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Ant Colony Algorithm Based on Path Planning for Mobile Agent Migration

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Abstract

Analysis of the travel agent questions (Travelling Agent Problem, TAP), and that it is a class of complex combinatorial optimization problems, mobile agent migration path planning is the most classic problems; Second, for ant colony algorithm to solve such problems in need long search time and ease into a local minimum shortcomings, the introduction of genetic algorithms and ant colony algorithm for global and local updating rules to improve, greatly reducing the travel agent ant colony algorithm to solve problems caused by the system into a local minimum stagnation phenomenon may be; Finally, through simulation experiments verify the validity of the proposed algorithm.

Keywords:Ant colony algorithm;path planning;mobile agent migration

1 .Introduction

Mobile agent in the network environment in accordance with its current mission requirements and network load to choose to move to a host one or several sub-tasks to complete the current task is complete and then move to another host to continue its subtasks, until the computational tasks execution is completed or fails.

How to plan the movement path of mobile agent is particularly important, Moizumi definition of travel agent the following issues: distributed network computing environment, there are hosts, the numbers were. Starting from the host mobile agent to perform a task, mobile agent on the host to complete its mission

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probability, these probabilities independent from each other. Regardless of whether the mobile agent on the host to complete its task, due to complete its task in the delay caused by both. To the host computer,. Mobile agent moves from host to host the required time. If the mobile agent to complete the task in a host, the host can be directly returned by the original host, without having to visit the rest of the host; if they failed to complete the task, the mobile agent need to continue to move to another host until the task is completed or completed through All hosts are unable to complete its task so far, on the way up to one visit per host. The problem is to find a travel agent makes the mobile agent to complete the task the expected minimum time required to move the path.

Research travel agent issue is important because the travel agent to solve the problem, the general sense can be given from the mobile agent moves between hosts in different migration path planning, making the mobile agent to concentrate the main effort priority access to those most likely to complete their task of the host to ensure that mobile agent

Can be completed within the shortest possible time users of distributed computing tasks assigned to it, which can greatly improve the operating efficiency of mobile agent system.

Application of the basic ant algorithm travel agent problems, can make ants on behalf of a mobile agent. Ants in addition to a higher probability of selection tend to spend a short time, high concentrations of pheromone path, we should also give priority to complete the task the probability is high, the short latency of the host, because ants have visited a number of tasks in a high probability , a short delay after the host is likely to have completed the task, you can return to the original host without direct access to the rest of the host.

When the mobile agent on all hosts are unable to complete their task and eventually return to the initial host, the travel agent on the degradation of the famous traveling salesman problem (Travelling Salesman Problem, TSP), so the traveling salesman problem is a travel agent issues special case. Travel agent is to promote the traveling salesman problem. Thus, the travel agent is a very complex combinatorial optimization problems, Moizumi in his doctoral thesis in the travel agent has been proved theoretically that the problem is NP-complete, its time and space complexity is very high, which requires to solve Travel agent problems generally must have the adaptive, self-learning, distributed, parallel intelligent features, which can be within an acceptable time frame arrive at the optimal solution or near optimal solution.

2. Related Research

2.1 Traveling Salesman Problem

Traveling salesman problem [1] is given a set of cities and the cost of travel between cities, looking through each city only once, and eventually return to the initial cost of the smallest cities in the path of travel. Can construct such a graph: vertices in the graph for the city, the edge between vertices that inter-city lines, right along the edge of the travel costs of the lines. So, traveling salesman problem on an abstract figure in the search for the shortest Hamilton circuit [2].

Any two cities A and B, if the cost of travel from A to B and B to A equal to the cost of travel, said this is the symmetric traveling salesman problem traveling salesman problem (Symmetric Traveling Salesman Problem, STSP), otherwise known as asymmetric Traveling Salesman Problem (Asymmetric Traveling Salesman Problem, ATSP). In general, not specifically mentioned in the case of the traveling salesman problem refers to the symmetric traveling salesman problem.

n-vertex traveling salesman problem in the path refers to the sequence of vertices: where and between the sides. A path is called legal path, if.

TSP is essentially a data optimization problem can be formally described as:

Which means the distance between the vertex and vertex. Algorithm show that the traveling salesman problem is NP-complete problems, computational complexity.

Since the TSP has been proposed, the solution method has been continuously improved. Now tens of thousands of the city can solve the traveling salesman problem [3]. In recent years, behavior-based ant colony algorithm has become a more effective method of solving the traveling salesman problem.

