American Journal of Engineering Research (AJER) **2023**

American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-12, Issue-11, pp-13-26
www.ajer.org
Research Paper Open Access

Research on Red Tourism Helping Rural Revitalization Development Based on the Background of Big Data Era ——Take Guangdong Province as an example

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ABSTRACT: *Tourism is an important force to win the battle against poverty and help revitalize the countryside.This paper takes Guangdong as an example,using integrated geospatial analysis and big data technologies.ArcGIS was used to analyze the spatial distribution characteristics among red sites, tourist attractions, and village points from geospatial using kernel density.By combining the GDP and tourism revenue of each region, the Moran Index was used to understand the geospatial distribution of tourism revenue in Guangdong Province and whether there is any spatial aggregation or spatial trend.Red attractions in Meizhou City, Guangdong Province, were found to have a greater impact on tourism revenue, but a smaller impact on tourism revenue and GDP in Meizhou City.Therefore, we can rationally plan the Meizhou tourism routes, so that the proportion of tourism income in Meizhou City to the gross domestic product is elevated, and provide rich resources and opportunities for the development of red tourism at the same time, to promote the development of tourism in Meizhou, and then promote the revitalization of the countryside has a more practical significance.*

273 questionnaires were collected in this paper, and more than 1/3 of the tourists think that the shortcoming of red tourism is the monotonous travel route.In this paper, accessibility analysis was used to assess the transportation connectivity between major highways to the red sites and other scenic spots to get the tourist attractions with high accessibility.Then the hierarchical analysis method (AHP) to get the weights of different levels of tourists' degree of interest in tourism features.Based on the Ant Colony Optimization (ACO) algorithm, the shortest route is calculated with the objective of minimizing the cost.Finally, these two objectives are combined into a multi-objective planning model to find the most cost-effective and accessible route.

KEYWORDS *ArcGIS, Red Tourism, Rural Revitalization, Hierarchical Analysis Method (AHP), Ant Colony Optimization (ACO).*

Date of Submission: 06-11-2023 Date of acceptance: 21-11-2023

I.INTRODUCTION

1.1 Background of the study, research methodology, and significance of the study

With the advancement of the "14th Five-Year Plan" for tourism development, the status and role of tourism in China's economy has become increasingly prominent. As an important part of China's characteristic tourism, red tourism, and rural tourism are of great significance in promoting local economic development and passing on the red culture.

Red tourism and rural tourism is a research field that has attracted much attention in recent years and is one of the important directions in tourism development. Many scholars and research organizations are conducting in-depth studies and exploring the development of red tourism and rural tourism. Taking Gulangyu Island as an example, Li Yuan et al. used the ArcGIS geographic information system and social network model to construct a travel route system for general tourist groups and red tourism groups based on the red tourism preferences of different groups of people.[1] Huiyun Wan and Yan Jiang studied the problem of 5A attraction tourism route planning based on the ant colony algorithm, aiming to derive the optimal tourism route scheme by synthesizing the four target benefits of time, cost, distance, and experience feeling.[2] Ge Youpeng et al.'s study used POI data from Zhejiang Province to quantify the spatial distribution characteristics of red tourist attractions by means of average nearest neighbor index, kernel density analysis, and standard deviation ellipse.[3] Many researchers have also made innovative suggestions on the relationship and synergistic development between red tourism and rural tourism. Wang Ning takes the planning and design of red village tourism as the research object, discusses the problems existing in the planning and design of red village tourism, and thinks that the planning and design of red village tourism need to focus on the three aspects of "cultural inheritance, tourism experience, and economic development".[4]

Overall, there have been several researchers who have studied the theme of red tourism, but there is still some room for giving appropriate decision-making advice on red tourism under different needs. This paper uses ArcGIS spatial analysis, from the economy of Guangdong Province, with red tourism as the core, using hierarchical analysis according to the interest characteristics of different levels of tourists to make the ant colony algorithm based on the cost-effective tourism route planning. To develop red tourism while helping local rural revitalization, to promote the dissemination of the spirit of red culture and rural economic development. It also puts forward feasible suggestions to provide a reference for the development of red tourism and rural revitalization in other provinces and cities.

