Judges a score, signature and notes	Team No： 10476	Three judges score, signature and notes
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The article is about how to choose the best tourist track,which belong to travelling salesman problem. For seeking shortest and most low-cost track,we simulated three models containing economical model,time-saving model and easy model.In order to solve different problems,we used ant colony optimization, modified circle algorithm and multi-objective programming.Then, we combined the fact to the three models and analysed residual.What ‘s more,we analysed the complexity of above algorithm.

For the first problem,referring to Global mapper,making sure 10 scenic spots’ longitude and latitude, calculating a shortest track.In another word,starting with the hotel,visiting every spots only once and ending up in the hotel.According to the longitude and latitude,we ‘ll make full use of geometry to calculate the distance from two cities.we can describle the problem as setting up 10 dots representing 10 cities.The line between each two dots means the tourist track.The route attributes such as the length of the said for the edge weights, you can travel the city network abstraction as a weighted directed graph. Set a weighted directed graph G for binary group G = (V, {E}), which contains V is the set of n nodes, E is a collection of h side , (I, j) is from edge nodes I and j E, edge (I, j) is nonnegative weights. Set S, T V respectively in the starting node and destination node, then the optimal path problem is refers to in the weighted directed graph G, then the optimal path problem is refers to in the weighted directed graph G, find from the specified initial node to the destination node of a path with the minimum weight sum The shortest tour line length is 92.2 kilometers.

In view of the problem, the purpose of this problem is to design the most economical travel plan, namely the minimum distance cost we use improved algorithm to solve traveling salesman problem, in any distance between two points of minimum cost matrices as the weights, using undirected graph adjacency matrix structure, according to the question I do not know the starting location, so using the Matlab software repeated 10 times improved circle algorithm in each city as a starting point, namely from 10 Hamilton got the optimal times, namely.

Between any two points on question three, give priority to in order to enjoy here, in a model based on the results of the model, we set principles: priority is convenient, when both the cost than taking a taxi on a luxury bus of the high cost of used within a certain range, is taking a taxi Here by dynamic programming to implement the plan, on the basis of the economy of the shortest route, through a change in a way, to make the final cost deviates from the value of the minimum cost of in our allowed range, thus to save money The purpose of saving time and convenient Ultimately satisfied tourists themselves need to travel plan, the total cost 1643 yuan (do not include

accommodation Under the condition of cost).
Then we combined with the actual situation of the three model for scientific error analysis, and analyzes the complexity of the algorithm is used, at the same time for us to solve traveling salesman algorithm is evaluated, which made us to the traveling salesman problem have the further understanding.
Keys:travelling salesman problem, ant colony optimization, modified circle algorithm, dynamic planning, error analysis.

The best travel route choice model

1 problem repeat

Summer vacation is coming, many parents will choose this time to take children to travel to a certain city, but different family has different requirements (number, cost constraints, time constraints, etc.), please choose a tourist cities (such as your city), considering travel routes, cost, time, and other factors do you think of the more important, for families with different demand design a best travel packages.

According to the different needs, we can put the problem into consideration from three different aspects:

The short circuit is designed according to the geographical location (longitude and latitude) travel plan.
Hypothesis between any two cities have luxury bus and taxi, 2 times the price of taking a taxi is the distance between two points (unit: yuan), is the price of luxury bus segment, is a distance of 2.5 times within 30 kilometers, more than 30 km and within 70 kilometers of is 1.7 times that of the distance is the distance of more than 70 km of 1.4 times, if a family can choose taxi luxury bus, design the most economical travel plan
(3) in the comprehensive practical cases, consider to save money To save time and convenient, set up corresponding evaluation criteria and indicators, establish corresponding mathematical model, the improved and under the premise that the revision of the above two options Assuming that luxury bus and taxi can increases with the increasing to walk, taxi speed is 80 km/h, luxury bus speed is 50 km/h

2 symbol

2.1 Condition assumptions

(1) Calculating the attractions of the distance between ignore terrain such as hilly basin natural factors influence on the calculation results;
(2) Hypothesis speed must be in the journey, and does not consider emergencies interference taxis or luxury bus trip;
(3) Hypothesis between any two spots have luxury bus and taxi, 2 times the price of taking a taxi is the distance between two points (unit: yuan), is the price of luxury bus segment, is a distance of 2.5 times within 30 kilometers, more than 30 km and is within 70 kilometers of the distance of 1.7 times, more than 70 km distance of 1.4 times;
(4) Assumes that the residence time in each scenic spot for a day.

2.2 Notational Conventions

n:Represents the number of cities;

d_{ij}:he distance between the two cities, $1 < i+1 < j < 10$

$$x_{ij} = \begin{cases} 1, & \text{表示走过城市}i\text{到城市}j\text{的路} \\ 0, & \text{表示没有选择走这条路} \end{cases}$$

C : Initial ring;

C_{ij}: C的改良圈, $1 < i+1 < j < 10$

$$\sum_{j=1}^{n} x_{ij} = 1\text{:}\quad \text{每个点只有一条边出去，} i = 1, 2, \cdots, 10 \quad ;$$

$$\sum_{i=1}^{n} x_{ij} = 1\text{:}\quad \text{每个点只有一条边出去，} j = 1, 2, \cdots, 10 \quad ;$$

$F(i, j)_{10\times 10}$:Minimum cost between any two points constitute the matrix tak

3 .Analysis of the Problem

3.1 Analysis of Problem Ⅰ

The problem is a combination of a travel path optimization problem, and its formal description is: represented by a node 10 attractions, connecting edge between two nodes indicates itinerary and length of the route, said the right to property and the value for the edge , then you can put Attractions Travel network Abstraction is a weighted directed graph.Given a weighted directed graph G is a tuple G = (V, {E}), where V is a collection containing n nodes, E is contained h edges (arcs) collection, (i, j) E is the edge from node i to j, and the edge (i, j) non-negative weights.Let S, T V, respectively the starting node and the destination node, then the optimal path problem refers to the weighted directed graph G, then the optimal path problem refers to the weighted directed graph G, looking from specify the starting node to a target node paths with minimum weight sum of the values.

Under the influence of the different needs of conditions, attractions travel route network not only has the physical attributes, such as road routes, but also has a variety of other logical attributes route length, travel time, ticket prices, etc., thus changing the optimal route of travel.

One problem, we have the latitude and longitude location based on actual use of the knowledge of geometry to calculate the distance between the two cities each, and the distance to the right, and then establish a model for solving. Explore 10 attractions set out the optimal travel routes.

3.2 Analysis of Problem Ⅱ

According to 10 attractions in latitude and longitude, the most economical design an itinerary, from a resident, after each attraction just once and spend the least.It can be seen that this issue is part of the traveling salesman problem, we can consider the use of improved algorithm for solving this problem circle. According to various attractions attractions order number, depending on the distance to attractions problem between one obtained, we can consider in order to drive between any two points at least spend as weights constructed using undirected graph, taking into account the starting point is not given, If certain attractions as a starting point, using the optimal loop algorithm was modified ring may not be the optimal solution, so we will use the Matlab software programming improved lap times repeated algorithm will get the best lap, thus ensuring optimal solution, that is the most economical travel routes.End constituted by a closed loop back to the beginning of the most economical route. This will design one of the most economical travel routes.

