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Research on Route Planning of Red Tourist Attractions in Guangzhou Based on Ant Colony Algorithm

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Abstract: The development of red cultural resources in Guangzhou is scattered, and there are problems such as many but not precise and repeated development. In this paper, the tourism group is divided into two kinds of red study groups and ordinary tourism tourists, based on the ant colony algorithm, with the shortest path as the objective function, for ordinary tourists this paper selects the top ten red attractions in Guangzhou combined with the surrounding characteristic attractions, and uses MATLAB programming to plan the tourism route; for red study groups, this paper divides the red attractions in Guangzhou into municipal districts, and does not consider the surrounding attractions in the same way to plan The best path is planned in the same way. In this way, we can promote the dissemination of red history and culture, help the development of red tourism, and provide some reference significance for red tourism route planning.

1. Introduction

In the context of promoting patriotism, implementing the rural revitalization strategy and the rise of tourism boom, red tourism has gradually become one of the hot spots of attention for scholars from different disciplines such as politics, tourism, planning and geography. Guangzhou city has rich red resources, and this paper proposes to take Guangzhou city as an example to develop and design a red tourism route that meets the needs of ordinary tourists as well as the red study crowd based on the ant colony algorithm by combining local resources. In the existing literature Huang Teng eslishes a mathematical model through the constraints in the tourism route, solves the shortest circuit length by genetic algorithm, and uses ant colony algorithm to solve the shortest circuit problem with constraints [1]. Li Yuan et al. used ArcGIS and social network models to construct a tourist route system for mass tourism groups and red tourism groups based on different population preferences [2]. Niu Yuecheng proposed an improved ant colony algorithm based on the traveler problem solving, so that the algorithm solves the traveler problem with higher search accuracy and shorter solving time [3]. In general, there have been multiple studies on travel route planning, but there is still some room to give appropriate decision suggestions for red tourism in the city under different needs. In this paper, the best travel routes are planned by ant colony algorithm and empirically analyzed to derive the shortest path as the objective function to design travel routes for different tourist groups. It provides some reference significance for other provinces and cities to promote the development of red tourism culture.

2. Ant colony algorithm

2.1 Algorithm Principle

The ant colony algorithm was first proposed by Italian scholars Dorigo.M et al. It is a heuristic bionic evolutionary algorithm that simulates the foraging behaviour of ants in nature and belongs to the random search algorithm [4]. The shortest path from the ants' nest to the food source is finally found through the information exchange among ants. The process in which ants seek food paths has similarities with the well-known Traveling Trader Problem (TSP). M. Dorigo et al. fully exploited the similarity between the process of an ant colony searching for food and the well-known TSP problem to solve the TSP problem by artificially simulating the behavior of an ant colony searching for food. The ant colony algorithm has the advantages of ①strong robustness ②easy distributed computation ③easy combination with other methods [5].For the ant colony algorithm to solve the TSP principle is.:

Ants searching for food leave pheromones on the path they pass through, allowing other ants in a certain range to sense the substance and move in the direction of high pheromone intensity [1]. Pheromones evaporate over time.

Assumptions:

There are m ants in the colony, place m ants randomly in a landscape n, set the pheromone size on each path equal, the distance between landscape i and landscape j is $R_{ij}(i,j = 1,2,\cdots,n)$, at a certain moment t , the pheromone concentration on the path between landscape i and landscape j is $\tau_{ij}(t)$, let the initial pheromone concentration between each landscape is the same, all $\tau_{ij}(0) = \tau_0$.

The ant $k(k = 1,2,\cdots,m)$ can decide the next scenic spot it needs to visit by the size of the pheromone concentration between the connecting paths in each scenic spot. $P_{ij}^k(t)$ represents the probability that the ant t will move from scenic spot i to scenic spot j at the moment of k. The calculation formula is as follows:

$$P_{ij}^k = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha \cdot [\eta_{ij}(t)]^\beta}{\sum_{s\epsilon allow_k}[\tau_{ij}(t)]^\alpha \cdot [\eta_{ij}(t)]^\beta}, s \in allow_k \\ 0, s \notin allow_k \end{cases} \tag{1}$$

Where $\eta_{ij}(t) = \frac{1}{R_{ij}}$ denotes the heuristic function, which is the probability that an ant expects to move from landscape i to landscape j, and $allow_k$ denotes the set of landscapes visited by an ant k [6]. The larger the value of α, the more likely it is that the ants will choose a previously travelled path, and the less random the search path is, while the smaller the value of α, the smaller the search range of the ant colony will be, and the easier it is to fall into a local optimum. β is the importance factor of the heuristic function; the larger the value of β, the easier it is for the ant colony to choose a locally shorter path, and the convergence of the algorithm is accelerated, but the randomness is not high [7].