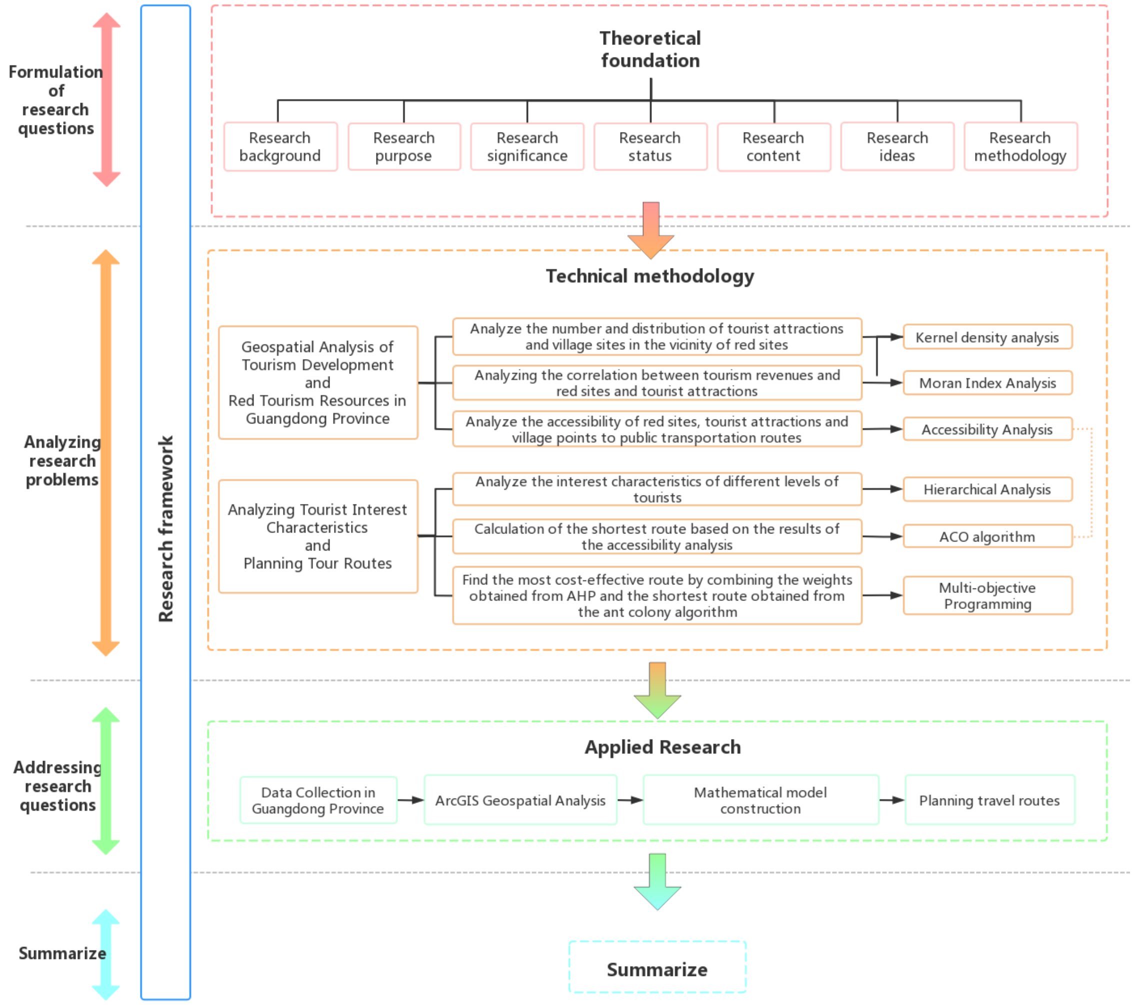

Figure 1: Research framework

1.2Data sources, Data preprocessing, Data processing software and processes

The data of key red revolutionary sites in Guangdong Province in this article comes from the red map in "Tianmap-Guangdong". The footsteps were written in Python to obtain the data of red tourism and rural tourism resources in Guangdong Province from the OGIS service of SkyMap and save them to an Excel file. The script uses the requests library for HTTP requests, the XML.etree.ElementTree to parse XML responses, and the openpyxl library to manipulate Excel files. The village point and tourist attraction data were obtained from the Golder Maps API for POI data. The main highway route data comes from SHP data obtained from Baidu Map API.

In this paper, we collect data on key red revolutionary sites, other tourist attractions, village points, and major highway routes in Guangdong Province, and import the data into ArcGIS to analyze the red sites, tourist attractions, and village points geospatially. There are over 166,000 villages in the Guangdong region, which is a high density. Relatively dense clusters of villages can be found in both urban fringes and rural areas. This paper adopts 374 key red revolutionary sites in Guangdong Province and 4585 tourist attractions for the study, which provides rich resources and opportunities for the development of red tourism and enhances the diversification of tourist routes by combining with other tourist bureau attractions to promote the development of the surrounding economy and the revitalization of the countryside.

