Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(5): 566-569

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

A Multi-population Immune Genetic Algorithm for Solving Multi objective TSP Problem

Wencheng Liu[1,a] and Xiaodong Huang[1,b]

[1]*College of Zhijiang, Zhejiang University of Technology, HangZhou 310024, China*

ABSTRACT

According to multi-object TSP problem subject to mathematical model and multi-population immune genetic algorithm (IGA). In this algorithm, the antibody inhibition are proposed to enhance the diversity of the population. And the thinking in multi-population evolutionary which ensures the independence of evolutionary process and extending the solution space. Simulation results show that IGA is effective effectively jump out of local convergence and obtain satisfactory results.

Key words: Immune Genetic Algorithm, TSP Model, Antibody Inhibition, Local Search

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INTRODUCTION

TSP (Traveling Salesman Problem, TSP) is a classic NP problem in the field of combinatorial optimization. how to find a way which is the shortest path from one city after city and back to the starting city is very difficult. It's very important to research TSP problem for solving vehicle scheduling, logistics and other practical issues. The multi-objective TSP problem which is the traditional TSP problems extend and expand. And not only consider one goal for the shortest path, but also consider that the trip may travel time, travel costs and other targets have special requirements, because of it's will affecting the right path decisions in practical.

TSP problem as a classical NP-hard, we studied it by exact algorithms and heuristic algorithms. exact algorithms including dynamic programming, branch and bound method [1-2]; heuristic algorithms including genetic algorithm, immune algorithm, ant colony algorithm, simulated annealing algorithm. scholars mainly uses heuristic algorithm [3-4], and made some achievements in traditional TSP problem research. However, with further research, it was discovered that the traditional TSP problem has certain limitations, multi-objective TSP problems began to conduct research, the main use of ant colony algorithm, genetic algorithm, immune algorithm [5-6] evolutionary algorithm to solve it. But a single evolutionary algorithm has its own advantages and disadvantages, making the algorithm easy to fall into local optimum embarrassment, a variety of evolutionary algorithms combine each other to form a cross-cutting of the new algorithm, is the main research directions.

This article will immune algorithm and genetic algorithm combined with each other, a new non-single populations immune genetic algorithm (IGA), for multi-objective TSP (MOTSP) mathematical model, the paper in a variety of groups based on the evolution of a new local search algorithm to accelerate the convergence speed, and the use of antibody inhibits, to ensure the diversity of population. Experimental results show that the algorithm can effectively overcome the local convergence, fast to obtain the optimal solution.

MOTSP MODEL

On MOTSP description of the problem as follows: For the existence of N cities, between any two cities have a variety of indicators, specific indicators can be distance, cost, time, safety factor and other attributes, the traveling salesman needs to be done is to find a path from a departure cities through all cities and returned to the starting city path. And to ensure to the extent possible, all the properties of this path is optimal or near optimal.

In this paper, the language of graph theory, the mathematical model for MOTSP description: Let $G=(V,E)$ is the weighted graph, $V=1,2,\cdots N$ is the vertex set, E is the set of edges, the distance between the cities denoted d_{ij} ,between the each city go and back the cost denoted c_{ij} . In the distance and cost consider only the case of these two goals, MOTSP mathematical model is:

Min $Y = w_1 f_1(x) + w_2 f_2(x)$ (1)

Including:

$$f_1(x) = \sum_{i \neq j} d_{ij} x_{ij} \qquad (2)$$

$$f_2(x) = \sum_{i \neq j} c_{ij} x_{ij} \qquad (3)$$

ST:

$$x_{ij} = \begin{cases} 1 & i,j \quad in \quad the \quad solution \\ 0 & other \end{cases} \qquad (4)$$

$$\sum_{i \neq j} x_{ij} = 1 \ , \ i \in v \qquad (5)$$

$$\sum_{i \neq j} x_{ij} = 1 \ , j \in v \qquad (6)$$

$$\sum_{\substack{i \in v \\ i \neq l}} \sum_{\substack{j \in v \\ i \neq j}} x_{ij} \leq |S| - 1 \ , \ S \in v \qquad (7)$$

The above Eq.1 represents the total objective function, w_1 and w_2 respectively $f_1(x)$ and $f_2(x)$ for the weight coefficient, the traveling salesman measure the proportion in practical;Eq.2 is the distance of the objective function;Eq.3 represented the cost of the objective function; with Eq.4, when $x_{ij} = 1$,it's means that traveling salesman from i city to j city through this path, then $x_{ij} = 0$, that does not go through the trail; Eq.5 and Eq.6 ensure that each city has only be accessed once; Eq.7 to ensure that the path will not occur in sub-loop.