2.2 ACO

Nature of the ant is a small but almost no vision of the animal, but when ants live in groups together Shique extremely complex behavior can be completed and show very strong vitality, not only through mutual cooperation they will exceed their size and weight food handling back to the colony several times, the colony can find the shortest path to food source. Biologists long observed between ant pheromones through a substance known as the exchange of information and ultimately to achieve cooperation. Ants in the course of the campaign, after which it can be left on the path of the substance, and ants can perceive in the course of the campaign this substance, and to guide their direction of motion. Ants will follow the pheromone concentration and the choice of path: the path on the pheromone concentration is larger, the ants choose the greater the probability of the path. Pheromone over time and will continue to evaporate, while moving the ants in the process will continue in accordance with certain principles of the new pheromone secretion, and thus the pheromone concentration over time and constantly changing, the overall trend is ant Few choose the path on the concentration of pheromone will be more low, and ants often choose the path of the pheromone will be increasing the concentration.

Ants looking for a new food source, in the initial stages of the absence of pheromone guidelines, so the path will appear in completely random search, which ants will choose the same probability to all paths, but because of long path ant finish this path takes longer than the short path length of time the ants, so finish at the same time, the number of ants is greater than the path length of the path, and thus the short path on the pheromone concentrations will be higher than long path. Meanwhile, the ants follow a short path in the process of moving new pheromone secretion will make a short path pheromone concentration continued to increase, while the long path because there are fewer ants choose the pheromone concentrations will continue to decrease. This forms a positive feedback process, will eventually lead to all the ants choose the short path, which makes the whole colony from the colony to be able to find the shortest path between food source.

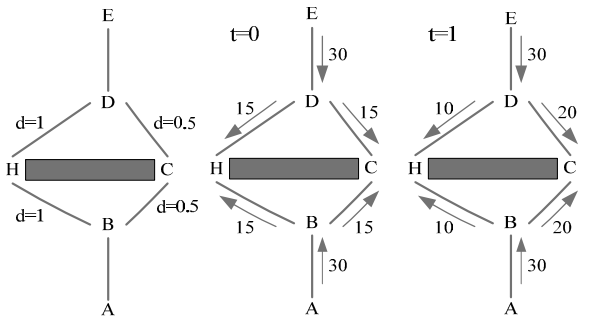

Fig.1 Schematic diagram of ant colony system

Marco Dorigo in [1] is given on the process description for the following, we refer to Marco Dorigo in the literature to the example vividly illustrates the basic working principle of ant colony system. Shown in

Figure 1, Let A be a colony, E is the food source, HC is an obstacle. Because the presence of obstacles, only after the ants from A to H or C to reach E, or E to reach A, the distance between the points chart has been marked. Each time unit is located 30 ants from A to reach B, 30 ant to reach point D from E, ants moving speed to 1, after the ants leave pheromone concentration of 1. For convenience, set pheromone is valid for one time unit, that pheromones secreted from the start time in the unit from the guidelines for follow-ant role, since the pheromone is completely volatile. In the initial moment, the path BH, BC, DH, DC had no information on the existence of elements in B and D of the ants can randomly select a path. From a statistical point of view that they are the same probability of selection BH, BC, DH, DC. After a unit of time, from A to B 30 H is ants in the path leading to a concentration of 15 found in the pheromone, which is 15 from B to H of the first ants left behind; in leading C can be found on the path of a pheromone concentration of 30 paths, which is 15 from B to C, the pheromone left by ants and 15 from D to B through C left and pheromone concentration. In time, according to concentration of pheromone on the path information, there will be 20 ants from the B and D to reach C, 10 ants reached by the B and D H. Over time, the ants will be increasing the probability of selection path BCD, eventually completely choose the path BCD, in order to find the food source from the nest to the shortest path. Thus, the exchange of information between individual ants is a positive feedback process, after a period of autonomous operation, will eventually give an optimal solution.

2.2.1 Artificial ants and ant real difference

Ant colony algorithm is more appropriate to say that the artificial ant colony algorithm, as proposed in Marco Dorigo proposed ant colony algorithm in real ants, artificial ants, and there is a difference. Artificial ants have two characteristics: First, it is a real ant behavior abstraction, through the observation of the behavior of real ants, ant colony foraging behavior of the most critical part of the given artificial ants; second, made of artificial ant to this concept to solve some practical engineering optimization problems, so in order to make more effective ACO, artificial ants have some real ants do not have the skills

Most of the characteristics of artificial ants are derived from real ants, they have a common main features are as follows:

(1) real ants, artificial ants, and as a group of mutual cooperation of the individual. These individuals through mutual collaboration between the global scope to identify problems on better solutions. Each artificial ant to build a solution, but high-quality solutions is the result of collaboration throughout the colony;

(2) artificial ants and ants share a common real task is to find the colony and that the shortest path between food;

(3) artificial ants with the real ants also communicate through pheromones. Indirect communication with similar real ants, artificial ants also possess the communication between the two characteristics: imitation of the real ant pheromone release; state variables can only be partially artificial ants to reach;

(4) and similar to real ants, artificial ants will also use pheromones as a feedback system through the evolution of self-enhancement solution Jiao, making the solution of the problem in the direction toward the global optimal solution to evolve and eventually be able to effectively to get on better solution relative;

(5) artificial ant colony algorithm in the existence of a volatile mechanism, similar to the real pheromone evaporation. This mechanism allows the ants to forget the past, the experience gained from over-constrained, which is conducive to ants toward a new direction to search, to avoid premature convergence;

(6) artificial ants and, like real ants, the application of probability near the state moves toward decision-making mechanism, in order to build solutions to problems, but this strategy takes advantage of local knowledge and information, and not to predict the future any forward-looking state.