II.MODEL INTRODUCTION AND MODEL BUILDING

2.1Kernel density analysis

Kernel density analysis is a spatial analysis method used to estimate the density of point data distributions, mainly used to study hotspot areas and density distributions.[3] Applying this method can analyze the spatial distribution of red sites, tourist attractions, and village points in Guangdong Province. The formula is as follows:

$$D(x)=\frac{1}{n\cdot h^2}\sum_{i=1}^{n}K\left(\frac{|x-x_i|}{h}\right) \quad (1)$$

Where $D(x)$ denotes the density value at point x ; n denotes the total number of point data ; x_i denotes the position of the i^{th} point ; h is the bandwidth parameter, which is used to control the degree of smoothing, and the choice of the bandwidth parameter affects the final density estimation results. $|x-x_i|$ denotes the distance between point x and point x_i . $K(u)$ is the kernel function that represents the weight of u at the distance.

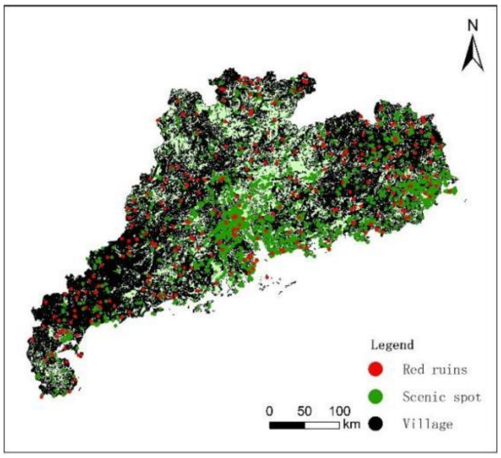

Figure 2: Distribution of Red Ruins, Tourist Attractions and Village Points in Guangdong Province

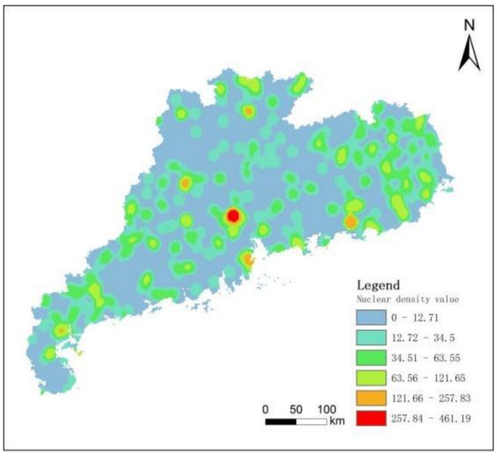

Figure 3: Kernel Density Map of Red Sites in Guangdong Province

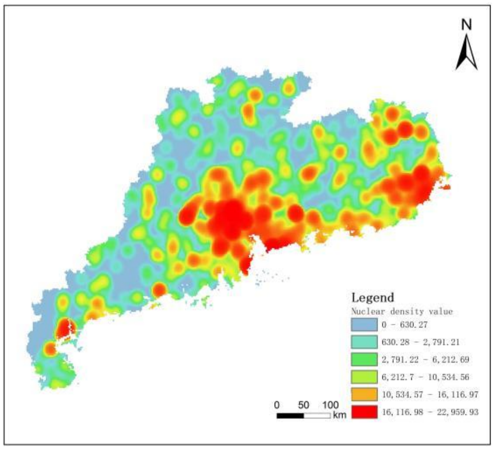

Figure 4: Kernel density map of tourist attractions in Guangdong Province

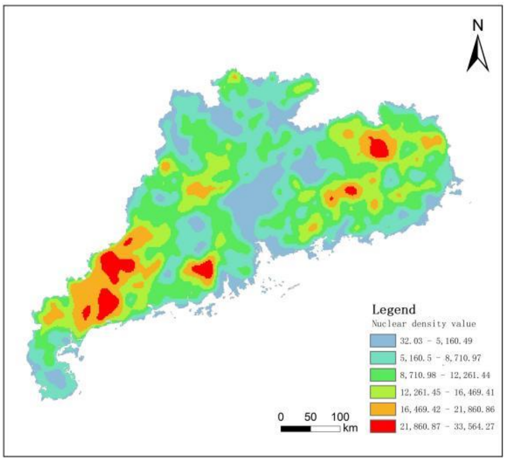

Figure 5: Density map of village point kernel in Guangdong Province

From Figure 2, in terms of quantity, Guangdong Province has a large number of red sites and tourist attractions and a large number of villages. Spatially, red sites are widely distributed; The number of tourist attractions is higher in economic centers and lower in other cities. The higher number of tourist attractions in the economic center of Guangzhou and some coastal cities such as Shenzhen and Zhuhai may be related to the marine and recreational tourism resources such as beaches, resorts, theme parks, etc. in these areas. Meanwhile, some mountainous cities such as Meizhou, Shaoguan, and Qingyuan also have more tourist attractions, which may be related to their natural beauty, landscape, and rural tourism resources. Since villages in Guangdong Province are covered all over, the villages around the red sites are denser.