3.3 Analysis of Problem Ⅲ

For Question 3 on the basis of a model, the results of the two models, we can consider setting principles: convenience priority, when the cost of two taxi used luxury bus ride than the high cost of not using a range, take a taxi.Consider the adoption of dynamic programming to implement this program, based on the most economical on the shortest route through the change to take way, if the final cost deviate from the minimum allowable spending within our range, to accept this solution, to save money provincial convenient time and purpose. Finally get to meet their own needs travel program.

4 Modeling and Solution

4.1Modeling and Solution to problem Ⅰ

According problem analysis, we first create Attractions Travel Network Diagram, given a weighted graph, which represents the set of vertices (points of interest) is expressed as: $V_G = \{1, 2, \cdots, 10\}$. E_G is empower the side (the distance between two spots) collection that the distance between the two places(km).Expressed as $E_G = \{(i, j, w_{ij}), i, j \in V_G, w_{ij} \in R^+\}$.

Hamilton path map can be expressed as: $S =< v_1 v_2 \cdots v_n v_1 >$;among $v_i \in V_G$, $1 \le \forall i \ne j \le 34, v_i \ne v_j$,and $1 \le i \le 34$, $(v_i, v_{(i \bmod n)+1}, w_{v_i v_{(i \bmod n)+1}}) \in E_G$.

$H(G)$ is a collection of G note of all Hamilton circuits,definitions $w(S) = \sum_{1 \le i \le n-1} w_{v_i v_{i+1}} + w_{v_n v_1}$;The purpose is to find a shortest Hamilton circuit S^*, Make $w(S^*) = \min_{S \in H(G)} w(S)$.

By Ant Colony Algorithm to calculate the resulting data to search.

4.1.1Estimate the distance between cities

Find attractions by Global mapper 10 specific latitude and longitude values (Table 1) as follows:

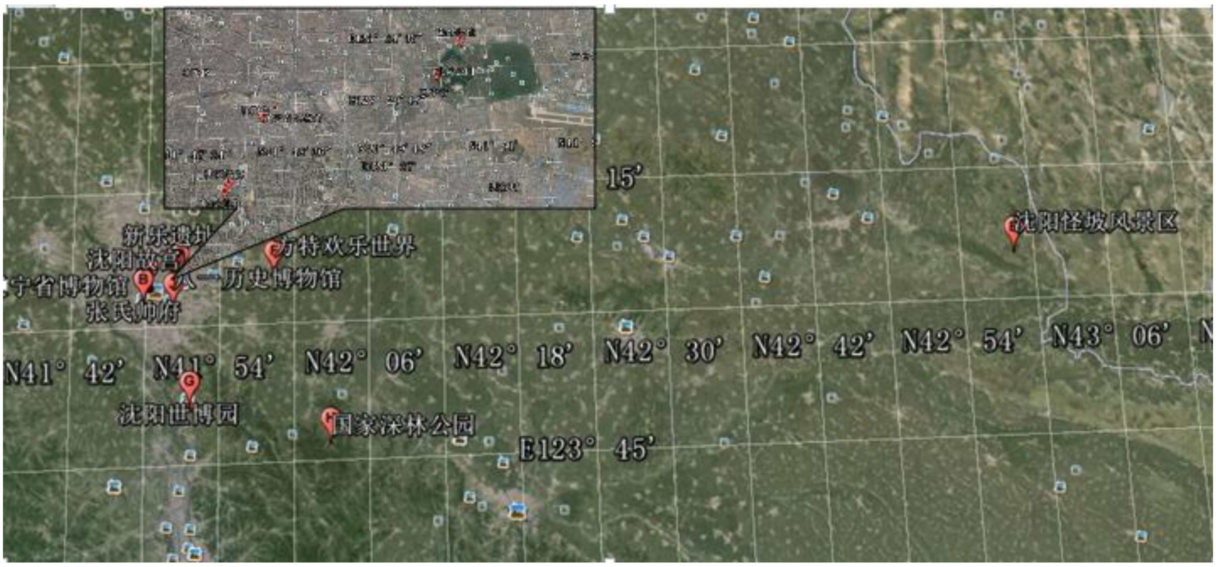


Figure 1 10 attractions map position display

Number	Attractions	Lat (latitude)	Longitude (East)
1	Shenyang Imperial Palace	41° 47′ 49.73″	123° 27′ 20.62″
2	Zhang Shuai Fu	41° 47′ 41.49″	123° 27′ 29.62″
3	Beiling Park	41° 50′ 20.76″	123° 25′ 29.83″
4	Xing Le Ruins	41° 50′ 40.87″	123° 24′ 50.03″
5	Shenyang Strange Slope	42° 04′ 12.58″	123° 37′ 47.31″
6	Fantawild	41° 58′ 20.04″	123° 24′ 49.95″
7	Shenyang Expo	41° 51′ 38.70″	123° 38′ 50.40″
8	Shenyang National Forest Park	42° 02′ 53.87″	123° 43′ 19.31″
9	Liaoning Provincial Museum	41° 48′ 12.11″	123° 26′ 11.34″
10	History Museum of 918	41° 50′ 12.42″	123° 28′ 04.04″

Table 1 Latitude and longitude of each city

According to 10 attractions in latitude and longitude, using matlab programming (see Table 1) plotted geographic relationship 10 attractions.

