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Research on the Optimal Combination of ACO Parameters Based on PSO

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Abstract—**As ACO's different value of parameters has impact on its performance. Try to find the optimal combination of parameters can make algorithm have best performance. On the basis of basic model of ACO, we analyzed parameters' effects on algorithm performance, then proposed "TwoStep" strategy for selecting algorithm parameters: First, determine a reasonable range of each parameter, then introduce fitness function and use PSO to receive optimal combination of parameters. Experiments demonstrate that the proposed strategy can obtain good searching results, which may contribute to the promotion and application of ACO.**

Keywords-ACO; PSO; optimization; two-step

I. ANT COLONY ALGORITHM

A. Principles of ant colony algorithm

ACA simulates the behavior of ant colonies in nature when they are foraging for food and find out the most efficient route from their nests to food sources. ACA has the advantage of resolving the large combinatorial optimization problems. These problems can not be resolved by traditional algorithm, such as dynamic programming, when the size of the problem is large. Till now, ACA has been successfully applied to a great many of combinatorial optimization problems, such as the quadratic assignment problem and the job shop scheduling problem. Ant colony system has also been used to build up classification rules for data mining.

Ants leave some chemical substance, which we call" pheromone" on the way of their route. If the route is short, ant would leave some pheromone to attract other ants, and the quantity of pheromone is in inverse proportion to the length of the route. Ants can also perceive the pheromone when they pass the route, and their actions could be influenced by the concentration of pheromone. They would select a route in a possible route in proportion to the concentration of the pheromone. In this way, the shorter the route is, the more frequently it is visited by ants, the more pheromone is accumulated on the route. This process will last until all the ants select the shortest route.

B. Overview of ant colony system

The topological graph of a network is defined as $G=(N,E)$,and there are arcs between any two nodes.The problem solving process of ant colony system is as follows.At the beginning of the algorithm, m ants are generated at time point t and are distributed randomly on the nodes in the graph. A tabu list T_k ,which records the nodes that ant k has visited up till now, is introduced to ensure that any node can not be visited more than once by the same ant in a cycle. The probability of ant k migrating from node i to node j at time point t is decided by the formula

$$P_{ij}^{k}=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}(t)]^{\beta}}{\sum[\tau_{ij}(t)]^{\alpha}[\eta_{ij}(t)]^{\beta}} & j\in allowed_k, s\subset allowed_k \\ 0 & \text{else}\end{cases} \quad (1)$$

where $\tau_{ij}(t)$ represents the concentration of pheromone on the edge of E_{ij} at time t .At the beginning, every edge will be given a rather small initial pheromone value, and this value is frequently updated in the consecutive steps. $\eta_{ij}(t)=1/d_{ij}$ is the local heuristic information which represents the expectation of migrating from node i to node j . d_{ij} is the Euclid distance between node i and node j . α , β are two parameters that control the proportion of pheromone and local information when calculating probability P_{ij} . N_i is the adjacent node set of the node i .After |N|-1 steps, each of the ants has finished a journey covering every nodes and m feasible solutions emerges, this process is called iteration. Then pheromone on edge is updated according to the quality of acquired routes.

When the ants finish an iteration, they would update the pheromone concentration of the edges they has passed. The updating formula as follows:

$$\tau^{k}{}_{ij}(t+1)=\rho\tau^{k}{}_{ij}(t)+\Delta\tau^{k}{}_{ij} \quad (2)$$

where ρ is the evaporating coefficient, $\Delta\tau_{ij}{}^{k}$ is the concentration increment of the edge E_{ij} . $\Delta\tau_{ij}{}^{k}$ can be computed as bellow. If ant k has passed edge E_{ij} ,then $\Delta\tau_{ij}{}^{k}=Q/L_k$ where L_k is the length of the route passed by the ant k ,else $\Delta\tau_{ij}{}^{k}=0$.

After developing for more than ten years, there are more improved algorithms in ant colony algorithm, but the

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heuristic factor α ,expectation heuristic factor β, pheromone evaporation factor ρ ,the number of ants m and pheromone quantity Q have always been an important parameter towards affecting the performance of algorithms. Study results indicate that the different values of the parameter have a greater impact on algorithm performance. In order to get the best portfolio parameters this paper will propose a solution which can make algorithm achieve the better performance.