2.2 Moran Index Analysis

From the kernel density analysis, it is obtained that Guangdong is rich in resources of red sites and tourist attractions. If we can explore whether there is an aggregation pattern or spatial trend of these tourism resources, we can develop targeted tourism routes. The Moran index, also known as Moran I or Moran spatial autocorrelation, is a statistical indicator used to assess spatial autocorrelation in a data set.[5] The Moran Index was used to analyze the distribution of red sites and tourist attractions in Guangdong Province in geospatial terms, with the following equation：

$$I = \frac{n}{W} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \left(x_i - \overline{x} \right) \left(x_j - \overline{x} \right)}{\sum_{i=1}^{n} \left(x_i - \overline{x} \right)^2} \tag{2}$$

where n is the number of elements in the data set ; W is the sum of spatial weights, which represents the spatial relationship between observations. Weight w_{ij} indicates the effect of element i on element j and is usually calculated based on distance or neighborhood; x_i and x_j are the values of the variables analyzed at positions i and j. $\overline{x}$ is the mean of all x-values.

When the Moran's index is close to 1, it indicates that the data show positive spatial autocorrelation, i.e., there is a tendency for aggregation.

When the Moran's index is close to -1, it indicates that the data show negative spatial autocorrelation, i.e., there is a tendency towards dispersion.

When the Moran index is close to 0, it indicates that the data are not spatially autocorrelated, i.e., they exhibit a random distribution.

The results yielded a value of 0.188 for the Moran index of autocorrelation of red sites, indicating that the spatial autocorrelation among red heritage sites is weak or even negligible. This means that the distribution of these sites is not significantly influenced by spatial proximity or other spatial relationships.

The value of Moran's index of autocorrelation of tourist attractions is -0.056, which is close to 0, indicating that the distribution of tourist attractions tends to be more homogeneous or random in space. This means that tourist attractions are less inclined to cluster together geospatially, but are relatively dispersed in different areas.

In summary, the spatial distribution of red sites and tourist attractions is relatively decentralized or randomly distributed. To make red tourism drive rural revitalization and promote the maximization of economic development. By studying the correlation between red sites for tourism income, this paper explores whether there is a spatial aggregation trend of cities, to promote rural revitalization through the development of red tourism to enhance the tourism economy.

Unsurprisingly, the Moran index of red sites on tourism income in Guangdong Province is -0.137 (e.g., Figure 6), which implies that there is a trend of dispersion between red sites and tourism income in geospatial terms. This may indicate that the distribution of tourism income in Guangdong Province is not influenced by red sites, or there is a weak spatial association between red sites and tourism income. However, in the spatial clustering diagram (e.g., Figure 7), we find that both red sites and tourism income in Meizhou City are relatively high and may show a spatially clustered trend. This implies that Meizhou City has abundant red tourism resources and that these resources contribute relatively more to tourism income. The Moran significant plot shows that the p-value of the Moran index is 0.001 (e.g., Figure 8). This p-value is an indicator used to determine whether the Moran Index is statistically significant. In this case, a p-value of 0.001 indicates that the Moran Index is highly significant, i.e., there is a non-random correlation between the spatial distribution of red attractions and the spatial distribution of tourism revenue.

