and comparisons with this algorithm on CHN144 experiment, conducted 50 comparison, corresponding to the optimal solution convergence curve [9, 10], as shown in Figure 4.

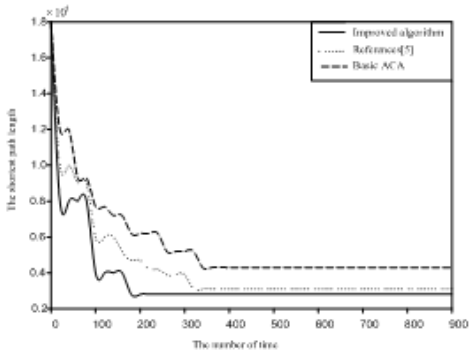

Figure 4. Shortest Paths Curve Comparison Chart

Selection in order to further verify the effectiveness of the algorithm, the coverage and between nodes under the different network scale curve, and the connectivity rate under different network scale and the change curve between nodes, as shown in Figure 5 and Figure 6.

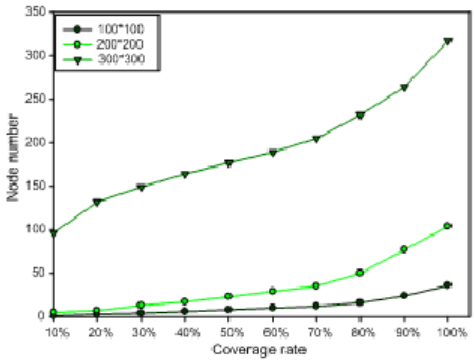

Figure 5. The Node Coverage under the Different Network Scale Curve

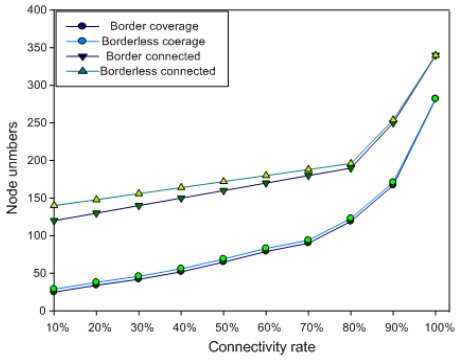

Figure 6. With and Without Considering the Boundary Effect

Figure 5 shows the implementation under the different network scale under different node coverage in a drawing of the number of deployed sensor nodes. Can get along with the expanding of network size from the chart, to meet the demand of certain network coverage, the deployment of the number of nodes will also increase, and the network coverage is higher, need to deploy the faster increase in the number of nodes, so that the focus of the target node to achieve complete coverage.

Figure 6 reactions are under the condition of without considering the boundary effect, realizes the different coverage and connectivity rate need to deploy the number of nodes. Compared with considering boundary under the influence of growth in the number of deployed

nodes slightly, with the increase in the number of nodes, node density between so will get bigger, the boundary effect reduced [11].

6. Conclusion

This article will genetic Ant group algorithm solution most optimization problem of advantage application Yu features select, and to out behaviour features select genetic Ant group algorithm optimization process, while for basic Ant group algorithm of limited for corresponding of improved, through on heuristic function, and information update policy, and cross and select policy on solutions value for optimization, in must degree Shang suppression has prematurely convergence phenomenon, improve on global found search ability, effective to avoid into local optimal solutions, speed up has convergence speed [9]. Set up the relationship between sensor nodes associated with the target node model. Under the condition of considering the effects of boundary, a local coverage optimization algorithm model is put forward. It can simplify the computational complexity of network coverage and connectivity, improves the algorithm performance, realized in the network coverage and connectivity requirements, the more accurate solution of the required deployment node the number of values. Finally, through the simulation experiment results verify the validity of the theory solution and the effectiveness of the algorithm.

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