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RESEARCH OF COMBINATORIAL OPTIMIZATION PROBLEM BASED ON GENETIC ANT COLONY ALGORITHM

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ABSTRACT

Ant colony algorithm of the traditional combinative optimization consumes a large amount of time in the process of solving the optimization, which has a tendency to partial optimization and slow convergence along with many redundant useless iterative codes and low operation efficiency. A generic optimized ant colony algorithm is thus proposed. This algorithm has the ability to fast global search of generic algorithm along with parallelism and positive feedback mechanism of ant algorithm. It determines the distribution of pheromone on the path by means of generic algorithm changing selection operators, crossover operators and mutation operators. Then ant algorithm is applied into feature selection. Supporting vector machine classifiers is used to evaluate the performance of the feedback sub-variorum. The pheromones are recombined through changing the pheromone iteration, parameter selection and increasing the local update of pheromones feature nodes. The simulation experiment shows that this algorithm can improve the accuracy effectively, speed up the convergence, improve global optimization, and promote the robustness and stability.

Keywords: *Ant Colony Algorithm, Combinatorial Optimization, Traveling Salesman Problem, Pheromones, Genetic Algorithm*

1. INTRODUCTION

In the 1990 of the 20th century, Italy scholar M.Dorig, who was inspired from the mechanism of biological evolution, Ant routing behavior by simulating the natural world, proposing a new simulated evolution of Ant Colony algorithm (Ant Colony algorithm ACA) [1,2]. Early was widely used in the traveling salesman problem (Traveling salesman problem, TSP) solution. Traveling 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.

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 (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 [3, 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

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the probability of so that they formed made up of a large number of Ant Colony collective behaviors of a positive feedback mechanism of information[6,7] . 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.

3. ALGORITHM FOR TSP PROBLEM DEFINITION AND ESTABLISHMEN

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 direc- ted grasp of nodes; E is a collection whose eleme- nts 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, traveling 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 (Hamilton) circ- uit, 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 $\tau_{ij}(0)=const$ had information pigment, $const$ is a constants, $b_i=(t)$ said t moments is located in elements of i Ant number, $m=\sum_{i=1}^{n}b_i(t)$, $tabu_k$ is taboo table, used to records k Ant by Traverse City knot points, V initial moments $tabu_k$ 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, $tabu_k$ 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. At the t moment, ants k in i urban transition j probab- ilites in select cities $P_{ij}^k(t)$:

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

Where $allowed=\{0,1,2,\cdots n-1\}-tabu_k$, α is information on inspiration factor, the relative importance of the path. β Are expectations inspired by factor, re- presents a relatively important visibility [8]. d_{ij} Re- presents the distance of the city, $\eta_{ij}(t)$ which inspired function is inversely proportional:

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

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 require make adjustments to the pheromone on each path, its expression:

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

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

$\Delta\tau_{ij}^k(t,t+1)$ 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 ρs 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[9].

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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 (Selection), 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 a regeneration (Reproduction). 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 (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. 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.

4. AN IMPROVED ALGORITH

4.1Global Pheromone in Updating Policies

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:

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

φ_k is the path of the solution corresponding to k the Ant pheromone (i,j) update on impact.

$$\Delta\tau_{ij}^k=\begin{cases}\dfrac{Q}{L_{best}} & (i,j)\in L_{best}\\ -\dfrac{Q}{L_{worst}} & (i,j)\in L_{worst}\\ 0 & \text{otherwise}\end{cases} \quad (7)$$

Q is the path to information on strength. When the completion message after update, each side of the pheromone $[\tau_{\min},\tau_{\max}]$ between limit, this avoids pheromone is too large, reduce the overall path gap on each side of the pheromone, which expanded search space of global solutions to a certain extent [10]. In a number of Ant Colony algorithm parameters, each parameter has its own practical implications. Reasonable parameter is set to improve the convergence speed of the system, enhanced search capabilities for global; effectively inhibit the premature emergence of stagnation. When there is α and β , too big or too hours adjusted formula as:

$$\alpha=\begin{cases}\kappa\alpha & \tau_{ij}(t+1)\le\tau_{ij}(t)\\ \alpha & \text{otherwise}\end{cases}$$
$$\beta=\begin{cases}\kappa\beta & \tau_{ij}(t+1)\ge\tau_{ij}(\text{t})\\ \beta & \text{otherwise}\end{cases} \quad (8)$$

k is the scaling factors. $k=\tau_{ij}(t)/\tau_{ij}(t+1)$ Through dynamic k adjustment of the scaling factors α and β can be completed to ensure the validity of the algorithm. ρ Are pheromones volatile factors, $(1-\rho)$ are residual factor pheromone. ρ is too large, the previous search and path was again selected probability increases, it will result in random and the drop in overall search capability. Once a hour, ρ increased global search capacity while reducing the rate of convergence.

4.2Adaptation Function

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

$$f(x)=\begin{cases}c_{\max}-g(x) & g(x)<c_{\max}\\ 0 & \text{otherwise}\end{cases} \quad (9)$$

$c_{\max}$ is an input or a theoretical maximum value. By adapting function on target selection and some kind of evolutionary process control function

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trans- formation in order to formulate an appropriate selection policy, evolution of hybrid Ant Colony algorithm for maximum capacity and the best search results.