ALGORITHM DESIGN

Artificial immune algorithm inspired by the biological immune system, which design simple and convergence faster of optimization algorithms. Genetic algorithm is biological evolution by natural selection and genetic mechanism, which has the design of a good ability of global optimization, but by the slow convergence and convergence of poor performance limitations. This paper will combine artificial immune algorithm with genetic algorithm, and play their advantages each other of the algorithm, the algorithm process shown in Fig 1.

Algorithm is as follows:

Step one: The antibody population is initialized, the initial population size is MP .
Step two: Calculation of the fitness values in antibody population.
Step three: According to the fitness value in antibody population, calculate the affinity of the antibody, and the antibody population are divided into M sub-antibody population.
Step four: Each antibody population cloning, crossover and mutation operation.
Step Five: Antibody population for local search.
Step Six: Whether antibodies in the antibody population exceeds the threshold, if the quantity exceeds the threshold, perform antibody inhibits operation; if not exceeded, the updated population into operation.
Step Seven: Whether the termination condition is satisfied, if satisfied, then the end of the calculation; if satisfied, go

to step three.

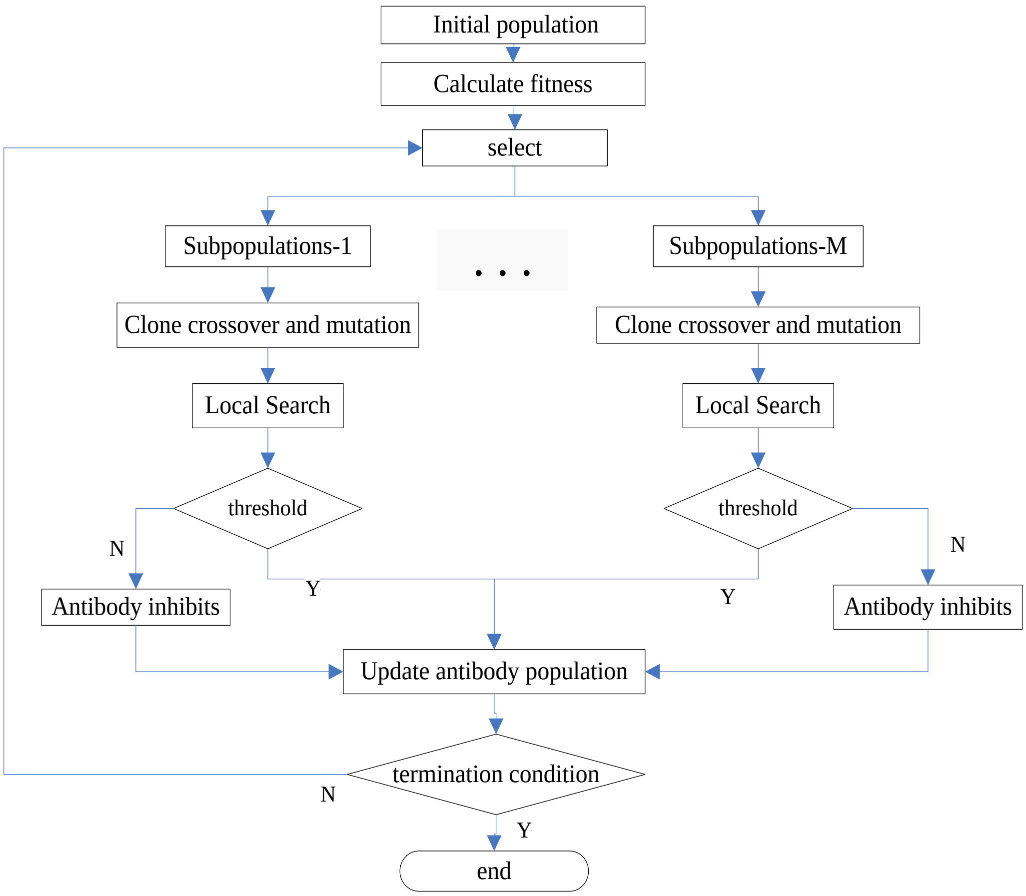

Fig 1 Multi-population immune genetic algorithm

how to ensure the antibody cross correctness in this article which is problem need to solved. This paper used way which is partially matched crossover for the antibody. Specific steps are: 1, selected two point randomly for antibodies A and B; 2, A, B exchange in the middle of two intersecting points; 3, generated after the exchange of the same portion of gene bit mapped replacement. Here in 10 cities antibody as an example:

Antibody A(8 2 3 6 4 7 5 1 10 9)

Antibody B(5 6 3 4 8 1 9 2 7 10)

Step one: randomly selected point of intersection of the selected hypothesis 3 and 7.