When the ants release pheromones, the pheromones on each scenic connection path will slowly disappear, so the degree of pheromone volatility is set as parameter;ρ is the information volatility factor, when ρ is too small, too many pheromones remain on each path, resulting in invalid paths continuing to be searched, affecting the convergence rate of the algorithm, and when ρ is too large, although invalid paths can be excluded from the search, it cannot It is guaranteed that valid paths will also be abandoned from the search, affecting the optimal value search. When all ants have completed one cycle, the pheromone concentrations on the connected paths in each landscape are updated [8]:

$$\begin{cases} \tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij} \\ \Delta\tau_{ij} = \sum_{k=1}^{n} \Delta\tau_{ij}^{k} \end{cases}, 0 < \rho < 1 \tag{2}$$

where $\Delta\tau_{ij}^{k}$ denotes the concentration of pheromones released by the k ant on the pathway connecting landscape i with landscape j [9]; and $\Delta\tau_{ij}$ denotes the sum of the concentrations of all pheromones released by the ant on the pathway connecting landscape i with landscape j. In particular, $\Delta\tau_{ij}^{k}$ is calculated as:

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{Q}{R_{ij}}, \text{The k}^{th} \text{ ant visits scenic area j from scenic area i} \\ 0,\ other \end{cases} \tag{3}$$

Here Q is a constant indicating the total amount of pheromone released by the ant in one cycle.

The ant-perimeter model has better performance when solving the travel quotient problem, so it is usually used as the basic model for the pheromone update principle of the ant colony algorithm [3].

2.2 Algorithm implementation steps

(1) Parameter initialization. Before the calculation, the correlation coefficients were initialized, such as the number of ants m, the pheromone importance factor α, the heuristic function importance factor β, the pheromone volatility factor ρ, the total amount of pheromone released Q, the maximum number of iterations $max\,i\,ter$, etc. Set the initial value of the number of iterations $iter = 1$, and then place m ants on n vertices.

(2) Construction of solution space. The initial departure point of each ant is now given to a randomly generated initialized population solution set that travels to the next scenic area at random. For each ant $k(k = 1,2,\cdots,m)$, travel to the next tourist landscape j according to the calculation of probability $P_{ij}^{k}$and place the vertex j in the initialized solution set until all ants have finished their visits to all landscapes.

(3) Update the pheromone. The path length $L_k(k = 1,2,\cdots,m)$ travelled by each ant is calculated, the optimal solution in the number of iterations is recorded and updated iteratively with this.

(4) Determine whether to terminate. If $< max\,i\,ter$, then $iter = iter + 1$, then empty the ant path record and skip to step (3), otherwise terminate the calculation and find the optimal solution.

(5) Output result: output the result of the program and output the indicators of the program's optimisation search process as needed to derive the running time, the number of convergence iterations, etc., and draw the trajectory route in accordance with the constraints and objective function.

3. Model building

3.1 Questions to ask

The object of this paper is how to plan the most suitable tourist routes for the red tourism sites in Guangzhou, and its optimisation objective is to plan tourist sites and suitable tourist routes according to the different group needs of red study tourists and general tourism tourists.

At present, there are two main groups of tourists involved in red tourism: one is the general tourism group with the goal of tourism, and the other is the red tourism group with the goal of study and education. The general tourism group refers to individuals or families who choose tourist attractions according to their own wishes and preferences, while the red tourism group refers to schools, organization and government organs, enterprises and institutions, social groups and other organisations that organise group building activities for the purpose of strengthening patriotic and organization education. These two groups of people have different tourism objectives in terms of the people they are targeting, and therefore their choice of red tourism routes and their acceptance of different red attractions will also differ.

In order to promote the development of red tourism, this paper combines the top ten red tourist attractions in Guangzhou with the special attractions around them, so that ordinary tourists can feel the red spirit and learn about other cultures of Guangzhou. For red study groups, this paper sets up all the tourist attractions as red attractions and does not conduct cross-district tours.

3.2 Model Assumptions

(1) Assume that there is a convenient road between any two red attractions.

(2) No consideration is given to the order in which the attractions are visited, and the attractions are treated equally in terms of time spent visiting them.