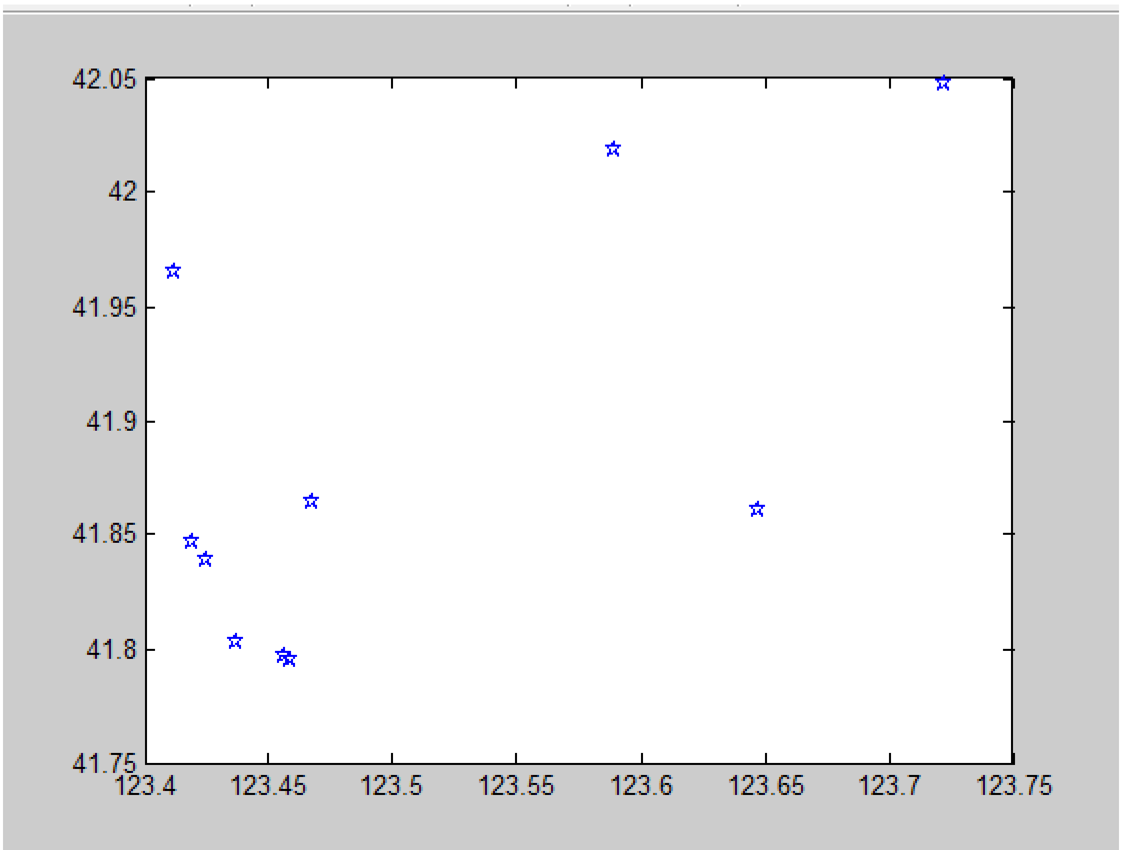


Figure 2 10 Things location diagram

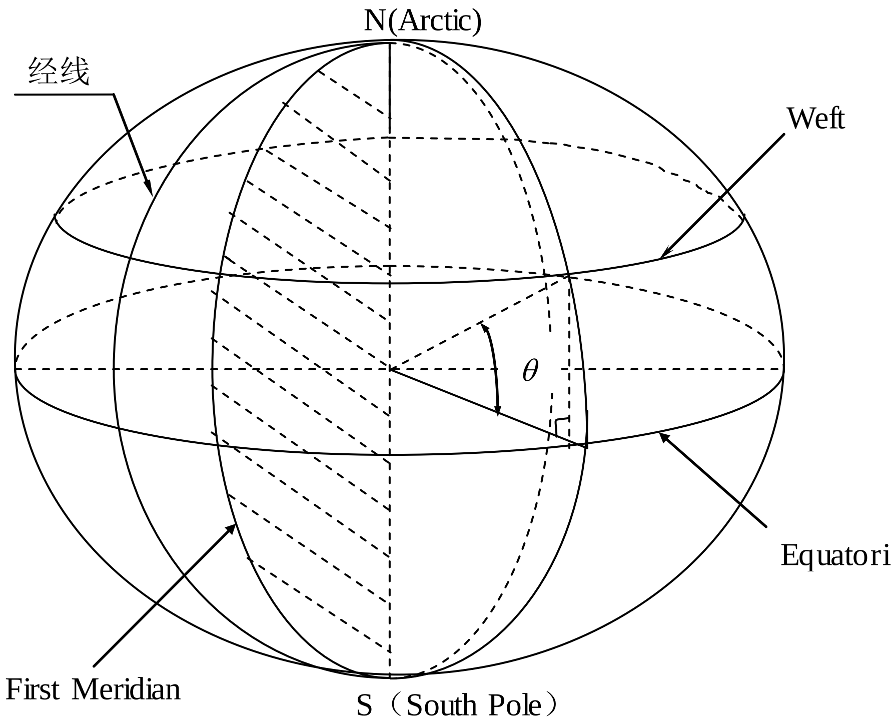


Figure 3 Earth geometry analysis diagram

First, the Earth as a standard sphere, sphere center as a point O, the arbitrary two spots as A, B, two points,A two points on the earth, B in the equatorial plane of the projected point, respectively. Assuming the Earth's average radius R, A point latitude, longitude, B point latitude, longitude, based on knowledge of geometry so you can get the ball:

$OA' = R\cos\theta_i$, $OB' = R\cos\theta_j$ (1)

Projection down $\angle A'OB' = \varphi_i - \varphi_j$ (2)

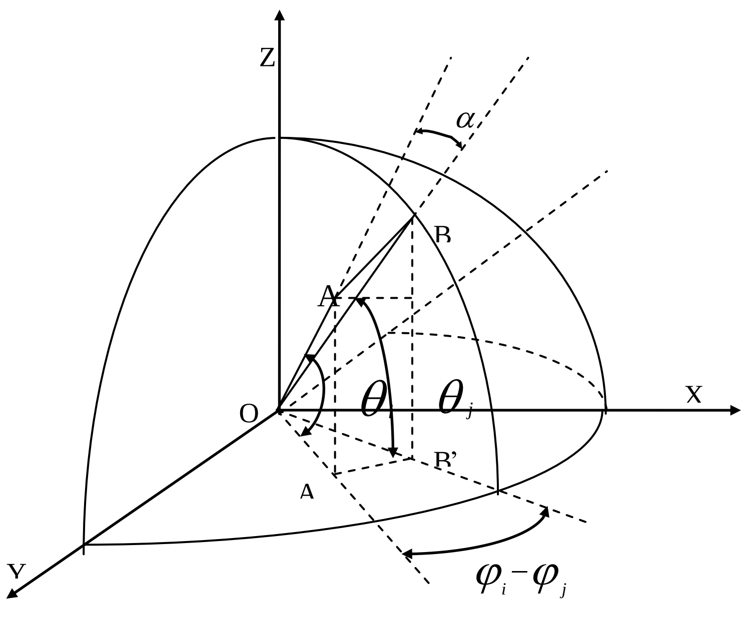


Figure 4 Earth's latitude and longitude

Use the law of cosines available:

$$A'B'^2 = R^2\cos^2\theta_i + R^2\cos^2\theta_j - 2\times R\cos\theta_i \times R\cos\theta_j \times \cos(\varphi_i - \varphi_j) \quad (3)$$

$$AB'' = R\times(\sin\theta_i - \sin\theta_j) \quad (4)$$

Obtained using the Pythagorean theorem:

$$AB^2 = A'B'^2 + AB''^2 \quad (5)$$

Take (3)、（4）in(5):

$$AB^2 = 2R^2 - 2R^2\cos\theta_i\cos\theta_j\cos(\varphi_i - \varphi_j) - 2R^2\sin\theta_i\sin\theta_j \quad （6）$$

AOB to make the same use of the law of cosines available:

$$AB^2 = R^2 + R^2 - 2\times R\times R\times\cos\alpha \quad (7)$$

$$\cos\alpha = \cos\theta_i\cos\theta_j\cos(\varphi_i - \varphi_j) + \sin\theta_i\sin\theta_j \quad (8)$$

AB is the distance between two points on the earth that is the arc length AB

$$A\widehat{B} = \alpha\times R = R\times ar\cos(\cos\theta_i\cos\theta_j\cos(\varphi_i - \varphi_j) + \sin\theta_i\sin\theta_j) \quad (9)$$

$A\widehat{B}$ is the actual path between the two places.

Therefore, we use latitude and longitude matlab software programming (see Appendix 2) According to the attractions shown in Table I calculated the distance between attractions (see Appendix 3).

4.1.2 Ant colony algorithm to model

Ant foraging process and this is similar to solving combinatorial optimization problems, only to find one through each attraction once and return to the starting point, the shortest path loop. Let i and j, the distance between the points of interest is.