II. "TWO-STEP" STRATEGY FOR DETERMINING THE OPTIMAL COMBINATION OF PARAMETERS

This paper attempts to determine the best combination of parameters of ant colony algorithm which can make the algorithm to achieve best performance. Based on the existing results, we propose the "two-step" strategy, use ant colony algorithm to determine reasonable scope of each parameter, then introduce a fitness function and combine with PSO to determine the optimal combination of each parameter. First, this paper will briefly introduce Particle Swarm Optimization, second it describes "two-step" strategy program, last it describes algorithm based on particle swarm ant colony algorithm to the optimal combination of parameters.

A. *PSO Optimization Theory*

PSO is a class of population stochastic global optimization techniques proposed from a natural phenomenon of birds to forage for food by Kennedy and Eberhart. In each iteration of algorithm, particle x_i according to equation (3) to be updated by the optimal solution which traced itself (individual extreme pbest) and found the optimal solution in the currently whole population(Global Extreme Gbest).Thereby guided the particles move to the optimal solution.

$$v_{k+1} = w \cdot v_k + c_1 \cdot r_1 (pbest_k - x_k) + c_2 \cdot r_2 \cdot (gbest_k - x_k) \quad (3)$$

$$x_{k+1} = x_k + v_{k+1} \quad (4)$$

Where v_k is the particle velocity vector, x_k is the current position of particle; c_1, c_2 is constant and called the learning factor; r_1 , r_2 is uniformly distributed random number at [0,1]; w is inertia weight. PSO' s advantage is easy and simple to realize, it is more suitable to solve combinatorial optimization problems of continuous domain.

B. *Concrete steps of "Two-step" Strategy*

- Step one: According to the basic ant colony algorithm, we determine the reasonable scope of each parameter. According to existing research results ,we can get the experience value of each parameter, that is $\alpha = 1$, $\beta = 5$, $\rho = 0.5$, $m = n / 1.5$ (n is the number of city), $Q = 100$. According to the scope of parameters given by the experts, we can use the basic ant colony algorithm to determine the reasonable range of each parameter. In the calculating of a parameter, the other parameter values are experience.

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follows: To determine the best combination of variables $\alpha, \beta, \rho, m, Q$,and to get the optimal value of the function $F(\alpha, \beta, \rho, m, Q)$ As the problem of parameters' combinatorial optimization are continuous field of combinatorial optimization. Therefore, this paper introduce the particle swarm algorithm to determine the best combination of parameter. Detailed algorithm will be described as below.

C. *Design ot he Optimal Combination of ACO parameters Based on PSO*

To achieve practical application of the "Two-Step" strategy, this paper proposed ant colony algorithm based on particle swarm algorithm for optimal combination of parameters. The mind is putting the algorithm parameters as the object of particle swarm optimization(the location of particle).In each iteration, we use the particle's current location information to run the ant colony algorithm, and use the fitness function $F(\alpha, \beta, \rho, m, Q)$ to make evaluation for its performance, then guide the particles towards the best direction. Algorithm for computing the steps can be listed as follows:

a) According to the first step of "two-step" strategy, determine the reasonable range of each parameter, design ant colony algorithm program, set parameters $\alpha, \beta, \rho, m, Q$ as entry parameters to facilitate calls. In order to ensure the reasonableness of results, it requires the results of procedures should take the average value of ten from each group parameters running;

b) Set the learning factor c_1 , c_2 and inertia weight w ,when it is in the reasonable range of each parameter, particles are all randomly selected the initial position and speed;

c) For location information of each particle corresponding to use ant colony optimization algorithm to solve standard optimization problem, use the fitness function $F(\alpha, \beta, \rho, m, Q)$ to evaluate the results, get the fitness value of all particles;

d) Compare suitable value of particles on the current position and $pbest$ adaptive value, if better, then use the current location to update $pbest$;

e) Compare each particle is *pbest* fitness value with fitness value of global extreme value *gbest* ,if better, then update *pbest* ;

f) Update the velocity and position of each particle according to equation *c), d)*;

g) Determine whether it is content with termination condition, if do, output the global extremum *gbest* and particle position, else break to *c)*.

To verify practical strategies and algorithms of this paper, we combined practical examples to do simulation.