Step two: the antibody cross, the antibodies after cross:

A' (8 2 3 4 8 1 5 1 10 9)

B'(5 6 3 6 4 7 9 2 7 10)

Step Three: produced in the same part of the mapping process, where the mapping of $6 \leftrightarrow 4, 4 \leftrightarrow 8, 7 \leftrightarrow 1$, the new antibody is:

A' (6 2 3 4 8 1 5 7 10 9)

B'(5 8 3 6 4 7 9 2 1 10)

Local search algorithm is mainly local optimization to improve the overall performance of the algorithm. According to DOTSP problem, this paper proposes a new local search algorithm is as follows:

Step one: for any antibody ($a_1 a_2 \cdots a_n$), search in which the optimal gene segments in 10 cities as an example here is assumed that the optimal gene segment is ($a_2 a_3$);Step two: the remaining genes were divided into a number of gene segments randomly, assuming that the remaining eight cities is divided into four sections; Step three: random insertion point and inserted into the optimal antibody gene segments, will get new sub-antibodies, assuming random point 2, the sub-antibodies ($a_1a_4 \quad a_5a_6 \quad a_2a_3 \quad a_7a_8 \quad a_9a_{10}$);Step Four: Calculate the fitness of sub antibodies, if better than the parent antibody, is retained; otherwise abandoned. Return to step three, until find a good antibody, or termination condition is satisfied.

EXPERIMENTAL ANALYSIS

This paper write algorithms which using C + + language in the C + + Builder software environment. And the computer's model is founder M580 and the operating system is Windows XP. The matrix which using simulation experiments in the instance of in the literature [6].

$$D = \begin{Bmatrix} \infty & 81 & 72 & 55 & 81 & 3 \\ 81 & \infty & 3 & 44 & 9 & 40 \\ 72 & 3 & \infty & 87 & 77 & 21 \\ 55 & 44 & 87 & \infty & 67 & 25 \\ 81 & 9 & 77 & 67 & \infty & 93 \\ 3 & 40 & 21 & 25 & 93 & \infty \end{Bmatrix} \qquad C = \begin{Bmatrix} \infty & 82 & 14 & 14 & 43 & 47 \\ 82 & \infty & 61 & 76 & 29 & 47 \\ 14 & 61 & \infty & 29 & 31 & 51 \\ 14 & 76 & 29 & \infty & 78 & 67 \\ 43 & 29 & 31 & 78 & \infty & 28 \\ 47 & 47 & 51 & 67 & 28 & \infty \end{Bmatrix}$$

Consider the first case, that is only consider the distance as the main target, so the cost overhead of weight coefficient (w_1, w_2) = (1,0). Results is ($1 \quad 6 \quad 3 \quad 2 \quad 5 \quad 4$), the distance length is 158.Then consider the second case, the distance and the cost is the same importance, weight coefficient (w_1, w_2) = (1,1). Results is ($3 \quad 2 \quad 5 \quad 4 \quad 1 \quad 6$), distance and cost were 158,280.Finally consider the third case, the cost is more importance than the distance, the weight coefficient (w_1, w_2) = (1,2). Results is ($2 \quad 5 \quad 3 \quad 4 \quad 1 \quad 6$), distance and cost were 271,197.

From the above simulation results, in the first and second case, the algorithm can guarantee that choose the shortest path between cities most of the time, and selected sub-optimal paths in the remaining cities. In the third case, only part of the distance increases, but a significant reduction in costs. Simulation acquire satisfactory results.

CONCLUSION

In this paper, According to multi-objective TSP problem object to mathematical model, and immune genetic algorithm. The simulation results show that to obtain satisfactory results. But this is only for small-scale simulation data, It will efforts for large-scale problems, and improve IGA in parallel computing from the perspective of reducing the running time algorithm, and improve the overall performance of the algorithm.

Acknowledgments

The authors wish to thank the Natural Science Foundation of Zhejiang University of Technology for contract 2013XY015, under which the present work was possible.

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