In the artificial ant algorithm, the ant search algorithm played a decisive role in the following four points:

(1) local search strategy. According to the definition of domain concepts, step through the limited movement of ants have established a solution to the problem. Local search strategy using random selection of direction of movement;

(2) The ant's internal state. Ant's internal state stores information about the ants in the past. Internal state can carry useful information used to calculate the value generated by the program;

(3) pheromone track. Local, global information includes both information on specific issues of inspiration, but also contains all the ants from the initial node of the search process began to accumulate knowledge. This knowledge path through the code in the form of pheromone expression, ants and gradually establish a time of global pheromone information. These global and local pheromone, ants could affect the decision-making;

(4) ant decision table. Ant decision table is inspired by the pheromone function and information function of a common decision. Ant decision table is a probability table, the ants use this table to guide its search towards the search space of the most attractive regional mobile.

2.2.2 Description of ACO

Ant colony algorithm can be seen as the solution space based on parameterized model of the probability distribution of the search algorithm framework. In the ant colony algorithm, the solution space parameterized probability model parameters is the pheromone, and thus the parametric probability distribution model is the pheromone model. Elements in the model-based search algorithm framework, a feasible solution in the solution space by parametric probability distribution model search produced this model with the parameters of the solution to update the previous generation, making the new model in the search to focus on high quality of the solution search space. Effectiveness of this method is based on the quality of the solution always contains elements constitute a good solution assumptions. Constitute elements of this solution through the study of the impact of the quality of the solution will help to find a mechanism, through the solution constitutes the best combination of elements to construct high-quality solution. In general, a memory model using the following two-step search algorithm is usually optimal iteration to solve the problem:

(1) a feasible solution in the solution space parameterized by the probability distribution model search produced

(2) to update the search for solutions generated by parametric probability model, which updates the solution space parameterized probability distribution of parameters, making the new model, the parameters of the search to focus on high-quality solution in the search space.

In the ant colony algorithm, pheromone-based solution space parameterized probability model to construct solution of the form given in Fig. In the solution structure map, then define a search mechanism as a colony of artificial ants construct solutions through a distribution map in the local pheromone information on the guidelines in the solution structure map is moved to the gradual construction problems feasible solution. Pheromone and the solution construction graph node or arc on the associated solution space parameterized as the probability distribution of model parameters.

As the traveling salesman problem solution can be directly mapped to the structural map (urban nodes, the path for the arc between the city, the distribution of pheromone on the arc), plus traveling salesman problem is also NP-hard, therefore, most applications of ant colony algorithm are concentrated in the

traveling salesman problem. In general, for solving the traveling salesman problem, optimization of production scheduling problems ant colony algorithms follow the framework of the unified algorithm.

Solving combinatorial optimization problems ant colony algorithm:
While condition is not be satisfied do
for each ant for According to pheromone, ants construct the asynchronous solutions;
Local pheromone is updated;
End for
End for
Acquired solutions are taken as starting point to local search;
According to the quality of solutions, global pheromone is updated.

2.2.3 Characteristics of ant colony algorithm

From the principle of ant colony algorithm is easy to see, ant foraging behavior is actually a distributed collaborative optimization system [3]. Although able to find a single ant colony to the food source from the path, but is very unlikely to find the shortest path only when multiple ant colony composition, their collective behavior only highlights the ability of ants find the shortest path. In the process of finding the shortest path, the ant uses an indirect means of communication, that is, all paths through the release of certain pheromones, other ants through the perception of the strength of this material to select the next way to go pheromone in the ant's collaboration and communication played an indirect role of the media, artificial ant problem by updating the state variables to simulate the real behavior of ants update the pheromone. Foraging behavior is another important mechanism for positive feedback mechanism, this positive feedback mechanism to guide the ant colony to find high-quality problem solutions, using self-catalytic mechanism, we must strive to avoid the premature phenomenon.

In addition to the foraging behavior of artificial ants, the ant colony algorithm there are two mechanisms: pheromone evaporation mechanism and back behavior. Forgotten is an advanced intelligent behavior, as a forgotten form of pheromone on the path will be volatile over time driven by artificial ants explore the solution space in new areas of the solution process in order to avoid premature convergence to local minimum optimal solution. Conduct the background search process, including local and global information collection.