III. SIMULATION AND ANALYSIS

The simulation based on the data from TSP problem in Eil51,uesd c++ language to determine the optimal combination of designing parameters for the program and conducting operation. Since the two algorithms are clustering algorithm, there are a large number of individual ants and individual particles generated, and we need iterative to produce optimal results. So the difficulty in programming was time expenditures of the algorithm. After optimization of program was designed and appropriate to reducing the number of iterations, made program get optimized results with an ideal time. Ant colony algorithm adopted 300 iterations, particle swarm algorithm adopted 100iterations, particle swarm algorithm parameter values choose $w=1, c_1=c_2=2$.

We determine the reasonable interval parameters of ant colony algorithm. Domain α is (0,10),step length is 0.5,domain β is (0,10), step length is 0.5,domain ρ is (0,1),step length is 0.05,domain m is (30,50),step length is 1,domain Q is (0,500),step length is 10.Each iteration does 1000 times, the average length of path is chosen by times it ran the 10 results. This paper listed the parameters of ρ which has influence on the results of the performance of ant colony algorithm in table 1 and convergence tendency in figure 1.

TABLE I. RELATIONAL TABLE OF ρ AND AVERAGE PATH LENGTH

No.	ρ	Path length	No.	ρ	Path length
1	0.05	494.306	11	0.55	454.270
2	0.10	482.493	12	0.60	455.280
3	0.15	479.798	13	0.65	453.892
4	0.20	468.993	14	0.70	453.848
5	0.25	464.618	15	0.75	452.821
6	0.30	458.782	16	0.80	455.582
7	0.35	455.572	17	0.85	455.572
8	0.40	456.255	18	0.90	453.674
9	0.45	454.695	19	0.95	450.135
10	0.50	453.848			

The size of pheromone evaporation factor ρ directly related to the global searching ability of ant colony algorithm and convergence rate. From the simulation results shown in figure1 can be seen that ρ was less than 0.3,due to the role of positive feedback of information was dominant, searched before the path was possible choose, lead the path to poorer outcomes. To sum up, when $\rho \in [0.3, 0.95]$, ant colony algorithm was in better overall performance. In short, the other parameters could get a reasonable range by using same methods: $\alpha \in [1,4]$, $\beta \in [2,6]$, $m \in [30,35]$,. $Q \in [50, 100]$.

TABLE II. TABLE WITH PARAMETERS OF ANT COLONY ALGORITHM FOR RANDOM COMBINATION

No.	α	β	ρ	m	Q	The average path length	usage time
1	1	2	0.3	30	50	448.765	32
2	1	3	0.8	31	150	451.609	33
3	2	4	0.5	32	100	464.794	57
4	2	5	0.6	33	100	466.103	58
5	3	6	0.7	34	150	469.687	58
6	3	2	0.3	35	90	475.348	60
7	4	3	0.4	30	150	466.697	62
8	4	4	0.5	34	80	449.825	65
9	5	5	0.6	32	80	462.978	67
10	5	6	0.7	35	80	469.961	68

TABLE III. RESULTS OF THE OPTIMAL COMBINATION OF ACO PARAMETERS BASED ON PSO

No.	α	β	ρ	m	Q	The average path length	usage time
1	1	5	0.8	30	100	429.413	35
2	1	4	0.5	33	50	440.510	27
3	1	5	0.8	33	80	433.471	35
4	1	5	0.7	33	80	426.345	28
5	1	5	0.6	34	100	431.670	27
6	1	4	0.6	34	100	436.963	26
7	1	5	0.95	34	100	425.720	40
8	1	3	0.7	34	50	440.576	30
9	1	5	0.9	30	150	449.891	40
10	1	3	0.8	30	150	450.529	35

