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# Comparative Study on Adjustable Parameter Interface of TSP based on Ant Colony Algorithm and Particle Swarm Algorithm

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## Abstract

**With the continuous development of intelligent algorithms, new algorithms emerge one after another, each has its own advantages and disadvantages. At the same time, the performance comparison of different algorithms has become an important work to test the algorithm. In this paper, the problem of travel agent (TSP) is studied by using the visualization and operability of GUI in MATLAB. The simulation of the interface of adjustable parameters is carried out for ant colony algorithm and particle swarm algorithm respectively. Through the running program, it can be concluded that ant colony algorithm has positive feedback of pheromone, particle swarm optimization has fast and global convergence, and the advantages of both can be complementary.**

## Keywords

**TSP Problem; Ant Colony Algorithm; Particle Swarm Algorithm; Adjustable Parameter Interfacee.**

## 1. Traveling salesman problem

Traveling salesman problem (TSP) is a typical combinatorial optimization problem, which can be understood as a traveling salesman visiting $n$ cities, the requirement is that each city can only visit once, and finally return to the original city [1]. If we use exhaustive search algorithm, we need to consider all possible paths, find out all the paths, and then compare all the paths to find the best path. An effective path can be regarded as an arrangement of $n$ city, and $n$ city has $n!$ arrangements [2]. The two paths in opposite order have the same itinerary, but for an arrangement, it is OK to start from any city. So the number of schemes with effective paths is $R_n = \frac{n!}{2n}$. It can be seen that the number of path schemes increases sharply with the increase of $n$, and the computation time of exhaustive algorithm increases exponentially with the increase of $n$. When the number of cities increases to a certain extent, the amount of calculation will also increase to an unimaginable level.

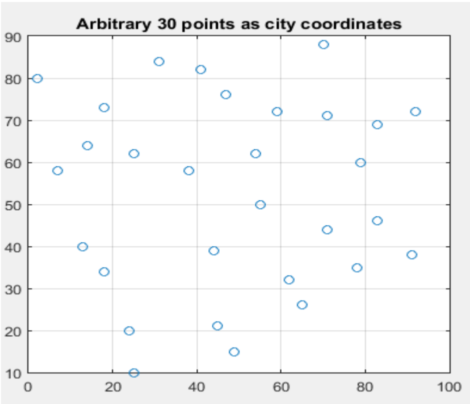


Figure 1. Arbitrary 30 points as city coordinates

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The mathematical description of TSP problem can be understood as: given the distance between *n* cities, a travel agent starts from a city, visits each city once and can only arrive once, and finally returns to the departure city, how to arrange the shortest route. That is to say, to find a shortest path to traverse $n$ cities, it can be described as a arrangement $\pi(X)$ ={$V_1$,$V_2$,……$V_n$} of natural subset X={1,2,……,n} (the element of *X* represents the number of *n* cities), so that $T_a = \sum_{i=1}^{n-1} d(V_i, V_{i+1}) + d(V_n, V_1)$ is the minimum value, where d ($V_i$, $V_{i+1}$) represents the distance from $V_i$ to city $V_{i+1}$, and $T_a$ is the shortest path to traverse *n* cities.

## 2. Research on the method of solving the adjustable parameter interface of TSP Based on ant colony algorithm

### 2.1 The basic principle of ant colony algorithm

Inspired by the research of real ant colony behavior in nature, ant colony algorithm is proposed. Biological research finds that a group of cooperating ants can find the shortest route between food source and ant nest, while a single ant can't. It preliminarily shows that ant cooperation is the key to find food source and ant nest. Ants will release a kind of material called pheromone in the process of its movement [3]. Ants complete the transmission of information between each other through pheromone, and ants can sense the concentration of pheromone in the process of movement. The higher the pheromone concentration is, the greater the probability of ants passing by, which makes the pheromone concentration on the route increase faster. Therefore, the cooperative behavior of the ant colony composed of a large number of ants can quickly find the optimal path. The phenomenon is called positive feedback phenomenon, that is, with the increase of ants on a certain route, the more likely the latecomers will choose the route. It is through this indirect communication between ants that they can search for food and the shortest route back to the nest.