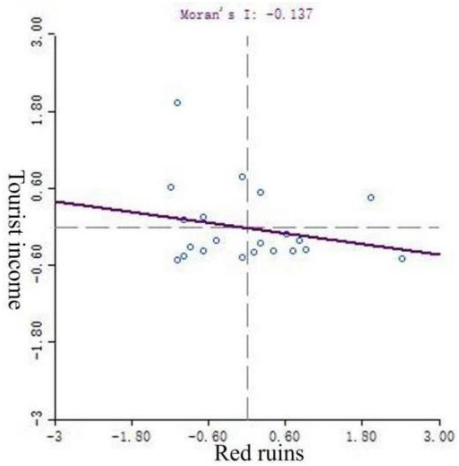

Figure 6: Moran's index of red sites on tourism income

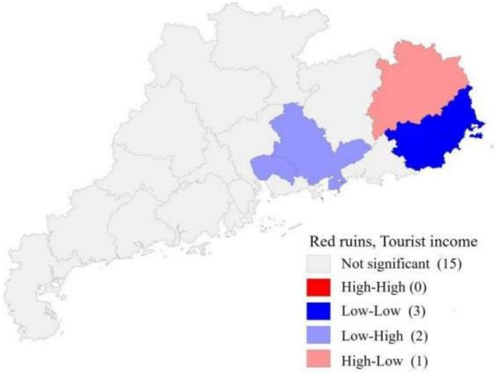

Figure 7: Spatial clustering of red sites on tourism income

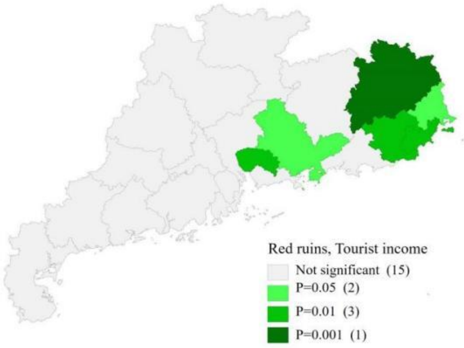

Figure 8:. Spatial clustering of red sites on tourism income

However, in the spatial clustering plot of the study of tourism revenue for GDP, Meizhou City is Low Low and Moran significant plot p=0.001. this shows that in Meizhou City, there is a significant negative correlation between tourism revenue and GDP. That is to say, tourism revenue in Meizhou city has a low impact on the gross product of Meizhou city and this correlation is statistically significant and unlikely to occur randomly.

These two findings have important implications for red tourism development and tourism resource planning. If by further exploring the tourism resources of Meizhou City in Guangdong Province, it can contribute more value to the economy of Meizhou City by boosting the city's tourism revenue and increasing the proportion of tourism revenue. This paper evaluates the transportation connectivity between major highways to red sites and other attractions in Meizhou City through accessibility analysis to identify tourist attractions with higher accessibility and provide tourists with more convenient travel routes. Then the hierarchical analysis method (AHP) is to determine the different levels of tourists' interest in tourism features of the degree of weight, and then the ant colony algorithm (Ant Colony Optimization) to calculate the shortest route, the synthesis of these two objectives for multi-objective planning, to find the most cost-effective and high accessibility of the route.

2.3 Accessibility analysis

Accessibility analysis is a methodology used to assess transportation connectivity or reachability between different locations in geographic space. In ArcGIS, reachability analysis can be performed through the Network Analyst extension, which has path solvers (i.e., Path Solver, Nearest Facility Point Solver, and OD Cost Matrix Solver) based on Dijkstra's Algorithm, the well-known algorithm used to find the shortest paths.[6] The accessibility analysis of red sites in Meizhou City is shown in Figure 9:

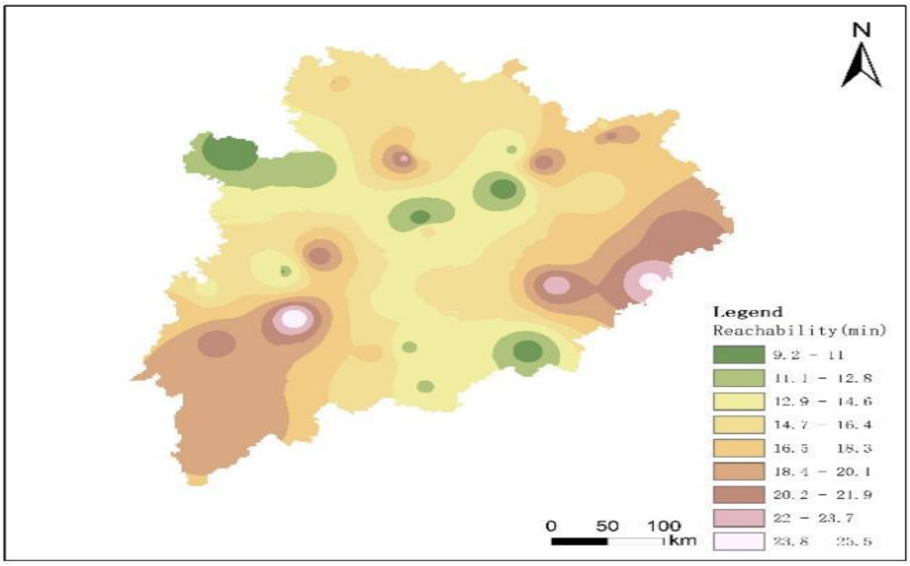

Figure 9: Accessibility Analysis of Red Sites in Meizhou City

In this paper, the accessibility value of the red sites in Meizhou City will be exceeded to find the average value of about 20.309, and the tourist routes will be planned with the sites exceeding the average accessibility value. The key red sites exceeding the average accessibility value are Yu's Ancestral Hall, the former site of the Central Red Transportation Line's Dajuzhong Station, Qiming Temple, the former site of the CPC Leungyuegan Border Committee, the organs of the Southern Working Committee of the CPC, the thirteenth regiment of the Guangdong Workers' and Peasants' Revolutionary Army and the founding of the Xingning County Committee of the CPC, the former site of the Xiping Ambush, the site of the Yingshakeng Ambush, the Yuankui Pagoda, the former residence of Li Jianshen, the Wuhua Revolutionary Martyrs' Mausoleum, and the former site of the revolutionary activities of Zhu De, the Yang's Ancestral Hall.