Solving, assuming each ant colony algorithm is simple agent with the following characteristics.

(1) Every time traveled, each ant in its slip through (i, j) are left on the pheromone.

(2) the balance from the ant pheromones choice probability and attractions attractions and the current connection between the branch circuit contains about.

(3) In order to be legally forced to travel around the ants until after the completion of the first to travel around, before allowing the ants walk has visited attractions (which is controlled by the tabu list).

The basic ant colony algorithm variables and constants are: the total number of m, ant colony; number n, TSP problem attractions; d_{ij} is the distance between i and j attractions,Wherein;, on the path at time t (i, j) connection the residual amount of information. In the initial moments of each path is equal to the amount of information, and set = const (const is a constant).

Ant k (k = 1,2, ..., m) during movement, according to the amount of information on each path to determine their transfer direction. Ant k at time t i of interest is transferred from j to the state transition probability of interest, according to the information on each path inspired residual amount of information and route to be calculated as (10) below. When selecting the ant will try to choose a path away from their close proximity and larger pheromone direction.

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}(t)]^{\beta}}{\sum\limits_{s \subset allowed_k} [\tau_{is}(t)]^{\alpha} \cdot [\eta_{is}(t)]^{\beta}} & j \in allowed_k \\ 0 & 其他 \end{cases} \quad (10)$$

In the formula, $allowed_k = \{C - tabu_k\}$ said the next step k at time t ant allows selection of attractions (ie no access to attractions);

$tabu_k$ (K = 1,2, ..., m) - said taboo table, record ant k currently has traveled attractions;

α - Information heuristic factor, reflecting the ACO process in motion relative importance of the residual amount of information;

β - Expressed the expectation that the heuristic factor, reflecting the relative importance of expectations;

η_{ij} - Said the transfer to the desired degree of interest i j attractions, the specific formula is as follows

$$\eta_{ij}(t) = \frac{1}{d_{ij}} \quad (11)$$

K ants, the smaller, the greater the greater.

In order to avoid the excessive residual pheromone flooded heuristic information, or at the completion of each ant has completed step traversal of all n attractions, you want to be updated residual pheromone treatment. (T + n) in the path timing (i, j) according to the rule the amount of information (3) and formula (4) can be adjusted.

$$\tau_{ij}(t+n) = (1-\rho) \cdot \tau_{ij}(t) + \Delta\tau_{ij}(t) \quad (12)$$

$$\Delta\tau_{ij}(t) = \sum_{k=1}^{m} \Delta\tau_{ij}^{k}(t) \quad (13)$$

In the formula, ρ - said pheromone evaporation rate. Mimic the characteristics of human memory, the old information will be gradually forgotten, weakened. In order to prevent unlimited accumulation of information, the range of [0,1) with 1 - ρ represents the residual factor information.

$\Delta\tau_{ij}(t)$ − Increment the amount of information represented in the cycle path (i, j) on the initial time.

$\Delta\tau_{ij}{}^{k}(t)$ - Ant k indicates the amount of information in the left path (i, j) on the second cycle. According pheromone update strategy

$$\Delta\tau_{ij}{}^{k}(t)=\begin{cases}\dfrac{Q}{L_K} & \text{第}k\text{只蚂蚁在本次循环中经过}(i,j)\\ 0 & \text{其他}\end{cases} \tag{14}$$

L_k - Denotes k ant in this cycle as the total length of the path to go.

Here's the basic ant colony algorithm specific algorithm steps are:

Step 1: initialization parameters. Time t = 0, the number of cycles $N_c = 0$, provided the maximum number of cycles, so that the path (i, j) to initialize the amount of information $\tau_{ij}(t)$ = const, the initial time.

Step 2: m ants randomly placed spots on n.

Step 3: The number of cycles $N_c \leftarrow N_c + 1$.

Step 4: Let the ants taboo table index number k = 1.

Step 5: k = k +1.

Step 6: Probability ants select attractions j according to the state transition probabilities, $j=\{C-tabu_k\}$.

Step 7: Choose the biggest attractions in the state transition probabilities, the ants move to the attractions included in the taboo list.

Step 8: If you do not have access to a collection of C finished all the attractions, namely, jump to step 5; otherwise, turn to step 9.

Step 9: Update the information amount of each path according to Formula (13) and (14).

Step 10: If the termination condition is satisfied, the output end of the cycle calculations; otherwise empty taboo table and jump to Step 3.

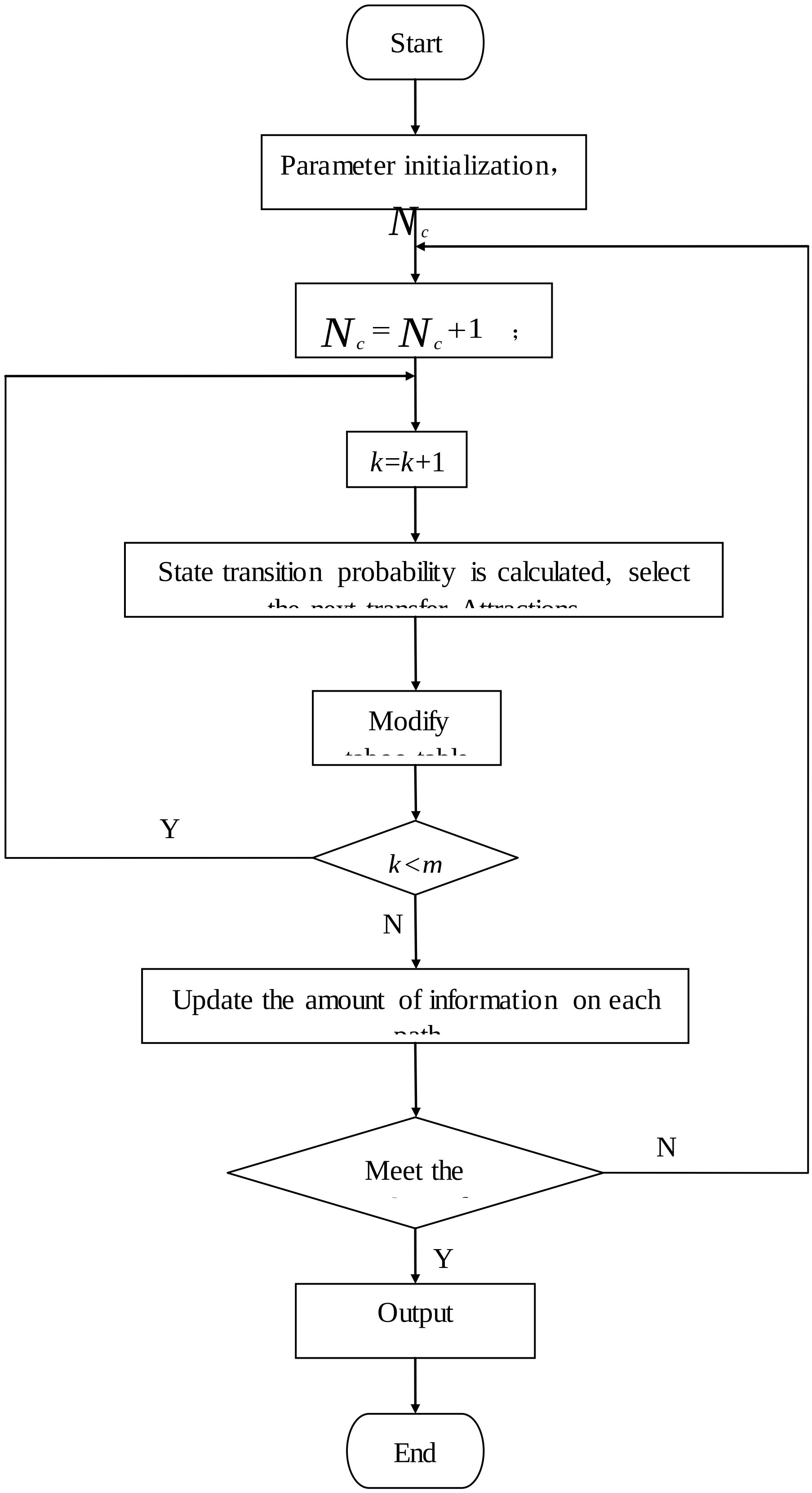
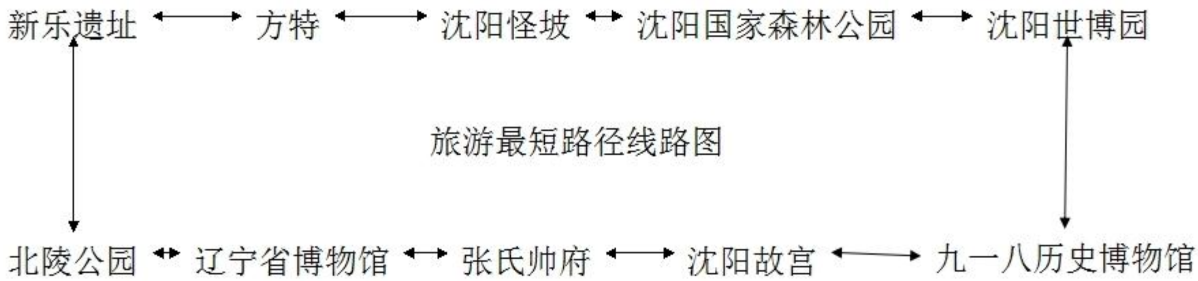