Ant colony algorithm is developed based on the principle that ants cooperate with each other to find food sources and ant nests. It adopts distributed control, and there is no central control; The independent individuals of ant colony algorithm can only perceive the local information, but can not directly perceive the global information [4]. Each individual can better adapt to the environment through mutual cooperation, and can communicate indirectly through the environment. Each individual has self-organization, that is, the complex behavior of the group is the intelligence that emerges through the individual interaction process. This is a kind of probabilistic global search method, which can get more global optimal solution, and its optimization process does not depend on the strict mathematical properties of the optimization problem itself. In addition, it has potential parallelism, and the search process is carried out from multiple points at the same time. The cooperation process of distributed multi-agent is asynchronous and concurrent, which can greatly improve the efficiency and quick response ability of the whole algorithm.

### 2.2 Implementation of ant colony algorithm for TSP

In this paper, the model of TSP Based on ant colony algorithm is established. Let the number of cities be n, the total number of ants be m, the length of the path between cities i and j be $d_{ij}$ (1≤i≤n, 1 ≤j≤n, i≠j), the pheromone concentration between paths (i, j) at time t be $\tau_{ij}(t)$, and the pheromone concentration of each path at the initial time is the same, which is constant $\tau_0$.

During the movement of ant k(k=1,2,⋯,m), we use tabu list $tabu_k$ to record the cities that we have passed, and use $allowed_k$ to record the cities that we can choose to walk in the future[5]. Since each city has and can only walk once, then $allow_k = \{C - tabu_k\}$. Then, there will be residual information $\tau_{ij}(t)$ and heuristic information $\eta_{ij}$ on each path, and ants calculate the migration probability through $\tau_{ij}(t)$ and $\eta_{ij}$. In time t, the migration probability $p_{ij}^k(t)$ of ant k from city i to city j can be expressed by formula (1). Among them, the heuristic information $\eta_{ij} = 1/d_{ij}$ and $\alpha$ are the relative importance of residual information, and $\beta$ is the relative importance of heuristic information [6].

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$$p_{ij}^{k}(t)=\begin{cases}\frac{[\tau_{ij}(t)]^{\alpha}.[\eta_{ij}]^{\beta}}{\sum_{s\in allowed_k}[\tau_{is}(t)]^{\alpha}.[\eta_{is}]^{\beta}}, if.j\in alowed_k\\ 0, otherwise\end{cases} \quad (1)$$

The pheromones on each path are updated according to equations (2), (3) and (4) after each individual ant walks through all cities. In equation (2), $\rho$ is a coefficient and $(1-\rho)$ is the pheromone volatilization rate from t to t + n; In equation (3), $\Delta\tau_{ij}$ is the pheromone added on the path (i, j) in this iteration, and D is the pheromone released by the kth ant on the path (i, j) in this iteration; In equation (4), Q is a normal number, and $L_k$ is the total length of the route taken by the kth ant in the city. By comparing the path of each ant in that length to find the best route.

$$\tau_{ij}(t+n)=\rho.\tau_{ij}(t)+\Delta\tau_{ij} \quad (2)$$

$$\Delta\tau_{ij}=\sum_{k=1}^{m}\Delta\tau_{ij}^{k} \quad (3)$$

$$\Delta\tau_{ij}^{k}=\begin{cases}\frac{Q}{L_K},\\ 0, otherwise\end{cases} \quad (4)$$

The combination of parameters and the change of pheromone in ant colony algorithm will affect the development ability and exploration ability of the algorithm, thus affecting the problem solving performance. The combination of parameters and the change of pheromone can greatly improve the optimization performance of ant colony algorithm.