(3) Assume a straight-line driving route in any two tourist areas.

3.3 Objective functions and constraints

The target for minimising the total distance travelled R_{min} is:

$$R \sum_{i=1}^{m} R_{ij_{min}} \tag{4}$$

According to the model assumptions, when conducting a study on the objective of minimising the total distance travelled, it is necessary to seek a planning solution that starts from a single starting point, visits the attractions in a certain order, where each attraction is visited and only once, and eventually returns to the end point to form a circuit, so that the total distance travelled is minimised. From the point of view of mathematical model transformation, this problem can be translated into the classical Traveling Salesman Problem TSP in Operations Research [4]. The Traveling Salesman Problem is often referred to as the minimal Hamiltonian loop problem in a graph-theoretic sense, i.e. it refers to a loop containing all nodes and no branches. Denote $G = (V, E)$ as the assignment graph, $V = (1,2,\cdots,m)$ as the set of vertices, Eas the set of edges, $R_{ij}(R_{ij} > 0, R_{ii} = \infty, i,j \in V)$ as the distance between vertices, and $prec_{ij}$ as the binary variable indicating that the attraction j in the route immediately follows i taking the value 1 and 0 otherwise.

$$prec_{ij} = \begin{cases} 1, & \text{If } (i,j) \text{ is on the loop path} \\ & 0, other \end{cases} \tag{5}$$

Then, combining the mathematical model of the traveler's problem, assuming that there are m attractions to be visited, $spots$ is the set of attractions, and R_{ij} denotes the distance from attraction i to attraction j, the objective function with the shortest path and the constraints are as follows:

$$R \sum_{i=1}^{m} \sum_{j=1}^{m} R_{ij} prec_{ij_{min}} \tag{6}$$

$$s.t. \sum_{i=1}^{m} prec_{ij} = 1 \quad i \in \{1,2,\cdots,m\} \tag{7}$$

$$\sum_{j=1}^{m} prec_{ij} = 1 \quad j \in \{1,2,\cdots,m\} \tag{8}$$

$$\sum_{i \in spots}^{i=1} \sum_{j \in spots} prec_{ij} \le m-1 \tag{9}$$

$$prec_{ij} \in \{0,1\} \tag{10}$$

The objective of the problem is to minimise the total distance through the attractions. Eqs. (7) to (10) are the feasible domains, also known as constraints, for the mathematical model of the combined traveller problem; Eqs. (7) and (8) constrain each attraction to have one and only one edge in and out; Eq. (9) constrains the entire weighted undirected graph to have at most $m-1$ edges and no subloops. Eq. (10) is the defining domain of the mathematical model of the travel agent and defines the decision variable $prec_{ij}$ to take values of 0 and 1.

4. Empirical studies

4.1 Data sources and processing

This article collects information on red sites based on the Red Sites in Guangzhou, which are officially announced by the Propaganda Department of the Guangzhou Municipal Committee and the Guangzhou Municipal Bureau of Culture, Radio, Film and Tourism as part of the "Red School at Your Doorstep" list, and the "Guangzhou Red Historic Sites" compiled by the Organization History and Literature Research Office of the Guangzhou Municipal Committee of the Communist Organization of China. , Gaode Map, TuBar Map, Google Online Map, National Earth System Scientific Data Centre, etc. to find the location of these red sites in terms of latitude and longitude with the surrounding characteristic resources and latitude and longitude. This article will collect information on the location of tourist attractions in Guangzhou, etc. organized and divided according to administrative districts; the top ten red tourist attractions in Guangzhou are recommended by the webpage.

In the list provided, some sites have been demolished or re-located; those that have been demolished are deleted by default, and the latitude and longitude of the re-located sites are updated. The latitude and longitude range of Guangzhou is known to be 112° 57′ to 114° 3′ East and 22° 26′ to 23° 56′ North. The geographical locations in the data that exceed the range are checked and deleted by default if they are not within the city.

4.2 Model solving

(1) General Visitors

Based on the above model we use the optimal calculation of ant colony arithmetic to solve the TSP problem under the constraint conditions, firstly we select the top ten red tourist attractions in Guangzhou for simulation tests , as shown in Table 1.