Figure 5 Algorithm is a block diagram of the basic ant colony algorithm

According to the above algorithm we use matlab software programming (programs see Appendix 4), simulated the tour ten tourist attractions in the shortest possible route, see below. Where each '*' indicates each city tours polyline represents the optimal travel path



Travel route length of 92.12138 kilometers.

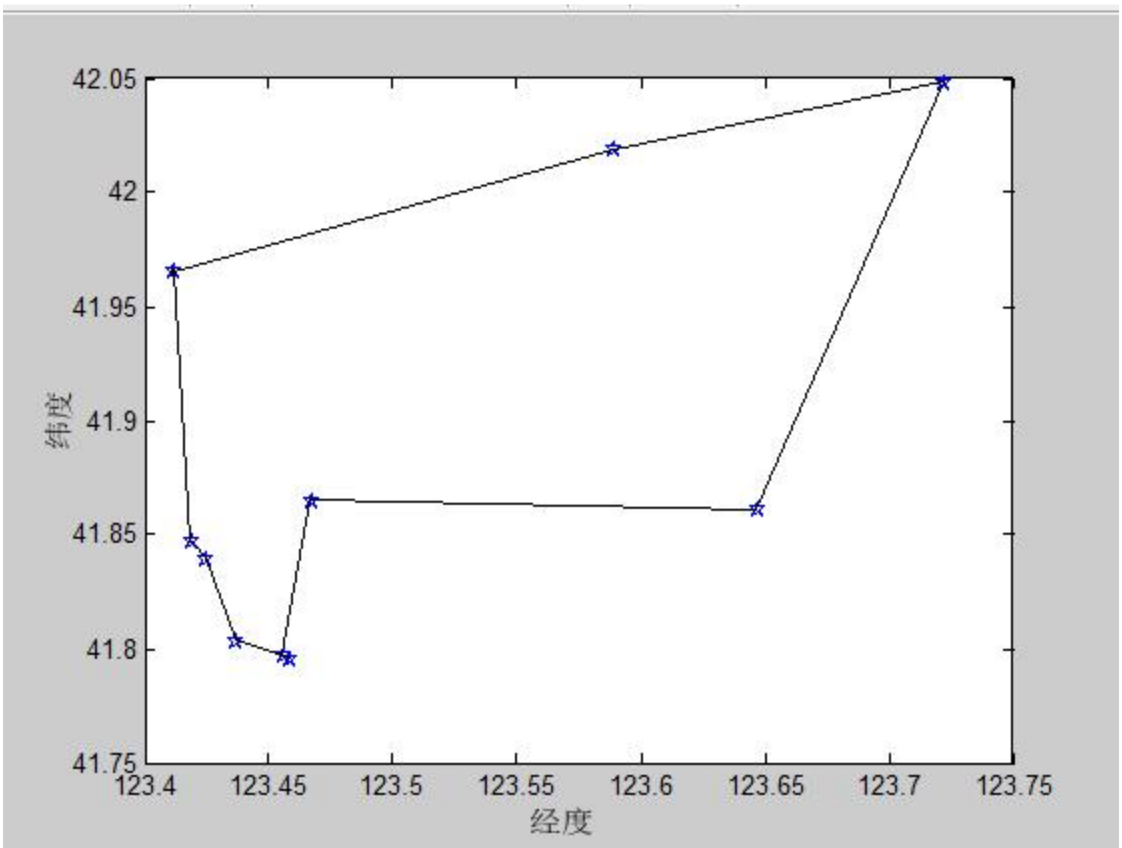


Figure 6 Ant colony algorithm optimal roadmap

4.2Solving problems with the build two models

4.2.1 The basic theory of the traveling salesman problem

N cities are heading to a traveling salesman selling goods, starting from a certain city, passes through the cities after the first return to the starting city, to determine a walking route, making the total shortest path. This problem is called the traveling salesman problem (TSP) [1]. Graph theory terminology that is empowering in a complete graph, find a minimum weight of Hamilton circle. This circle is called the optimal circle. And the shortest path problem and connection issues contrary, although there is no efficient algorithm to solve the traveling salesman problem. But there is a feasible way is to find a Hamilton circle, then appropriate changes to get another Hamilton has a smaller circle right. Modification method called modified circle algorithm. Let the initial ring $C = v_1 v_2 \cdots v_n v_1$。

(1) For the $1 < i+1 < j < n,$ construction of new Hamilton Circle:

$$C_{ij} = v_1 v_2 \cdots v_i v_j v_{j-1} v_{j-2} \cdots v_{i+1} v_{j+1} v_{j+2} \cdots v_n v_1,$$

(2) Transfer (1), until not improve, stop.
The results obtained with the improved algorithm turns almost certainly not optimal. In order to obtain higher accuracy, the premise is not given the starting position, you can choose different initial laps, repeated times algorithms to obtain accurate results.