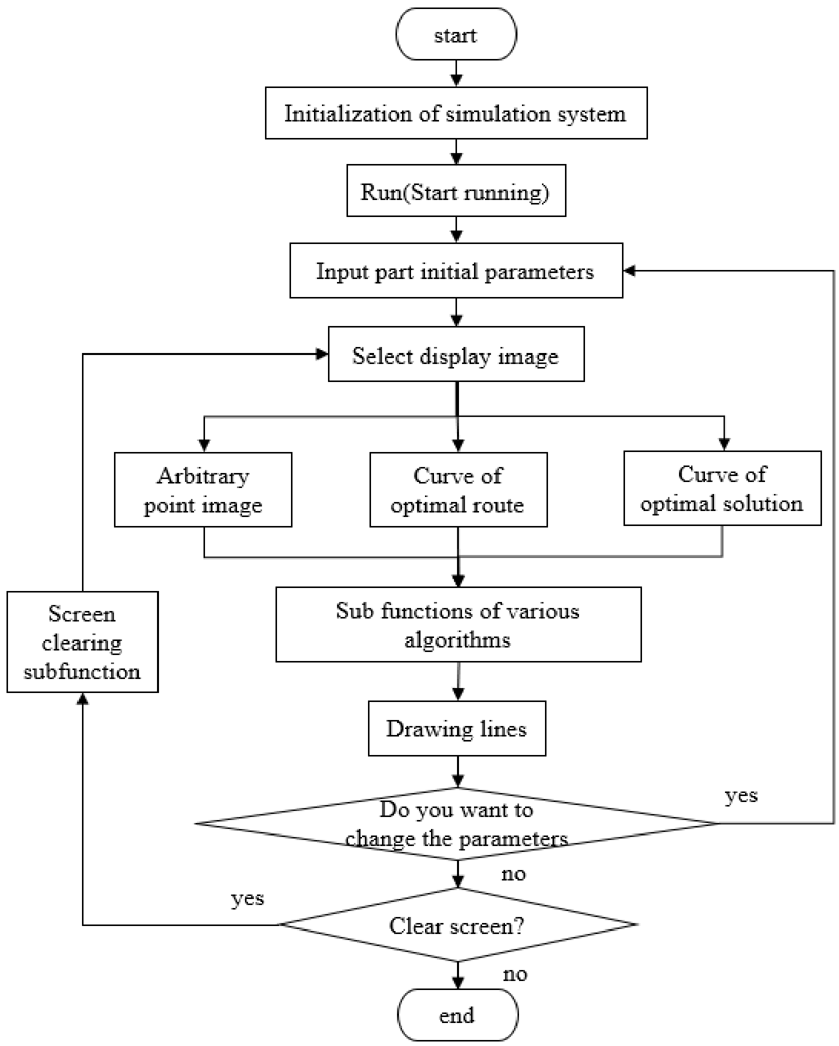


Figure 2. Flow chart of adjustable parameter interface method for TSP Based on ant colony algorithm

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This section is programmed and simulated on the MATLAB platform. In order to intuitively see the results of ant colony algorithm solving TSP problem, two graphical interfaces are compiled by using the advantages of GUI function visualization in MATLAB, which are the optimal route curve and the optimal solution curve. Through the curve, it can be clearly seen that with the increase of the iteration number, The optimal path will also continue to shorten, after a certain number of iterations to find the optimal path, based on ant colony algorithm to solve TSP problem adjustable parameter interface method flow chart is shown in Figure 2.

In MATLAB, the GUI program based on ant colony algorithm to solve TSP problem is written, which makes the result of the program run directly. The interface can draw the optimal route, iteration times and optimal solution. Before drawing, we need to take the coordinate positions of 30 cities at first, and set relevant parameters in advance, including Number of ants, Maximum number of iterations, Importance factor of pheromone, Importance factor of heuristic function, Pheromone volatilization factor and Total pheromone release. these parameters will be assigned during system initialization. In this paper, 30 urban coordinates set above are selected for simulation study in order to compare with particle swarm optimization method. At the same time, the following parameters are set: Number of ants=35, Maximum number of iterations=200, Importance factor of pheromone=1, Importance factor of heuristic function=5, Pheromone volatilization factor=0.1, Total pheromone release=1. The interface of parameters adjustable for TSP problem based on ant colony algorithm is shown in Figure 3.