2.4 Hierarchical analysis method AHP

In real life, different tourists have different tourism concerns. To make the article more realistic, this paper will use the hierarchical analysis method (AHP) to determine the weights of different levels of tourists' interest in tourism features. Hierarchical analysis is a decision-making method that breaks down the elements related to decision-making into levels such as objectives, guidelines, and options, based on which qualitative and quantitative analyses are conducted.[7]

●Step 1: Define the hierarchy

Decision level: tourist destinations are selected as key red sites that exceed average accessibility values.

Criteria layer: the following criteria are selected in this paper: aesthetics of attractions, cultural and historical value, natural environment, transportation convenience, and tourism cost. From the statistics of 273 points questionnaire

Program level: four types of tourists (family tourists, student tourists, sunset tourists, government workers).

●Step 2: Create a judgment matrix

In the criterion layer, it is necessary to compare each tourism characteristic two by two to construct a judgment matrix. Each criterion in the criterion layer does not necessarily have the same weighting in the objective measure, and in the mind of the decision maker, each of them has a certain proportion. Define the judgment matrix $A=(a_{ij})_{n\times n}$ [7] by invoking the numbers 1-8 and their reciprocals as scales. In this paper, weights were set to be evaluated based on 273 questionnaires.

Table I: AHP data

	Aesthetics of the site	environment	Tourism costs	Convenience	Cultural and historical value
Aesthetics of the site	1.000	0.500	0.250	0.167	0.125
environment	2.000	1.000	0.500	0.250	0.167

Table I: AHP data

	Aesthetics of the site	environment	Tourism costs	Convenience	Cultural and historical value
Tourism costs	4.000	2.000	1.000	0.500	0.250
Convenience	6.000	4.000	2.000	1.000	0.500
Cultural and historical value	8.000	6.000	4.000	2.000	1.000

●Step 3: Calculate the weight vector

Default AHP hierarchical analysis study using sum and product method of calculation. The results of the analysis are shown in Table II:

Table II: Results of AHP hierarchical analysis

Term	eigenvector (math.)	weighting	Maximum eigenvalue	CI value
Aesthetics of the attraction	0.221	4.414%		
environment	0.379	7.586%		
Tourism costs	0.718	14.355%	5.046	0.012
Convenience	1.340	26.806%		
Cultural and historical value	2.342	46.839%		

The use of the AHP hierarchical analysis method for weight calculation also needs to carry out consistency test analysis for the study of evaluation of the consistency of the results of the weight calculation test results, that is, the calculation of consistency indicators CR value. Usually, the smaller the CR value, the better the consistency of the judgment matrix, in general, if the CR value is less than 0.1, the judgment matrix meets the consistency test; if the CR value is greater than 0.1, it means that there is no consistency, and the judgment matrix should be analyzed again after appropriate adjustment. This time for the 5^{th}-order judgment matrix calculated CI value is 0.012, for the RI value of the table for 1.120, so the calculation of the CR value of 0.010<0.1, means that this study judgment matrix to meet the consistency test, the calculation of the resulting weights have consistency.

After normalization, the criterion weight vector is calculated. The weight vector of the criterion W = [0.04415266, 0.07588704, 0.14354686, 0.2680461, 0.46836733].

●Step 4: Calculate the weights of different levels of visitors' interest in each criterion.

By weight averaging the weight vectors based on the guidelines and then normalizing them, the overall level of interest weights for each tourist category for tourism features can be calculated.

2.5 Ant Colony Algorithm for Multi-Objective Planning

This paper focuses on the tourism route planning problem, to improve the tourists to get a better experience under the limited time and distance conditions, other tourism projects with higher accessibility within the radius of the red ruins will be selected to match to improve the richness of the route. This paper will be solved by the ant colony algorithm.

Ant colony algorithm was first proposed by Italian scholars Dorigo.M et al. It is a heuristic bionic evolutionary algorithm that simulates the foraging behavior of ants in nature and belongs to the stochastic search algorithm.[8] The algorithm releases pheromone and senses the pheromone concentration on the path by simulating ants and using it to guide the direction of movement, the ants tend to move in the direction of high pheromone concentration, and eventually, all the ants will travel along the shortest path.