4.2.2 The mathematical expression of the traveling salesman problem

Let the city's number is n, d_{ij} is the distance between the two cities, (expressed through the city's road, which means that there is no choice to go this route). There

$$\min \sum_{i \neq j} d_{ij} x_{ij}$$

$$\begin{aligned} s.t. \quad & \sum_{j=1}^{n} x_{ij} = 1, \quad i = 1, 2, \cdots, n, (\text{每个点只有一条边出去}) \\ & \sum_{i=1}^{n} x_{ij} = 1, \quad j = 1, 2, \cdots, n, (\text{每个点只有一条边出去}) \\ & \sum_{i,j \in s} x_{ij} \le |s| - 1, \quad 2 \le |s| \le n-1, \quad s \subset \{1, 2, \cdots, n\} \end{aligned}$$

4.2.3 Solving a model

Calculated using the following piecewise function takes the smallest matri**x** $F(i,j)_{10\times10}$

$$\begin{cases} F(i,j) = d(i,j) \times 2, & d(i,j) <= 30 \\ F(i,j) = 1.7 \times d(i,j), & 30 < d(i,j) <= 70 \\ F(i,j) = 1.4 \times d(i,j), & 70 < d(i,j) \end{cases}$$

The order given by the number of the cities, asking obtained in the previous distance between any two spots as the distance between the two spots, we spend at least a matrix between any two points of the weight matrix, constructed using undirected graph, according to the title Italy did not know the starting place, and therefore repeated using Matlab software lap times improved algorithm tries to every city as a starting point (see Appendix algorithm 5), the first set, the best lap after lap at this improved algorithm is obtained by changing the initial laps to go in turn, determine the optimal loop to meet the requirements of the most economic return from the end to ensure that the starting point for the minimum cost, that is the most economical travel program, as follows:

We use Matlab software to simulate the most economical travel routes, as shown below. Where each '*' means every city, polylines tourist routes, marked with one of the city is the starting point for travel, marked the end of 100, the city is tourism by the end of the closed-loop 100 returns constituted the starting point 1 is the most economical the travel route, which takes a minimum of 185 yuan road.

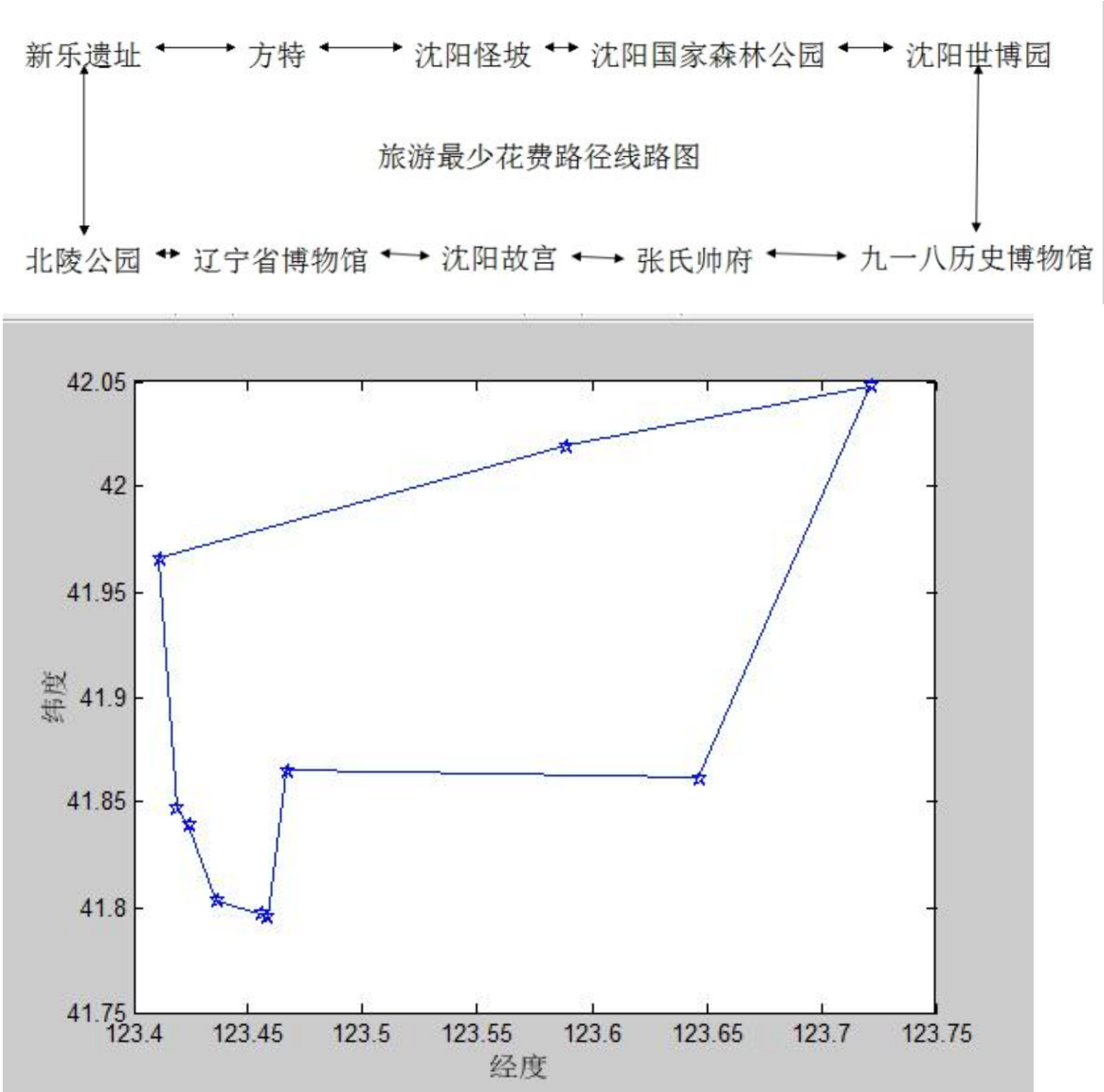


Figure 7 The most economical travel routes schematic simulation

4.3 Establishment and solving the problem of three models

4.3.1 Multi-objective planning ideas

Based select save money, save time and facilitate the best travel solutions, we have established with the sequential algorithm for multi-objective planning [2] model. Core sequential algorithm is based on the priority of priorities will be decomposed into a series of goal programming problem single objective programming problem, and then turn to solve.

Sequential algorithm for solving goal programming:

For solving the single objective planning:

$$\min \quad z=\sum_{j=1}^{l}(w_{kj}^{-}d_{j}^{-}+w_{kj}^{+}d_{j}^{+}) \tag{1}$$

$$s.t. \quad \sum_{j=1}^{n}a_{ij}x_{j}\le(=,\ge)b_{i}, \quad i=1,\cdots,m \tag{2}$$

$$\sum_{j=1}^{n}c_{ij}x_{j}+d_{i}^{-}-d_{i}^{+}=g_{i}, \quad i=1,2,\cdots,l \tag{3}$$

$$\sum_{j=1}^{l}(w_{sj}^{-}d_{j}^{-}+w_{sj}^{+}d_{j}^{+})\le z_{s}^{*}, \quad s=1,2,\cdots,k-1 \tag{4}$$

$$x_{j}\ge 0, \quad j=1,2,\cdots,n \tag{5}$$

$$d_{i}^{-},d_{i}^{+}\ge 0, \quad i=1,2,\cdots,l \tag{6}$$

The optimal target value, when the constraint (4) is empty constraints. At that time, the corresponding solution is optimal target planning.