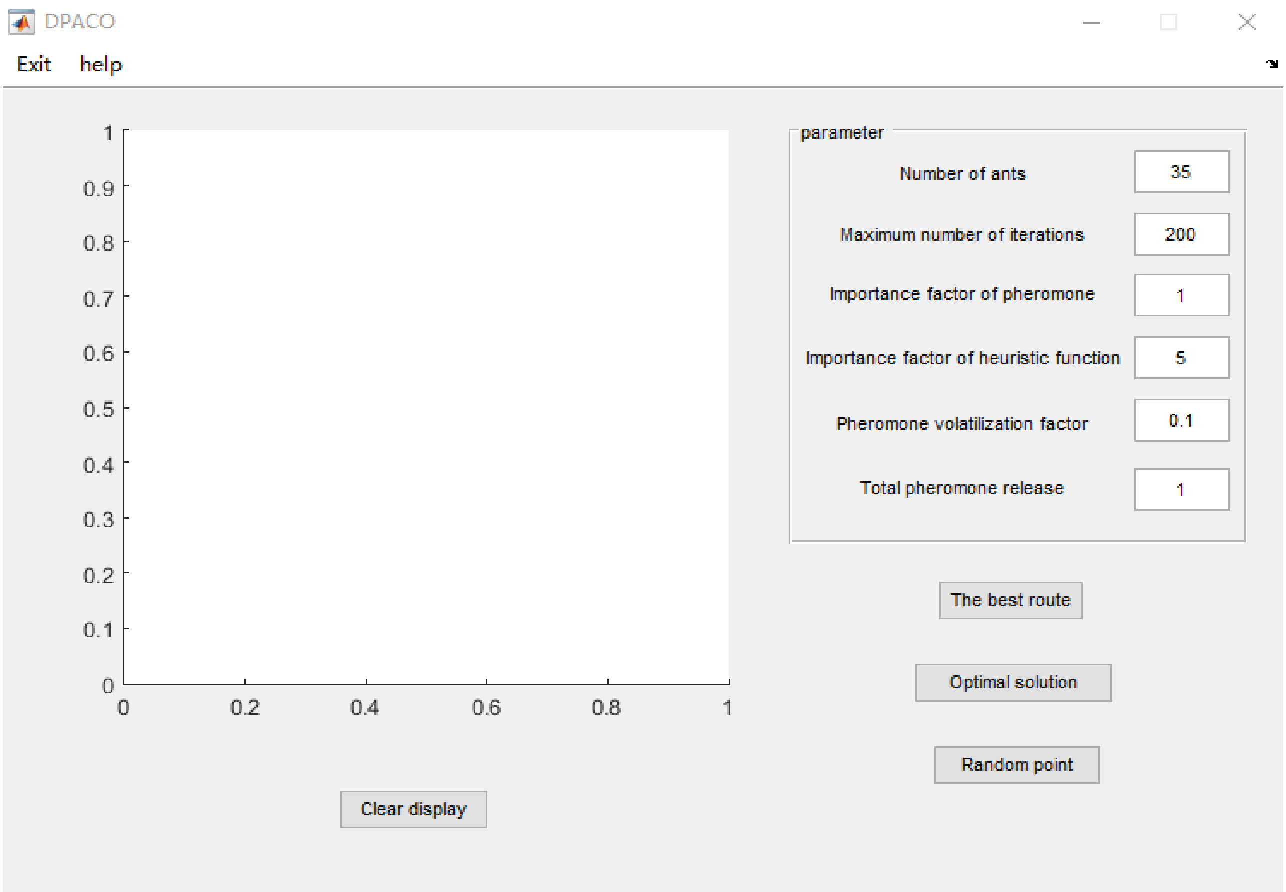
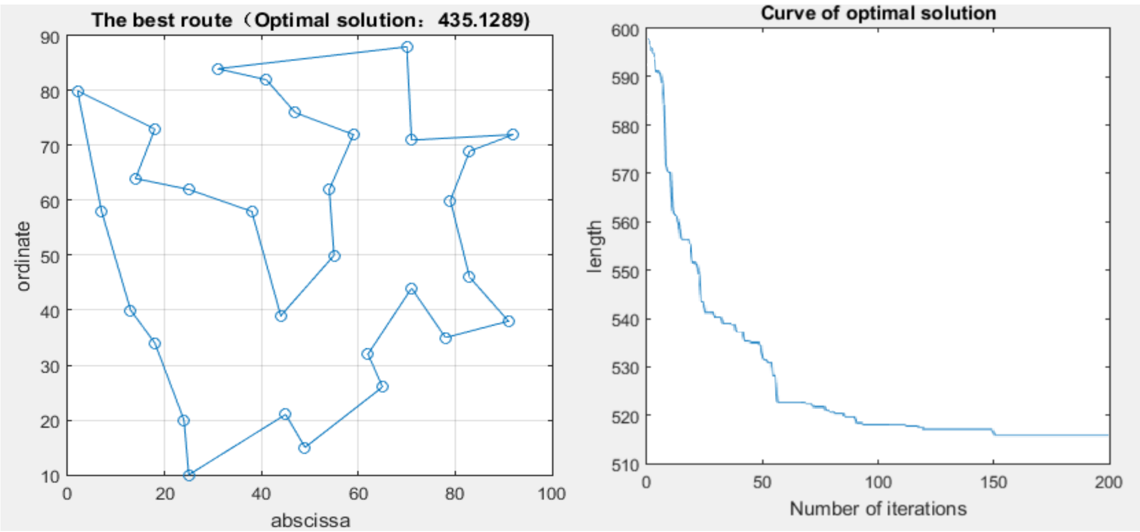