Theorem1: equipment information $\tau_{ij}(t)$ global ma- ximum value $\tau_{\max}$ for $\forall \tau_{ij}$ type:

$$\lim_{t\to\infty} \tau_{ij}(t) \le \tau_{\max} = \frac{1}{\rho} g(s^{'})$$

Proof: If after each iteration, an arbitrary path isolated section of the amount of information on the (i, j) not more than $g(s^{'})$. Obviously, in the first iteration, the maximum possible amount of information for $(1-\rho)\tau_0 + g(s^{'})$; after a second iteration, is $(1-\rho)^2 \tau_0 + (1-\rho) g(s^{'}) + g(s^{'})$ followed by analogy. Therefore, due to the volatile pheromone, in the t iterations, the amount of information of the upper limit value is:

$$\tau_{ij}^{\max}(t) = (1-\rho)^t \tau_0 + \sum_{i=1}^{t} (1-\rho)^{t-i} g(s^{'})$$

Thus, when $\rho \subset (0,1)$, and will eventually converge to: $\tau_{\max} = \frac{1}{\rho} g(s^{'})$

5. AN IMPROVED ALGORITH

TSP is as a simulation object. Simulation experiments from a generic select three symmetric TSP TSPLIB instance simulation experiments. Development environment for Microsoft Windows XP, Matlab6.5, AMD2.4GHz,1G memory. Its parameter for α = 2, b = 3, ξ = 0.1, τ 0=0.1,Q=100, ants and the number of cities are equally divided, in experiments 50 times every 100 cycles, and 20 times the basic results of improved Ant Colony algorithm and algorithm of solutions for optimal solutions, the worst solution and average, Table 1 and table 2:

Table 1: Basic Experimental Results Of Ant Colony Algorithm

problem	Basic Ant Colony Algorithm		
	Optimal Solution	Worst Solution	Mean Solution
Olive30	425.703	431.071	427.611
Eil51	429.885	449.593	436.007
Eil76	552.107	568.389	562.508
CHN144	31339.1	32799.5	31785.6

Table2: Experimental Results Of This Algorithm

problem	Improved Ant Colony Algorithm		
	Optimal Solution	Worst Solution	Mean Solution
Olive30	422.325	427.003	425.068
Eil51	426.000	429.102	428.061
Eil76	544.895	549.927	546.623
CHN144	30839.3	31331.3	31158.7

Through table 1 and table 2 comparisons of experimental results, are this worst value must be less than the basic algorithm of Ant Colony algorithm for the optimal value. 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 comp- arsons' with this algorithm on CHN144 experiment, conducted 50 comparison, corresponding to the optimal solution convergence curve, as shown in Figure 1

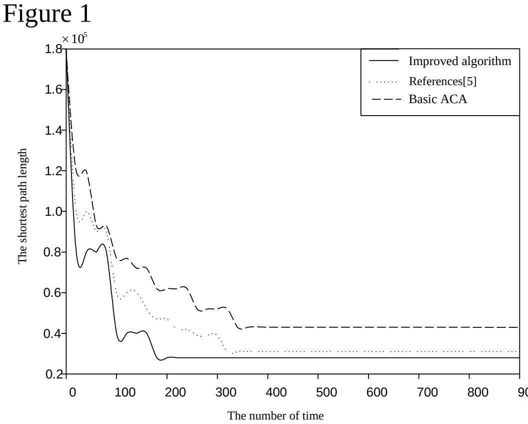

Figure1: Shortest Paths Curve Comparison Chart

Fig 2 and 3 were given Olive30TSP improved algorithm the best solutions and the most bad solution evolution curve. The simulation results can be obtained, the improved algorithm can make the global search ability, accelerate the convergence rate, prevent premature fall into local optimal solution.

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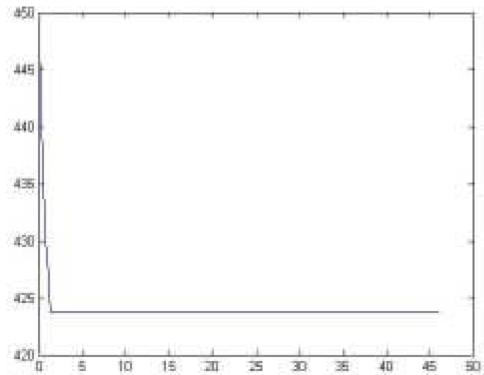

Figure 2: The Improved Ant Colony Algorithm Optimal Solutions Of The Evolution Curve

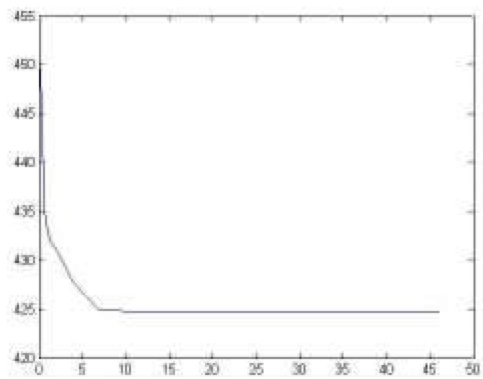

Figure 3: The Improved Ant Colony Algorithm For The Worst Solution Evolution Curve

6. CONCLUSION

In this paper, we focus on the application of feature selection for the genetic colony algorithm solving optimization problems, and give the behavior feature selection for genetic ant colony algorithm optimization process. At the same time, improve the limitation of the basic ant colony algorithm. Use the heuristic function, Information update strategy and crossover and selection strategy optimize the solution, inhibit premature convergence phenomenon to a certain degree, improve the capacity of global optimum, avoid the local optimal solution effectively, speed up the convergence rate. Finally, through TSP Simulation experiment, verify the feasibility and validity of the algorithm. How to select parameter effectively and reduce the complexity of the algorithm will be a key issue for future research.

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