

Traveling Salesman Problem Solving Based on Hybrid Particle Swarm Optimization Algorithm

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Abstract. Genetic algorithms all the methods used to solve the Traveling Agent (TSP) problem, the use of genetic algorithms on TSP problems is more common than other methods, and it is also possible to achieve global search and obtain the best values. Compared with the traditional genetic algorithm, the particle swarm algorithm is not only easy to be applied, but also can be widely used because of the function of rapid search, but at the same time, the shortcomings of the traditional standard particle swarm algorithm are more prominent, and it is easy to fall into the situation of optimal solution of local problems. So first of all, we use the classical TSP algorithm to propose a mixed particle swarm algorithm, which solves the TSP problem by using the selection, crossover, variation and other operators of the traditional genetic algorithm, and through the conclusion of the solution, it can be shown that the method not only greatly improves the search function of the traditional standard particle swarm, but also greatly improves the convergence speed while obtaining the approximate optimal solution.

Keywords: hybrid particle swarm optimization algorithm; genetic algorithm; particle swarm optimization algorithm; TSP.

1. Introduction

The traveling salesman problem (TSP), also known as the salesman problem, is a basic path problem. The TSP problem can be expressed as follows: the distance between cities in n countries is known, a salesman leaves from one country to another country once and only once, and then returns to the country of departure, how to choose the travel route as the shortest distance. The mathematical model of the travelling salesman problem was first proposed by Dantzig (1959) et al. The TSP problem is a classic example of a problem that belongs to the vehicle routing problem (VRP) and confirms that the travelling salesman problem also belongs to the NP puzzle.

The solution method for the TSP problem mainly consists of exact algorithms for obtaining the optimal solution to obtain an approximation algorithm that is most similar to the solution. The exact algorithms include methods such as dynamic programming, full enumeration and global search algorithms. The exact computational work on TSP problems is often exponentially complex and cannot be satisfied with the large number of research examples, and due to the growing understanding of TSP problems, research on exact computation is becoming less and less available. In recent years, people have been inspired by nature, and various new generation of artificial intelligence computing techniques have been created, such as ant colony optimisation computing, genetic algorithms, artificial neural networks, artificial immune networks, and computational methods such as particle swarm optimisation. Intelligent optimisation methods have brought a new approach to TSP problems and are therefore commonly used to solve a variety of NP problems. Although the best solution to a problem is often not guaranteed, it is often possible to obtain a more satisfactory solution in a reasonable time when the scope of the problem is large. In real life, many problems are TSP problems, for example, the postal route problem, the screw problem on an assembly line, or even the production assembly problem of a product are all travelling merchant problems in life, not only that, but TSP problems have important applications in circuit board drilling timing, genetic testing and robot monitoring. So, not only in theory but also in practice, the solution of the TSP problem has great significance for human life and production.

A large number of methods have been proposed by many researchers to improve particle swarm optimisation algorithms. Among them, the application of genetic algorithms can make use of

crossover operators to enhance the information exchange between particles, thus increasing the diversity of the population, adjusting the individual optimality and optimal situation of the population, and freeing the operators from defects. Local optimisation and ultimately global optimisation are obtained. Kennedy et al. [2] first proposed a discrete binary version of the particle swarm optimisation algorithm; Clerc [3] redefined the velocity, position and associated operations of the particles and proposed a discrete particle swarm optimisation algorithm to solve the TSP problem, but its performance still has a large gap compared with other algorithms. Shang Gao et al. Gao Shang et al. [4] added the idea of genetic algorithm to the particle swarm optimisation algorithm and constructed a hybrid algorithm; Hendlass et al. Hendlass et al. [5] successfully computed a small-scale TSP problem using the discrete particle swarm optimisation algorithm by adding the memory function of each particle; Deng et al. [6] introduced the concepts of "commutator" and "commutator order", and gave a new particle swarm optimization algorithm for solving TSP, which provided a new idea for solving TSP problems. Cheng Bi Yun et al. [7] proposed a local search chaotic discrete particle swarm optimization algorithm (ILCDPSO) based on excellent coefficients and applied it to the solution of the TSP problem. The results show that the algorithm can perform global search and converge quickly. Zhang Jiangwei et al. [8] proposed an adaptive hybrid particle swarm optimisation algorithm that introduces a variational operator and uses the mechanism of evolutionary process information to reduce the size of the problem. Yu Liangliang et al. [9] used the powerful global search capability of genetic algorithm to optimise the solutions obtained by the particle swarm optimisation algorithm, and used the elimination of cross paths to optimise the global optimal path, thus further improving the performance of the hybrid algorithm. Shen Jihong et al. [10] introduced swappers, swapping sequences and chaotic sequences, and proposed a new hybrid intelligent optimization algorithm which exploits the advantages of optical optimization algorithm, an optical chaotic particle swarm optimization algorithm for the travel quotient problem. Liu Boying et al. [11] introduced the basic particle swarm optimization algorithm and analysed the performance of the particle swarm optimization algorithm in the application of the classical traveler problem and the relevant operations of the particle swarm optimization algorithm in solving the traveler problem. Wang Dong et al. [12] combined particle swarm optimisation with local search methods, which not only improved the convergence speed of particle swarm optimisation, but also suppressed premature convergence of particle swarm optimisation. Cai Rongying et al. [13] proposed a particle swarm optimisation algorithm with a self-learning operator based on the characteristics of the travelling quotient problem and discrete quantity operations, defining the variational speed to maintain the diversity of the particle swarm, so that the algorithm can achieve a better balance between spatial exploration and local refinement. Pang Wei et al. [14] used fuzzy matrices to study the displacement and velocity of particles and redefined their optimisation method. It was experimentally demonstrated that the operator could achieve better results.