Figure 3. Adjustable parameter interface for TSP Based on ant colony algorithm

After setting the relevant initial parameters, run "The best route", "Number of iterations" and "Optimal solution" respectively to get the corresponding three images, namely the optimal route map, iteration curve and optimal solution curve under the parameters. At the same time, the drawn image can be saved through the save image command under the file menu. The optimal roadmap, iteration number curve and optimal solution curve are shown in Figure 4. (a) and (b) respectively.




(a) (b)

Figure 4. (a) Optimal route image based on ant colony algorithm. (b) The optimal solution curve of ant colony algorithm

## 3. Research on the method of solving TSP problem with adjustable parameter interface based on particle swarm optimization

### 3.1 The basic principle of particle swarm optimization

Particle swarm optimization algorithm is also inspired by the research of real bird behavior in nature. The particles in particle swarm are the birds in the foraging process [7]. When using the particle swarm optimization algorithm, the function will first determine a fitness value, which includes all the particles in this time. When running the function, each particle flies according to its own will, with its own speed and direction, and then the particles in the whole particle swarm will fly to the path of the best particles in the current swarm, for the same goal [8]. In the use of particle swarm optimization algorithm, the initial particles, also known as random solution, are first initialized, then iterated in the program, and finally the optimal solution is found. In each iteration, particles will fly towards two "extreme values": one is the individual extreme value pbest, which is found by independent particles in their own flight space, and the other is the global extreme value gbest, which is the optimal value of the whole particle population flight. In addition, the particle may find the optimal solution in a small region, then the solution is the local extremum.

Particle swarm optimization has strong robustness. It starts from multiple starting points at the same time through a group, and obtains the optimal solution through continuous iteration. Only the fitness function value transformed from the objective function value can be used to determine the further search direction and search range [9]. At the same time, the particle swarm optimization algorithm does not need to determine the transfer relationship and transfer direction [10]. The algorithm belongs to a group search method and has potential adaptability.

### 3.2 Implementation of particle swarm optimization for TSP

Particle swarm optimization algorithm first initializes all particles, initializes their velocity and position, and then finds the optimal solution through iteration. In each iteration, the fitness function value of each particle is calculated. If the current fitness function value of the particle is better than its historical optimal value, the historical optimal value will be covered by the current value; If the historical optimal value of the particle is better than the global optimal value, the global optimal value will be covered by the historical optimal value of the particle [11]. Each particle continuously updates its speed and position by tracking individual extreme value and global extreme value, such as formula (5) and formula (6). Through continuous iteration, the optimal solution is found.