3. mobile agent migration path planning based on ant colony algorithm

The basic ant colony algorithm for solving the problem travel agent

The basic ant algorithm in accordance with the idea of applying the algorithm to solve the problem when the travel agent, so that ants can perform distributed computing tasks on behalf of a mobile agent, the system also more generations of ants to solve the same problem in parallel, each ant migration route is the travel agent seeking a solution to the problem. Problem solving process is the continuous process of evolution, the evolution of ants according to the experience gained by constantly adjusting the concentration of pheromone on the path to promote mobile agent migration routes continue to be optimized, and finally get the optimal solution or near optimal solution.

The travel agent based on ant colony algorithm to solve the problem

In the ant colony algorithm, artificial ants have memory function, as time goes by, the old pheromone gradually weakened, before leaving the pheromone will gradually disappear. In the ant colony count, the use of that pheromone volatility.

When the ants move from host to r s, the concentration of pheromone on the path according to equation (1) partial update:

$$\tau(r,s) \leftarrow (1-\rho)\cdot\tau(r,s) + \rho\cdot\tau(r,s) \tag{1}$$

Of which:

$$\tau(r,s) = \sum_{k=1}^{n} \tau_k(r,s) \tag{2}$$

$$\tau_k(r,s) = \frac{P_r + P_s}{d(r,s)\cdot(t_r + t_s)} \tag{3}$$

- Pheromone evaporation coefficient;
- All along the path of the total pheromone left by ants;
- The first ants to stay in this cycle the pheromone on the path;
, - To complete the task on the host ant probability;
- Host of the delay.

Ant for improvements made during the local pheromone update more targeted, to avoid the ants converge to the same path, it is also to some extent improve the search speed.

4. Simulation and Results Analysis

In order to verify the performance of the algorithm, carried out simulation experiments. Experiments in the number of required data, including the host, mobile agent to move between the time the host, mobile agent in the probability of completing the task on the host, the host and delay. Experiments need to set the parameters as follows:

Number of hosts n = 20; ant number m = 20, the number of ants in the ant colony algorithm selection is generally selected as m = n (problem size) is appropriate; pheromone evaporation factor of choice, first consider the algorithm stability and global optimal solution, followed by the convergence rate, combined with the experimental results, ACO pheromone volatility is appropriate, that; weighing factor; heuristic factor value can speed up the convergence of the algorithm, change the values are also reduced iterations while improving the quality of the solution. Ants in motion the process of cumulative information and the path parameters in ants choose a path in the different roles played by that heuristic factor.

We were the basic ant algorithm, ant colony algorithm and the improved ant colony algorithm for this experiment, each experiment performed 10 times, each time the loop runs a total of 1500 times, and take the average results of 10 experiments. Three algorithms for optimal evolution curve shown in Figure 2.

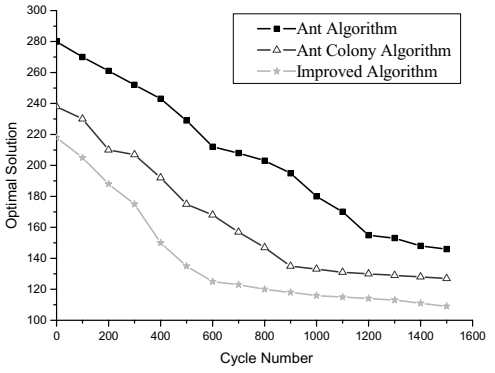

Fig.2 Evolution curve of optimal solution

Evolution curve from the optimal solution algorithm can be seen, the basic ant algorithm, ant colony algorithm, the improved ant colony algorithm to obtain the optimal solution, respectively, 146, 127, 109. Three algorithms to achieve optimum number of cycles required was 1213 times, 1089 times, 877 times. This improved ant colony algorithm converges much faster, and basic ant algorithm, ant colony algorithm, to achieve convergence of the cycles were increased by 28% and 20%. Convergence speed can not only provide better quality solutions, but also reduce the time to complete the task. Robustness of the algorithm to be strengthened to avoid a local minimum due to the emergence of stagnation.

5 . Conclusions

Travel agent is a class of complex combinatorial optimization problem, aimed at addressing the mobile agent to move between different hosts how to plan the optimal migration routes. In the ant colony algorithm based on the introduction of genetic algorithms and ant colony algorithm for global and local updating rules to improve, greatly reducing the ant colony algorithm into a local minimum and cause the system to a standstill phenomenon possible. The simulation results show that the improved ant colony algorithm makes mobile agent can better efficiency and shorter time to complete the task, robustness of the algorithm to be strengthened.

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