The ACO algorithm consists of two main parts: pheromone updating and path selection probability.

●Pheromone update:

Pheromone updating is when an ant releases a pheromone after traveling a path, depending on the quality of the path. A higher concentration of pheromone indicates a shorter path. The pheromone updating formula is as follows:

$$\tau_{i,j} = (1-\rho)\cdot\tau_{i,j} + \sum_k \Delta\tau_{i,j}^k \tag{3}$$

Where $\tau_{i,j}$ is the pheromone concentration from city i to city j ; ρ is the pheromone evaporation coefficient, which takes values in the range of [0,1] and indicates the degree of pheromone evaporation during the updating process; $\Delta\tau_{i,j}^k$ is the pheromone increment released by the kth ant on the path, depending on the ant's path quality.

●Path selection probability:

Path selection probability is the ant's choice of the next attraction based on pheromone and heuristic information. The probability formula is as follows:

$$P_{i,j}^k = \frac{\left[\tau_{i,j}\right]^\alpha \cdot \left[\eta_{i,j}\right]^\beta}{\sum_{g\in n}\left[\tau_{i,g}\right]^\alpha \cdot \left[\eta_{i,g}\right]^\beta} \tag{4}$$

Where $P_{i,j}^k$ is the probability that the k th ant chooses attraction i from attraction j ; α and β are the weighting coefficients of the pheromone and heuristic information, is the weighting coefficient of pheromone and heuristic information, which is used to adjust the ants' emphasis on pheromone and heuristic information ; $\eta_{i,j}$ is the heuristic information that represents the heuristic information from attraction i to attraction j ,It can be the distance between the attractions or the cost, etc.

2.5.1 Model Assumptions and Constraints

(1) Starting point

An ant colony algorithm is used to traverse each residence and select the appropriate residence as the starting point to start a journey and eventually return to the starting point.

(2) Travel costs

Assuming that the cost of admission to attractions is not taken into account and that only the cost of accommodation and the costs incurred on the journey are taken into account, and assuming the cost of accommodation according to the star rating of the accommodation, five-star hotel accommodation is 500 a day, four-star hotel accommodation is 400 a day, three-star hotel accommodation is 300 a day, and other hotel accommodations are 200 a day; and assuming that the cost of the journey is \$3 per kilometer. L is the length of the journey, T is the number of days traveled, and the total cost of the trip :

$$cost = 3\times L + T \times zhusu \tag{5}$$

(3) Limit on the total number of attractions

For time reasons, it is assumed that tourists will reach a maximum of five attractions per day of their journey.

$$\sum_{i=1}^n x_i \le 5 \tag{6}$$

where x_i denotes whether or not to choose to go to the i th attraction and i th attraction and n denotes the number of attractions.

(4) Limit on the number of red attractions

There are a total of 10 red attractions. Assuming that different types of tourists need to include red attractions in their routes, family tourists and sunset tourists need to reach at least 1 red attraction in a day's journey, student tourists need to reach at least 2 red attractions in a day's journey, and government workers need to reach at least 3 red attractions in a day's journey.

$$\begin{aligned} &\sum_{i=1}^{10} x_{f,i} \ge 1 \quad \text{(Family Traveler)} \\ &\sum_{i=1}^{10} x_{x,i} \ge 1 \quad \text{(Elderly Traveler)} \\ &\sum_{i=1}^{10} x_{s,i} \ge 2 \quad \text{(Student Traveler)} \\ &\sum_{i=1}^{10} x_{z,i} \ge 3 \quad \text{(Government Worker Traveler)} \end{aligned} \tag{7}$$

Where $x_{f,i}$ indicates whether the household visitor chooses to go to the i th red attraction or not, $x_{x,i}$ indicates whether sunset tourists choose to go to the i th red attraction or not, $x_{s,i}$ indicates whether the student visitor chooses to go to the i th red attraction or not, $x_{z,i}$ indicates whether government worker tourists choose to go to the i th red attraction.