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$$v_{id+1} = v_{id} + c_1 \times rand() \times (p_{id} - x_{id}) + c_2 \times rand() \times (p_{gd} - x_{id}) \quad (5)$$

$$x_{id+1} = x_{id} + x_{id} \quad (6)$$

Where: rand ()— [0,1], c1 and c2 are acceleration coefficients. In the search space, the number of particles is m, the position of the ith particle is $x_{id}$, and its flight speed is $v_{id}$. the current optimal position of the particle is $P_{id}(pbest)$, and the current optimal position of the whole particle swarm is $P_{gd}(gbest)$.

This section is programmed and simulated on the MATLAB platform. In order to intuitively see the results of TSP problem solved by particle swarm optimization algorithm, two graphical interfaces are compiled by using the advantages of GUI function visualization in MATLAB, namely the optimal route curve and optimal solution curve. The flow chart of adjustable parameter interface method for TSP problem based on particle swarm optimization algorithm is shown in Figure 5.

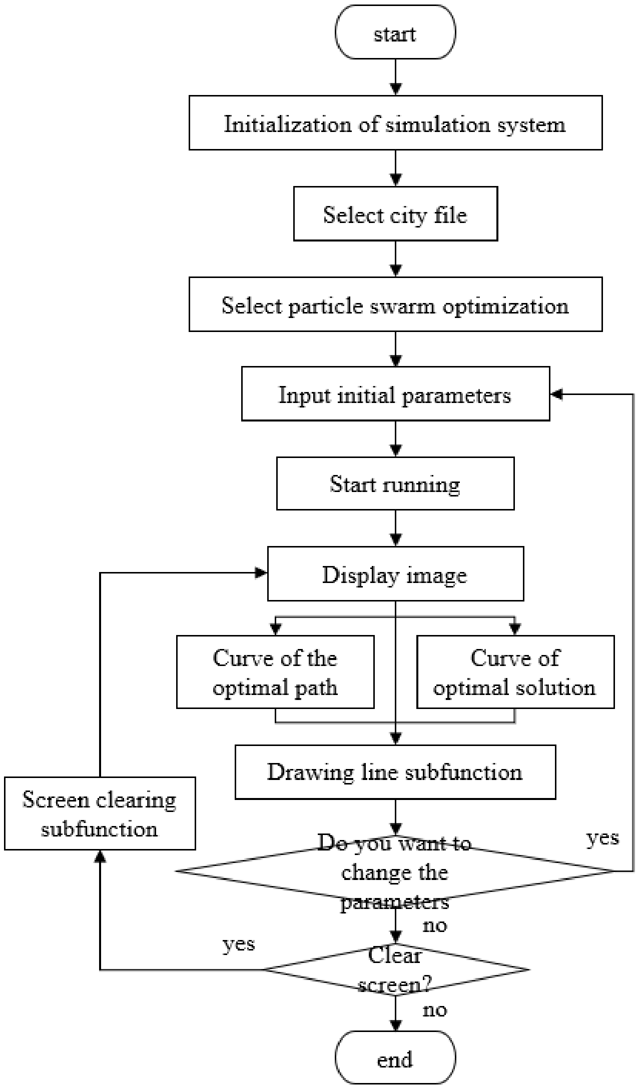


Figure 5. Flow chart of the method of solving the adjustable parameter interface of TSP Based on particle swarm optimization

The GUI program of solving TSP Based on PSO is written in MATLAB, which can draw the optimal route and solution. Before drawing, select the 30 city coordinates that have been set above for simulation research, and set other relevant parameters, including Number of particles and Number of

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iterations. These parameters will be assigned during system initialization. This time, the following parameters are set: Number of particles = 50, Number of iterations = 200.After the relevant initial parameters are set, run the program to get the optimal route map, optimal solution curve, optimal solution and optimal path under the parameters, or click Save image button to save the drawn image. The adjustable parameter interface of TSP Based on PSO is shown in Figure 6.