In this paper, based on the reading of relevant literature and the basic theory of particle swarm algorithm, a hybrid particle swarm algorithm based on the idea of genetic algorithm is proposed to solve the TSP problem [15].

2. Overview of the basic algorithm

2.1 Overview of genetic algorithms

The components of a genetic algorithm include the following: (1) chromosomal coding method: symbolic coding is mainly used for the travel quotient problem; (2) individual fitness evaluation: the fitness of individuals is assessed using a fitness function; (3) genetic operators: selection operators, crossover operations, variation operations; (3) basic operational parameters: population size, crossover probability, variation probability, etc.

2.2 Particle swarm optimization algorithm

Particle Swarm Optimization (PSO) is a population-based evolutionary method that solves a widely studied optimization problem for each particle in the ensemble space. PSO is widely used for its fast retrieval capability and easy parameter setting. However, it also faces the difficulties of poor global retrieval, easy access to local optimisation, and possible decline in population diversity in the later stages of the algorithm.

2.3 Improved hybrid particle swarm algorithm based on the principle of genetic algorithm

In the standard particle swarm algorithm, individuals update their acceleration direction according to their historical optimality and the population's historical optimality, making the individuals in the population increasingly concentrated. However, the particles may wander around the local optimum solution, preventing the population from obtaining a better approximation. The hybrid particle swarm algorithm uses some of the ideas of genetic algorithms, adding crossover and variation to the evolutionary process, with particles crossing individual optima and population optima, and then searching for the optimal solution by variation. Although the particle swarm algorithm cannot completely avoid the local optimum, this method improves the global search function of the algorithm.

3. Solving TSP problems based on hybrid particle swarm algorithms

The particle swarm algorithm completes the extreme value finding result by following the individual extreme value and the population extreme value, which is not only easy to operate and run, but also has a fast convergence speed, but with the gradual increase in the number of iterations of the operation, the particles will become more and more similar to each other in the process of convergence concentration of the population, which may eventually lead to the situation that the algorithm cannot jump out of the local optimal solution. In this paper, the hybrid particle swarm algorithm constructed on the basis of the traditional algorithm discards the use of tracking polar values to update the particle positions, and instead uses the operation of crossover and variation in the introduction of genetic algorithms, while the search for the optimal solution of the TSP problem utilizes the crossover of particles, individual and population polar values, and the method of the particles' own variation.

The flow of the TSP algorithm based on the hybrid particle swarm algorithm is shown in Figure 1.

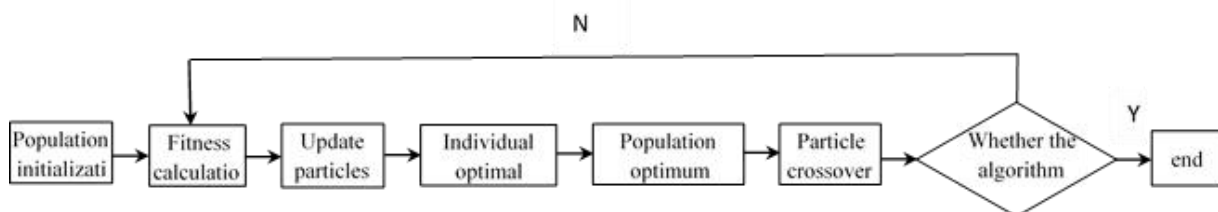


Fig1 Algorithm flow chart

The particle population is initialised by the population initialisation module; the fitness value of the individual particles is calculated based on the fitness value; in the update particle module, the optimal particles of the population and the optimal particles of the individuals are updated based on the fitness value of the particles; in the individual optimal crossover process, the new particles are obtained by crossing the optimal particles within the individuals; in the population optimal crossover process, the individuals are crossed with the optimal particles of the population to obtain new particles; and in the particle variation process, new particles are obtained based on the changes of the particles.