Table 1: Top 10 Red Tourist Attractions in Guangzhou

No.	Name of attraction
1	Comrade Mao Zedong Hosts the Former Site of the Peasant Movement Workshop Memorial Hall
2	Guangzhou Uprising Memorial Hall
3	Guangzhou Uprising Martyrs' Mausoleum
4	Sanyuanli People's Anti-British Fighting Year Memorial Hall
5	Huanghuagang Martyrs' Mausoleum
6	Former site of Whampoa Military Academy
7	Memorial Hall of the Three Great Congresses of the Communist Organization of China
8	Hong Xiuquan Former Residence Memorial Hall
9	Xinhai Revolution Memorial Hall
10	Sun Yat-sen Grand Marshal's Mansion Memorial Hall

According to the location of these attractions, the surrounding attractions are selected for viewing, the surrounding attractions are: 11. Donghao Chung Museum, 12. Sha Mian Island, 13. Night tour of the Pearl River (Tianzi Pier), 14. Guangzhou Zoo, 15. Cheung Chau Island, 16. North Island Creative Park, 17. Red Garden, 18. Guangzhou Huadu Lake National Wetland Park, 19. Furong Roach Provincial Tourist Resort, 20. Guangfu Herbal Museum. Add these special attractions to the target tourist attractions as well.

1) Calculate the distances between the sites, programmed by converting latitude and longitude into distance coordinate formulas, thus finding the symmetric distance matrix $\boldsymbol{d}$.

2) Initialisation parameters: number of ant colonies $\boldsymbol{m}$, pheromone importance factor $\boldsymbol{\alpha}$, heuristic function importance factor $\boldsymbol{\beta}$, pheromone volatility factor $\boldsymbol{\rho}$, total number of pheromone releases $\boldsymbol{Q}$, maximum number of iterations $\boldsymbol{max\,iter}$, etc. Set the initial value of the number of iterations $\boldsymbol{iter = 1}$.

3) Construct the solution space: place 50 ants at different departure points and go to the next attraction randomly. For each ant $\boldsymbol{k(k = 1, 2, \cdots, m)}$, calculate its next attraction to visit according to the constraints until all ants have visited all cities.

4) Update the pheromone, calculate the path length $\boldsymbol{L}$ of each ant, record the historical optimal solution in the current number of iterations, i.e. the shortest path, and update the pheromone concentration of the paths connected to each city.

5) Determine whether the termination condition is reached, i.e. whether the maximum number of iterations is reached.

The model was programmed using MATLAB2021b to first solve for the shortest path between the attraction and the attraction based on the data, then the initial parameters were set according to the content solution and the model was combined with the corresponding data for 300 iterations before solving for the results. The travel path is obtained as:15 9 6 16 14 5 17 7 20 3 11 1 13 10 2 12 4 8 19 18 15. The final route planning solution and the shortest distance vs. average distance pairs are shown in Figures 1 and 2.