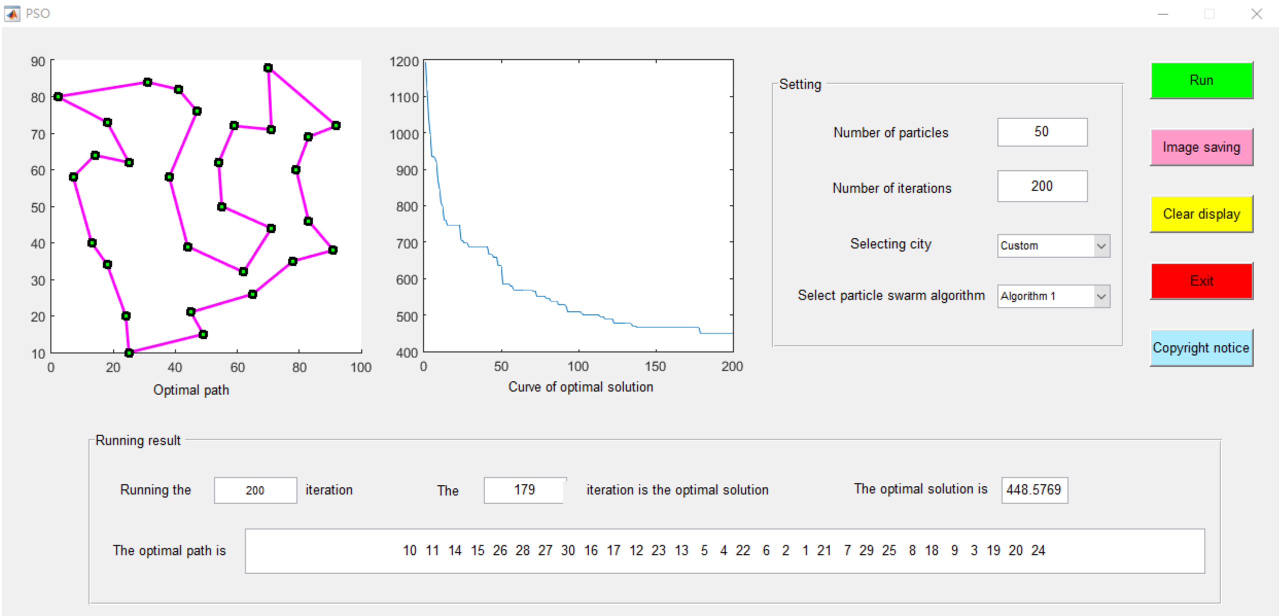


Figure 6. The solution of the tunable parameter interface of TSP Based on particle swarm optimization

## 4. A comparative study on TSP problem based on ant colony algorithm and particle swarm optimization

Both ant colony algorithm and particle swarm algorithm are randomized algorithms based on biological population. Particle swarm algorithm can carry out global search with fast convergence speed, simple parameter adjustment and good expansibility. In solving complex mathematical problems, it can quickly find the optimal solution in a reasonable time. However, the local search ability of PSO is poor, and it is easy to premature, which leads to the low search efficiency of pure PSO in the late evolution. Ant colony algorithm is essentially a parallel algorithm, which is a heuristic search method. Through the continuous transmission of information between independent individuals, it is conducive to find the better solution, and can effectively avoid falling into the local optimum. At the same time, the positive feedback mechanism of ant colony algorithm can play a self enhancement effect on the better solution, and make the better solution develop towards the global optimum, Finally, the global relative optimal solution is obtained. Similarly, ant colony algorithm also has some defects, such as long search time, slow solution speed, easy to stagnation and so on.

From the above analysis of the advantages and disadvantages of the two algorithms, we can see that if the two algorithms are combined, we can make full use of the pheromone positive feedback of ant colony algorithm and the fast and global convergence of particle swarm algorithm, so as to achieve the effect of complementary advantages.

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