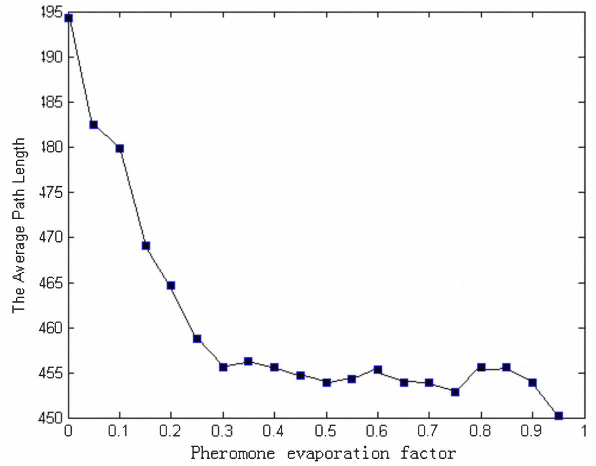

Figure 1 The relationship between average path length and ρ

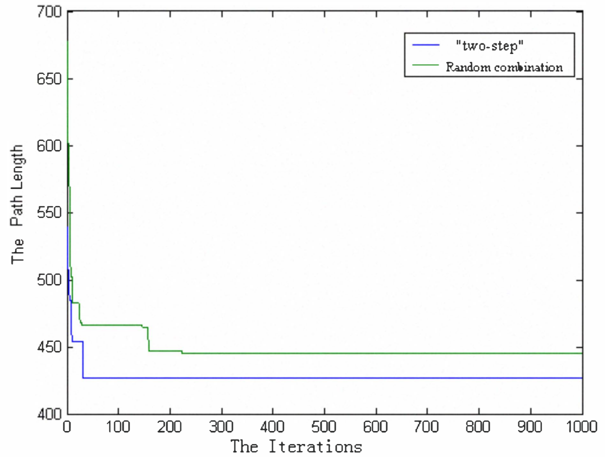

Figure 2 Two groups for optimal results of convergence tendency

The convergence tendency of the optimal path in two groups was in figure 2.We can see from table2,different values of each parameter on the performance can influent the algorithm, reasonable interval within the parameters of random combination does not make the best performance of the algorithm. We can see from table3 that the best combination of various parameter values are the experience of the values for each parameter were closer but there exist time. Compared tables2 with table3,we can conclude that using "two-step" can improve the performance of the algorithm. Both time and optimal solution are better than results of the random combination, figure 2 is the two results in contrast to the optimal parameter combination of ant colony algorithm for solving the path time. Compared table 2 with table 3,we can conclude that seven rows optimal result value(425.720) is better than TSP officials announced by optimal results, we can conclude that using “two-step” can improve the performance of the algorithm. Both time and optimal solution are better than the results of random combination.

Especially the difference which algorithm spent time on relatively too large. Thus, we should be base on the actual to ascertain the value of the parameter in solving practical problems.

IV. CONCLUSION

Each parameter of ant colony algorithm has significant impact on its algorithm performance, the random combination of parameters makes the algorithm into a local optimum and takes too long time etc. To solve this problem, experiments demonstrate that the proposed strategy can obtain good searching result. It also proves that the strategy and proposed algorithm in this paper can overcome the defect of random parameter combination of the ant colony algorithm. In this paper, the strategies and algorithms have got the optimal value results. Stability has been got reasonable results, it can help enhance the usefulness and promote the application of ant colony algorithm.

REFERENCES

[1] Ding Jianli,Chen Zengqiang, Parallel Ant Colonies Optimization Algorithm Based on,Nearest Neighbor Classify Used to DynamicK-Means Cluster, Systems Engineering Theory and Practice, 2003,(9):105-110

[2] COLORM A, DORIGOM, MINIEZZO V. Distributed optimization by ant colonies[C].Proceeding of the First Europea nConference on Artificial Life.Paris France:Elsevier Publishing,191:134-142.

[3] Ding Jianli, Chen Zengqiang, Parallel Ant Colonies Optimization Algorithm Based on,Nearest Neighbor Classify Used to DynamicK-Means Cluster,Systems Engineering Theory and Practice, 2003,(9):105-110

[4] Lao Juan. Research Based on Ant colony algorithm for TSP problem of improvement strategies [J].Science Technology and Engineering.2009,9(9): 2459-2462.

[5] Zhang Yi,Liang Yanchun. Ant Colony Algorithm for Solving Optimal Selection of Parameters [J]. Application Research Of Computers, 2007,24(8):70-72.

[6] Duan Haibin,Wang Daobo.The Research of Ant Colony Algorithm theory and application progress [J].Control and Decision,2004,19(12):1322-1340.

[7] Zuo Guoming,Yu Wanjun, Ad hoc network routing algorithm based on ant colony optimization algorithm,Application Research of Computer, 2008,(25):59-61

[8] Zhang Xuemin,Zhang Hang,Research An Improved Ant Colony Algorithm of the Optimal Routing Problem,Control Theory and Applications,2009,28(6):4-7