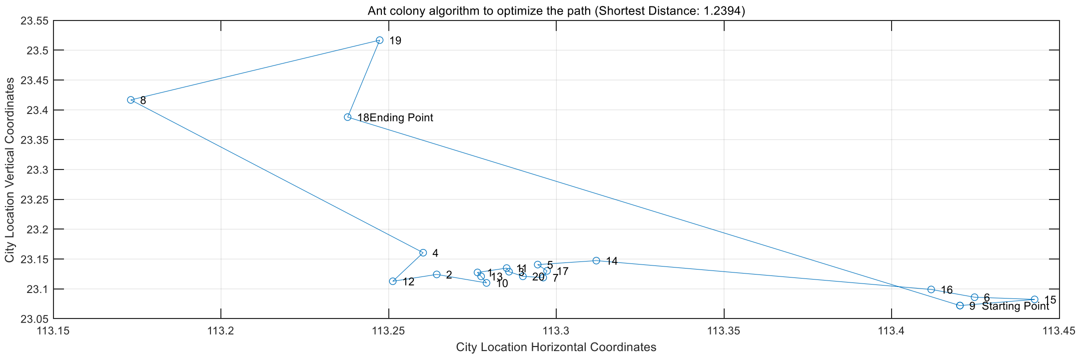

Figure 1: General visitor path planning results

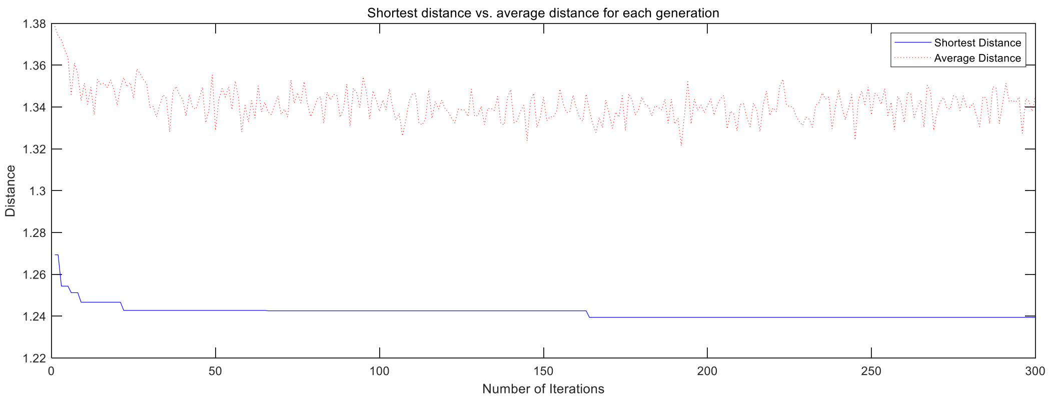

Figure 2: Shortest distance and average distance

(2) Red Study Groups

Calculated in the same way as for regular visitors, except that only red sites are considered here and for space reasons only the Yuexiu district is considered. As shown in table 2.

Table 2: Red Tourist Attractions in Yuexiu District

No.	Name of attraction	No.	Name of attraction
1	The site of the southern relocation of the New Youth Society to Guangzhou	20	Former Site of the Great National Congress of the Kuomintang
2	Former Residence of Yang Lagenda	21	Former site of Guangdong Farmers' Association
3	Site of the founding of the Guangdong Branch of the Communist Organization of China	22	Former Site of the All-China Federation of Trade Unions
4	Former site of the Southern Branch of the Secretary Department of the Chinese Labour Union	23	Site of the Provincial Strike Committee of Hong Kong
5	Former site of the Guangzhou Congress against Sha Mian's harsh regulations	24	Monument to the Dead Martyrs of the Workers' and Peasants' Movement
6	The site of a meeting of the Chamber of Commerce	25	Site of Mao Zedong's former residence
7	Site of the meeting of organization cadres of the Northern Expeditionary Army convened by Zhou Enlai	26	Former Site of the Military Committee of the Communist Organization of China Guangdong District Committee
8	Former site of the advanced political training course organized by Zhou Enlai	27	Guangzhou Uprising Martyrs' Cemetery
9	Former site of the first CPC Guangzhou Committee	28	Site of the sacrifice of Zhou Wenyong and Chen Tiejun
10	The site of the battle of Guanyin Mountain during the Guangzhou Uprising	29	Site of Beixin Study House
11	The site of the Guangzhou Municipal Committee of the Communist Organization established after the Guangzhou Uprising	30	Site of the former organs of the CPC Guangzhou Outer County Labour Committee
12	The former residence of Xu Zhuo and Xu Xixiju	31	Former site of the Summer Palace where the anti-Japanese revolutionary struggle took place
13	Former site of the press reception hosted by Liao Chengzhi	32	Former site of the Spring Garden of the Central Committee of the Communist Organization of China
14	Former site of the Dongjiang Column Traffic Station	33	Former site of the Guangzhou Committee of the New Democratic Youth League
15	Former site of Guangzhou Brothers Book Company	34	Ruins of the First Congress of the Communist Organization of China
16	Former site of the Guangzhou Municipal Committee (Special Commissioner) of the Communist Organization of China	35	Former site of Zhongyuanxing, the secret contact point of the South China Branch of the Communist Organization of China
17	Former site of the Guangzhou office of the China Business News	36	The former site of the parade platform of the People's Liberation Army entering the city
18	Former site of the Guangdong District Committee of the Communist Organization of China	37	Guangzhou Liberation Memorial Statue
19	Site of the Three Communist Organization Congresses		

Use MATLAB to find the shortest distance:0.26204，The shortest path is :19 32 25 27 24 21 29 7 33 13 15 14 8 17 12 9 11 16 37 35 5 4 36 6 30 3 2 10 28 20 26 18 22 23 34 31 1 19. The final route planning solution and the shortest distance vs. average distance pairs are shown in Figures 3 and 4.