4.3.2 Solving the model

Selected is not greater than 30 km distance between the various attractions, reason for taking a taxi is the most economical and time-saving way to travel.

attractions	way	attractions	way	attractions	way	attractions	way
1→2	taxi	7→8	taxi	6→4	taxi	9→1	taxi
2→10	taxi	8→5	taxi	4→3	taxi		
10→7	taxi	5→6	taxi	3→9	taxi		

table 2 The most convenient transportation choice between travel scenic spot

Shenyang attractions	adult	Shenyang attractions	adult	Shenyang attractions	adult
The imperial palace in shenyang	65	Shenyang GuaiPo	36	Shenyang national forest park	25
Zhang ShuaiFu	50	Party fun world	201	Liaoning province museum	2
Beiling park	45	Shenyang expo garden	46	The 918 history museum	2
XinLe site	14				

table 3 The scenic spots in ticket prices Unit:Yuan

According to various attractions tickets cost calculated in table 3 in does not contain a normal family meals, accommodation conditions (calculate by a family of three) under the condition of the most time saving and money saving the total cost is 1643 yuan.

5 Scientific feasibility of the model, the error analysis

Thought is idealized model, the algorithms in the actual travel problems, not only to consider the length of the trip, consider the time and cost. By establishing the mathematical model of mechanism after carried on the thorough analysis, we know effective control problem of "travel", namely to find out a is the best travel plan to save money, save time and convenient. Now, in accordance with the above algorithm to make a scientific feasibility and error analysis.

In practical problems, we consider not only the problem of transport, given in the reality of each traffic tools in the speed, the ticket prices are different, even there is no direct train between some attractions, from the economical point of view, all can choose the plane to travel, because all passenger prices shall be formulated by the ministry of railways, and the model is calculated according to the attractions of longitude and latitude of the distance between two spots, regardless of the emergency interference taxis or luxury bus trip, you can according to the shortest path before travel, can travel budget the amount of the shortest time and cost, it has certain feasibility and practicality. But in general the longer the distance the more time spent, spent is, the more money, but in the actual situation, according to the cab, the luxurious bus operation trajectory is not necessarily the shortest, so it takes time and money is not always the least. And the model is according to the linear distance between the two sites to find the shortest path, and this model one there is a biggish error inevitably. In general, determine the adopted by the means of transport, determine the travel time between the two cities. So time can be used to calculate both save time and travel path of the economy, the error is smaller, so the model 2 and the actual contact more closely. Make the model close to actual, strong commonality.

6 The complexity of the model analysis

6.1 Ant colony algorithm complexity analysis

Ant colony algorithm complexity analysis is theoretically on the analysis of the efficiency of the algorithm of ant colony algorithm. For the model of ant colony algorithm, 10 cities is the size of the TSP, m is the number of ants, N_c As the cycles of the algorithm, we get from the ant colony algorithm process each link of time complexity, shown in the table below:

Step	content	T(n)
1	Initialize the：set t=0；set N_c =0 set $\tau_{ij}(t)$ = const，$\Delta\tau_{ij}(t)$ =0；	$O(n^2+m)$
2	Set the ants tabu table set s=0； for k= 1 to m do Buy the first k ants starting city to tabu table $tabu_k$	O(m)
3	An ant structure solution separately Until the tabu table full cycle calculation set s=s+1； for k= 1 to m do According to the transition probability $p_{ij}^k(t)$ Select the next city	O(n^2m)

	Add the serial number j city tabu table $tabu_k$	
4	Solution of the evaluation and calculation of quantity of trajectory update Will be the first k ant from taboo table transferred to Calculate the first k ant path length in the loop Update the optimal path Calculation of every path information feedback $\Delta\tau_{ij}(t)$	O(n^2)
5	Information update number concentration of trajectory Calculation of every path information before the next round of cycle $\tau_{ij}(t+n)$ set t =t+n; set $N_c = N_c + 1$	O(n^2)
6	Determine if termination conditions have been met If, and search to stop Empty all taboo table Back to step2 Otherwise Output the shortest path The end of the	O(nm)

6.2 The complexity of the dynamic programming algorithm is analyzed

Problem 3, the number of tourist attractions is more, we use dynamic programming method, there is no doubt that the amount of calculation and storage capacity is very big, spent more time in solution.

7 Evaluation and improvement of the model

7.1 Evaluation of the model

In this paper, we study is the best travel route choice problem, this problem belongs to the traveling salesman problem, we established the shortest path, take the least, economic, time saving, convenient three model, according to different requirements, we use ant colony algorithm, improved algorithm and multi-objective programming to solve the problem to choose the best route.

In view of the problem a, know this problem belongs to the traveling salesman problem. First of all, we according to the order number from city to city in the table, we according to the actual location latitude and longitude, use geometrical knowledge to calculate the distance between every two spots, simplify the problem. Then, we use ant colony algorithm to solve traveling salesman problem, the shortest distance between two points in an arbitrary matrices as the weights, using Matlab software programming to calculate the shortest route of travel. According to question 2, we use improved algorithm, the weight matrix is set to "least cost",

model 2. Also improved circle algorithm using Matlab software to zero, you'll get the optimal circle, namely the cost minimum route of travel. For three, problems are here in a model, based on the results of model 2, we set principles: priority is convenient, when both the cost than taking a taxi on a luxury bus of the high cost of used within a range, taking a taxi. We give any between takes the least amount of matrix and the matrix least expensive assign different weights. By dynamic programming, and finally get the best travel plan.
Then we combined with the actual situation of the three model for scientific error analysis, and analyzes the complexity of the algorithm is used, at the same time for us to solve traveling salesman algorithm is evaluated, which made us to the traveling salesman problem have the further understanding.

7.2 The improvement of the model

Model 1 we put the question simplification, we are according to the longitude and latitude calculated the distance between two spots, and the distance between the two is actually because of the matters and the actual situation and changeable, to calculate the distance to replace the actual distance, this assumption is only convenient for problem solving, model to further improve to walk closer to the actual distance, such ability are more persuasive.
Model 2, we conclude the results considering the cost of transportation and the scenic spots, have ignored the government's macroeconomic regulation and control, market economy, the impact of oil price changes on the ticket and the change of weather on the travel distance and time, in fact, the government's strategy in China, the market economy, factors such as the price of oil will have an impact on travel fares, the change in the weather will also affect the process of tourism, so the model is improved to consider the effect of policy and the changes in the weather.