3.1 Algorithm implementation

3.1.1 Individual encoding

The city traversal method on the TSP problem can be presented through particles. In this paper, integers are used to correspond to each city, and then the specifics of the traversal method for all cities can be expressed using encoded positions. For example, when the number of cities with a calendar of 10 is coded as [5 7 4 6 10 1 8 3 2 9], then the city traversal starts from 5, goes through 7, 4, 6, 10, 1, 8, 3, 2, 9 and finally returns to 5, thus achieving a traversal of all cities.

3.1.2 Adaptation values

The particle fitness value is expressed as the length of the traversal path and is calculated as

$$fitness(i) = \sum_{i,j=1}^n path_{i,j} \quad (1)$$

3.1.3 Crossover operations

Individuals are updated by crossover with individual extremes and population extremes, this paper using the integer crossover method as the crossover method[16]. The integer crossover method not only ensures the independent nature of the particles to a certain extent, but also ensures that the scheme reflected by the particles is feasible at the same time. If, after the crossover is performed, a duplication of locations occurs, the city in which the original duplication of locations occurred is replaced with a city number that is not already included in the other individuals. The specific operation can be summarised as follows: first, the selection of the two crossover positions, and then crossover the individual and the individual extremum or the individual and the population extremum, with the crossover positions chosen randomly. If the assumed crossover positions are 3 and 5, the operation is as follows: crossover the individual: [9 4 2 1 3 7 6 10 8 5] with the extremum: [9 2 1 6 3 7 4 10 8 5] to obtain a new individual: [9 4 1 6 3 7 6 10 8 5].

If there are duplicate positions in the resulting new individual, it is necessary to adjust it by replacing the city where the duplicate position originally occurred with a city number that is not already included in other individuals, e.g. [9 4 1 6 3 7 6 10 8 5] can be adjusted to [9 4 2 1 3 7 6 10 8 5].

Finally, the strategy of retaining good individuals is used to keep the new individuals obtained and the operation of updating the particles is performed when and only when the new particles have better fitness values than the old ones.

3.1.4 Variation operation

In this paper, a mutation method with two-digit interchange within individuals, and the mutation to implement other different traversal methods were adopted, which increasing the diversity of traversal methods. The update process can be completed when the mutated particle is better adapted than the original particle, otherwise the original particle state will be maintained. Firstly, two mutation positions are randomly selected and then the two mutation positions are swapped. Assuming that the mutation positions selected are 2 and 4, the mutation operation is shown below: [9 4 2 1 3 7 6 10 8 5] mutates to [9 1 2 4 3 7 6 10 8 5].

Finally, the strategy of retaining good individuals is used to keep the new individuals obtained, and the particles are updated only when the new particles have better fitness values than the old ones.

3.2 Simulation results

Based on the principle of hybrid particle swarm algorithm, the TSP hybrid particle swarm search algorithm based on hybrid particle swarm is written on MATLAB. The city distribution map is shown in Figure 2. the population size of the hybrid particle swarm algorithm is set to 1000 and the number of evolutions is set to 200. the final resulting planning paths selected through the hybrid

particle swarm algorithm are shown in Figure 4. it can be seen from Figures 3 and 4 that the optimal paths between different cities can be searched for more quickly through the hybrid particle swarm approach.