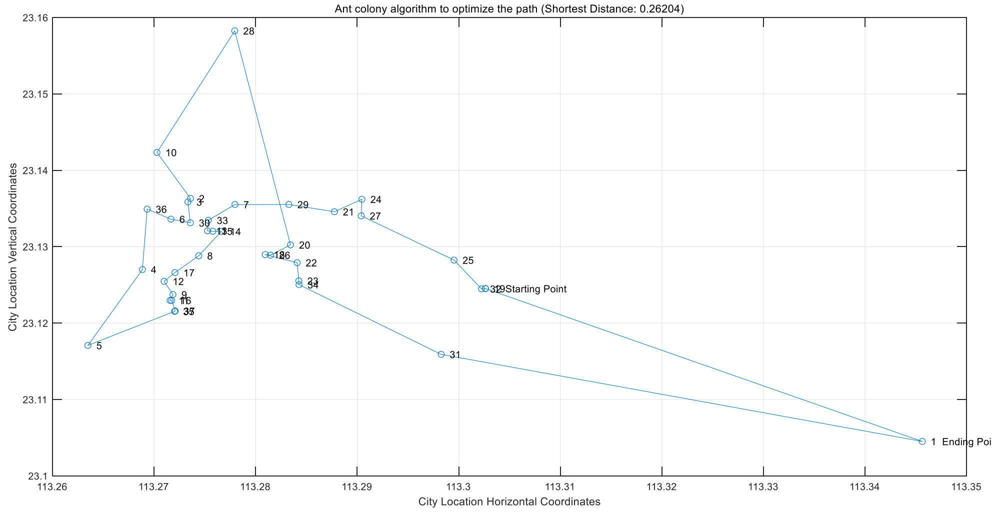

Figure 3: Results of the Red Study Path Planning in Yuexiu District

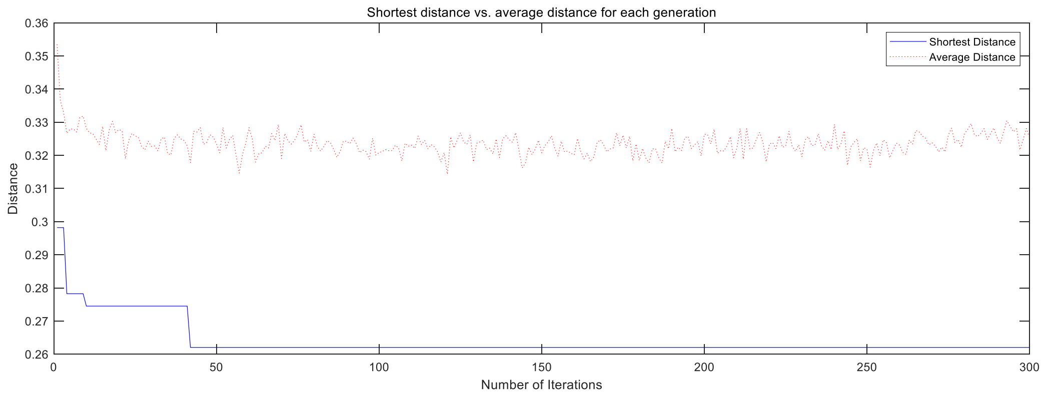

Figure 4: Shortest distance versus average distance

4.3 Model evaluation

This paper uses the ant colony algorithm in the scheme of shortest red tourism path to analyse and systematically describe the planning scheme of Guangzhou red tourist attractions based on the ant colony algorithm, considering the degree of difference of different groups and the limitation of travel expenses, which makes the planned tourism route more suitable to the actual situation. The simulation results show that the method has good practicality and effectiveness.

5. Conclusion

This paper not only considers the shortest path of tourism in the application of the ant colony algorithm, so that the algorithm can be applied to red tourism path planning in a more mature and complete way, so as to get a tourism planning path that can bring better tourism experience to travellers and make the algorithm more practical, which can bring some reference significance to the current stage of red tourism route planning [10].

In addition to the factors considered in this paper, there are other factors that affect the reasonableness of travel path planning. For example, travellers also need to consider the time dimension when travelling, such as the time spent playing, eating and staying, etc. In reality, there is also a need to consider the degree of travel experience of the tourists, as each attraction brings a different sense of experience to the tourists, which will also have an impact on the planning of the travel routes. As this paper does not consider the travel time of tourists and the impact of different attractions on their travel experience, the next step will be to consider more real-life situations and refine the analysis accordingly, to propose a more reasonable route planning scheme. In addition, this paper only uses the ant colony algorithm to solve the problem, which has its own shortcomings and may result in a relatively optimal solution rather than an optimal solution. If a hybrid algorithm can be programmed with other algorithms, better results may be achieved.

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