Model 3 combines the result of model 1 and model 2, on the basis of this to consider the problems of tourism transportation it is concluded that the optimal solution, so the model can be used to model the influence of one, two, three, and not considering scenic spot the traffic problem, so the model is improved to consider the influence of the scenic spot the traffic problem

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The appendix:

Appendix 1:

```
x1=123.45574;x2=123.45819;x3=123.42492;x4=123.41893;x5=123.58896;x6=123.41196;x7=123.64732;x8=123.72206;x9=123.43648;x10=123.46709;y1=41.79708;y2=41.79479;y3=41.83902;y4=41.84718;y5=42.01887;y6=41.96573;y7=41.86067;y8=42.04823;y9=41.80329;y10=41.86441;
plot(x1,y1,'p')
hold on;
plot(x2,y2,'p')
hold on;
plot(x3,y3,'p')
hold on;
plot(x4,y4,'p')
hold on;
plot(x5,y5,'p')
hold on;
plot(x6,y6,'p')
hold on;
plot(x7,y7,'p')
hold on;
plot(x8,y8,'p')
hold on;
plot(x9,y9,'p')
hold on;
plot(x10,y10,'p')
hold on;
```

Appendix 2:

（1）利用中国城市经纬度，计算任意两座城市之间的经纬度程序：

```
a=[41.79708 41.79479 41.83902 41.84718 42.01887 41.96573 41.86067 42.04823 41.80329 41.86441 ];%各个城市纬度
b=[123.45574 123.45819 123.42492 123.41893 123.58896 123.41196 123.64732 123.72206 123.43648 123.46709];%各个城市经度
for i=1:10,
    for j=1:10,
c(i,j)=6371.3*acos(cos(a(1,i)*pi./180)*cos(a(1,j)*pi./180)*cos(b(1,i)*pi./180-b(1,j)*pi./180)+sin(a(1,i)*pi./180)*sin(a(1,j)*pi./180))%利用经纬度计算地球上两点距离
    end
end
```

Appendix 3（10 cities at any distance km）:

	The imperial palace in shenyang	Zhang ShuaiFu	Beiling park	XinLe site	Shenyang GuaiPo
The imperial palace in shenyang	0	0.3257	5.3173	6.3516	27.0151
Zhang ShuaiFu	0.3257	0	5.6385	6.6727	27.1665
Beiling park	5.3173	5.6385	0	1.0342	24.1691
XinLe site	6.3516	6.6727	1.0342	0	23.7138
Shenyang GuaiPo	27.0151	27.1665	24.1691	23.7138	0
Party fun world	19.101	19.3901	14.1309	13.1954	15.7771
Shenyang expo garden	17.378	17.2993	18.5786	18.9763	18.2422
Shenyang national forest park	35.5739	35.6499	33.8413	33.591	11.4679
Liaoning province museum	1.7395	2.0328	4.087	5.0926	27.0906
The 918 history museum	7.5459	7.7768	4.4913	4.4251	19.9155

	Party fun world	Shenyang expo garden	Shenyang national forest park	Liaoning province museum	The 918 history museum
The imperial palace in shenyang	19.101	17.378	35.5739	1.7395	7.5459
Zhang ShuaiFu	19.3901	17.2993	35.6499	2.0328	7.7768

Beiling park	14.1309	18.5786	33.8413	4.087	4.4913
XinLe site	13.1954	18.9763	33.591	5.0926	4.4251
Shenyang GuaiPo	15.7771	18.2422	11.4679	27.0906	19.9155
Party fun world	0	22.7113	27.216	18.1771	12.1553
Shenyang expo garden	22.7113	0	21.7532	18.5981	14.9317
Shenyang national forest park	27.216	21.7532	0.0001	36.0571	29.3664
Liaoning province museum	18.1771	18.5981	36.0571	0	7.2543
The 918 history museum	12.1553	14.9317	29.3664	7.2543	0

Appendix 4

蚁群算法求解程序：

```
%蚁群算法选择路径
function
[R_best,L_best,L_ave,Shortest_Route,Shortest_Length]=ACATSP(d,NC_max,m,
Alpha,Beta,Rho,Q)
%d 为任意两城市间距离
%NC_max  最大迭代次数
%m  蚂蚁个数
%Alpha  表征信息素程度参数
%Beta  表征启发因子程度参数
%Rho  信息素蒸发系数
%Q  信息素增加强度
n=34;
Eta=1./d;
Tau=ones(n,n);
Tabu=zeros(m,n);
NC=1;     %迭代计数器，记录次数
R_best=zeros(NC_max,n);
L_best=inf.*ones(NC_max,1);
```

```
L_ave=zeros(NC_max,1);
while NC<=NC_max  %停止条件一，达到迭代次数
%将 m 个蚂蚁放到 n 个城市上
Randpos=[];
for i=1:(ceil(m./n))
Randpos=[Randpos,randperm(n)];
end
Tabu(:,1)=(Randpos(1,1:m))';
for j=2:n
for i=1:m
visited=Tabu(i,1:(j-1));
J=zeros(1,(n-j+1));
P=J;
Jc=1;
for k=1:n
if length(find(visited==k))==0
J(Jc)=k;
Jc=Jc+1;
end
end
for k=1:length(J)
P(k)=(Tau(visited(end),J(k))^Alpha)*(Eta(visited(end),J(k))^Beta);
end
P=P/(sum(P));
Pcum=cumsum(P);
Select=find(Pcum>=rand);  %若计算的概率大于原来的就选择这条路线
to_visit=J(Select(1));
Tabu(i,j)=to_visit;
end
end
if NC>=2
Tabu(1,:)=R_best(NC-1,:);
end
%记录本次迭代最佳路线
L=zeros(m,1);
for i=1:m
R=Tabu(i,:);
for j=1:(n-1)
L(i)=L(i)+d(R(j),R(j+1));
end
L(i)=L(i)+d(R(1),R(n));
end
L_best(NC)=min(L);
pos=find(L==L_best(NC));
```

```
R_best(NC,:)=Tabu(pos(1),:);
L_ave(NC)=mean(L);
NC=NC+1        %迭代继续
%更新信息素
Delta_Tau=zeros(n,n);
for i=1:m
for j=1:(n-1)
Delta_Tau(Tabu(i,j),Tabu(i,j+1))=Delta_Tau(Tabu(i,j),Tabu(i,j+1))+Q/L(i
);
end
Delta_Tau(Tabu(i,n),Tabu(i,1))=Delta_Tau(Tabu(i,n),Tabu(i,1))+Q/L(i);
end
%禁忌表清零
Tau=(1-Rho).*Tau+Delta_Tau;
Tabu=zeros(m,n);
end
Pos=find(L_best==min(L_best));
Shortest_Route=R_best(Pos(1),:)
Shortest_Length=L_best(Pos(1))
subplot(1,2,2)    %绘制图形
plot(L_best)
```

Appendix 5

```
clc,clear
d=xlsread('juli.xls');
w=zeros(100)
for i=1:99
    for j=i+1:100
        if d(i,j)<=1500
            w(i,j)=1.5*d(i,j);
        end
        if d(i,j)>1500
            w(i,j)=1700+(d(i,j)-1000)*1.1;
        end
    end
end
w=w+w'
xlswrite('feiyong',w,'sheet1');

function main
clc,clear
load mydata
```

```
ug=xlsread('feiyong')
[i,j,y]=find(ug);
a=sparse(i,j,y);
a=tril(a);
L=size(ug,1);
c1=[1 2:99 100];
[circle,long]=modifycircle(c1,L);
c2=[1 100 2:99];%改变初始圈，该算法的最后一个顶点不动
[circle2,long2]=modifycircle(c2,L);
if long2<long
long=long2;
circle=circle2;
end
circle,long
x=[x0(circle) x0(1)]
y=[y0(circle) y0(1)]
scatter(x,y,'b','*')
hold on
plot(x,y)
```