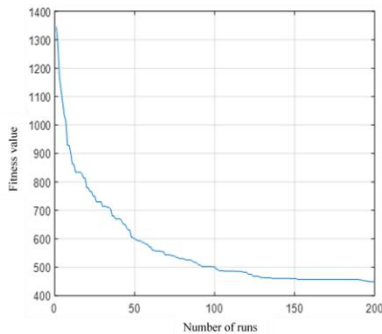


Fig 2 Urban Distribution Map

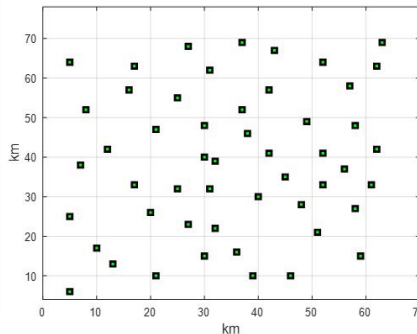


Fig3 Change of fitness value

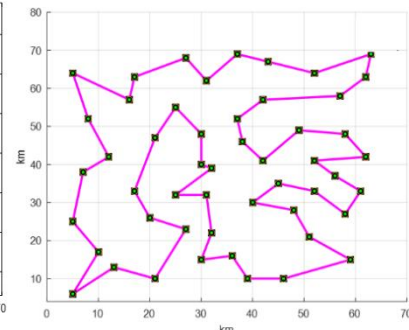


Fig4 Optimal path map

4. Conclusion

Of all the methods used to solve the traveling salesman problem (TSP), genetic algorithms are more commonly used in TSP problems than others, and can be used to achieve global search and optimal values. Particle swarm algorithms are not only easier to apply than traditional genetic algorithms, but they are also widely used due to their fast search capabilities, although the traditional standard particle swarm algorithms are notorious for their drawbacks and face the problem of easily falling into local problem optimality. This method solves the TSP problem by using the selection, crossover and mutation operators of the traditional genetic algorithm, and by the conclusion of the solution, it can be shown that the method not only improves the finding function of the traditional standard particle swarm, but also obtains a near-optimal solution while greatly improving the convergence speed. The hybrid particle swarm algorithm is also able to obtain better paths for large scales traveler.

Reference

- [1] Wang Jianwen,Dai Guangming,Xie Baiqiao,Zhang Quanyuan.A Survey of Algorithms for Solving TSP Problems[J].Computer Engineering and Science,2008(02):72-74+155.
- [2] Kennedy J, Eberhart R C. A discrete binary version of the particle swarm algorithm[C]//1997 IEEE International conference on systems, man, and cybernetics. Computational cybernetics and simulation. IEEE, 1997, 5: 4104-4108.
- [3] Clerc M. Discrete particle swarm optimization, illustrated by the traveling salesman problem[M]//New optimization techniques in engineering. Springer, Berlin, Heidelberg, 2004: 219-239.
- [4] Gao Shang,Han Bin,Wu Xiaojun,Yang Jingyu .Hybrid particle swarm optimization algorithm for traveling salesman problem[J].Control and decision-making,2004(11):1286-1289.
- [5] Hendtlass T. Preserving diversity in particle swarm optimisation[C]//International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems. Springer, Berlin, Heidelberg, 2003: 31-40.
- [6] Deng Y, Liu Y, Zhou D. An improved genetic algorithm with initial population strategy for symmetric TSP[J]. Mathematical Problems in Engineering, 2015, 2015.
- [7] Cheng Biyun,Lu Haiyan,Xu Xiangping,Shen Guanqiang.Improved local search chaotic discrete particle swarm optimization algorithm for traveling salesman problem[J].Computer application,2016,36(01):138-142+149.
- [8] Zhang Jiangwei.Adaptive hybrid particle swarm optimization algorithm for large-scale traveling salesman problem[J].Computer Application and Software,2015,32(12):265-269.

- [9] Yu Liangliang,Wang Wanliang,Jie Jing.Traveling Salesman Problem Based on Hybrid Particle Swarm Optimization Algorithm[J].Computer Engineering,2010,36(11):183-184+187.
- [10] Shen Jihong,Wang Kan.Hybrid particle swarm optimization algorithm for traveling salesman problem[J].Journal of Intelligent Systems,2012,7(02):174-182.
- [11] Liu Boying,Wu Jingsong,Tan Tiechun,Li Shijie.Discrete particle swarm optimization algorithm for traveling salesman problem[J].Computer Engineering and Science,2008(10):64-66.
- [12] Wang Dong,wu xiangbin,mao xiancheng,liu wenjian. — Improved hybrid particle swarm optimization algorithm for TSP[J].Computer Engineering,2008(06):185-187.
- [13] Cai Rongying,Li Lishan,Lin Xiaoyu,Zhong Yiwen. Self-learning particle swarm optimization algorithm for traveling salesman problem[J].Computer Engineering and Design,2007(02):261-263+266.
- [14] Pang wei,Wang Kangping,Zhou Chunguang,Huag lan,Ji xiaohui.Fuzzy discrete particle swarm optimization algorithm for traveling salesman problem[J].Minicomputer system,2005(08):1331-1334.
- [15] Wang Chong,Li jun,Li bo,Zhang yue.Improved hybrid algorithm of ant colony optimization and particle swarm optimization for traveling salesman problem[J].computer simulation,2016,33(11):274-279.
- [16] Wang chao,Jin chun ,Han Qingping.Kruskal like hybrid particle swarm optimization algorithm for traveling salesman problem[J].Operations Research and Management,2014,23(03):30-37.