(5) Travel restrictions

Through constant testing, the total distance traveled per day needs to be set slightly larger, as some residences may be too far from the attractions, and if they keep generating scenarios that don't satisfy the conditions, they will keep looping. To avoid entering a dead loop, it is assumed that the total distance traveled by transportation for a journey does not exceed 200km;

$$L \le 200 \tag{8}$$

In this paper, the distance between two points of interest is calculated using Haversine's formula. Haversine's formula is a method of calculating the distance between any two points on the Earth and is usually used to calculate the great circle distance (the shortest distance, i.e., the length of the arc on the sphere) between two points on the sphere. The formula is given below:

$$a = \sin^2\left(\frac{\Delta lat}{2}\right) + \cos(lat_1)\cdot\cos(lat_2)\cdot\sin^2\left(\frac{\Delta long}{2}\right) \tag{9}$$

$$c = 2\cdot a\tan 2\left(\sqrt{a}, \sqrt{1-a}\right) \tag{10}$$

$$L = R\cdot c \tag{11}$$

Where Δlat is the absolute value of the latitude difference ; $\Delta long$ is the absolute value of the difference in longitude ; lat_1 and lat_2 is the latitude of two points ; R is the radius of the Earth ; c represents the arc length of the sphere between two locations.

(6) Level of interest

Tourist experience often also depends on the aesthetics of the attraction, the natural environment, the cost of travel, transportation accessibility, cultural and historical value, etc. Therefore, in this paper, by scoring each attraction and using the weights to indicate the degree of interest of tourists in these five aspects of the attraction. It is assumed that the weight matrix of the degree of interest of family tourists is [0.2,0.3,0.1,0.1,0.3]; student tourists are [0.1,0.2,0.2,0.3,0.2]; sunset tourists are [0.3,0.2,0.1,0.2,0.2]; and government worker tourists are [0.15,0.1,0.25,0.25,0.25]. The weight vectors of the guidelines were weighted by a weighted average and then normalized to allow the calculation of the overall level of interest weights for each tourist category for the tourism features.

2.5.2 Objective function

In this paper, we consider arranging a three-day tour route for tourists, and the attractions are not duplicated. In this paper, we will comprehensively consider the cost-effectiveness of the tour route, i.e., the total interest of the tourists/total cost, and make the cost-effectiveness maximized by reasonably planning the attraction visit routes. The cost-effective calculation formula is as follows:

$$CP_{\max} = \frac{w_{interest} \times \sum_{i=1}^{n} \tau_{i,j}}{cost}, \forall j \in \{1,\dots,n\}, x_j \notin SC \tag{12}$$

Where $CP_{\max}$ denotes the best value for money, $w_{interest}$ indicates the weight of the level of interest of different tourists for each criterion. τ_{ij} denotes the attraction weights as the pheromone released by the ants on the pathway ; SC indicates that there is a memory to store the nodes that have been accessed.[9]

According to the objective function and constraints, this paper uses an ant colony algorithm to solve. The travel routes with the greatest cost-effectiveness for different tourists are obtained.

III.MODEL SOLUTION

3.1 model solution

Through MATLAB R2021b programming, after setting the data requirements, the first step traverses each residence with the ant colony algorithm, and the second step calculates the distance based on the latitude and longitude between attractions based on the Haversine formula; and combines the model with the corresponding data requirements to find out the optimal routes, and calculates the cost-effective ratio on each ant's path to record the best cost-effective ratio. The results are displayed as follows: Figure 9 shows the family tourists path planning results and the shortest distance compared with the average distance; Figure 10 shows the sunset tourists path planning results and the shortest distance compared with the average distance; Figure 11 shows the students tourists path planning results and the shortest distance compared with the average distance; Figure 12 shows the government workers tourists path planning results and the shortest distance compared with the average distance; and Figure 13 shows the optimal tourist planning starting point, path number per day, length of journey per day and overall value for money; and Figure 14 shows specific path planning.

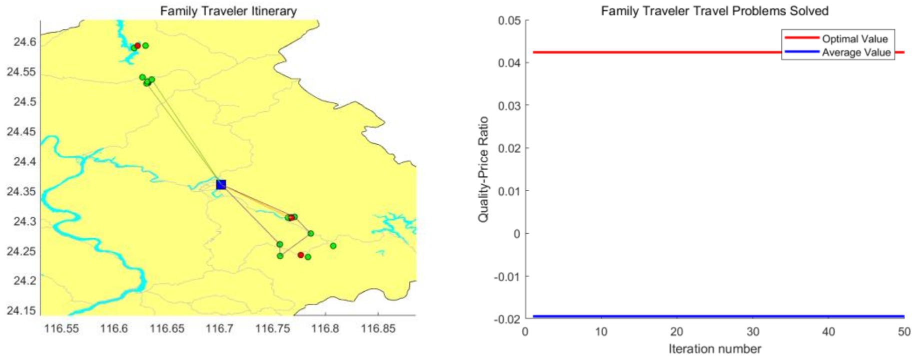

Figure 9: Family Traveler path planning results and shortest distance vs. average distance

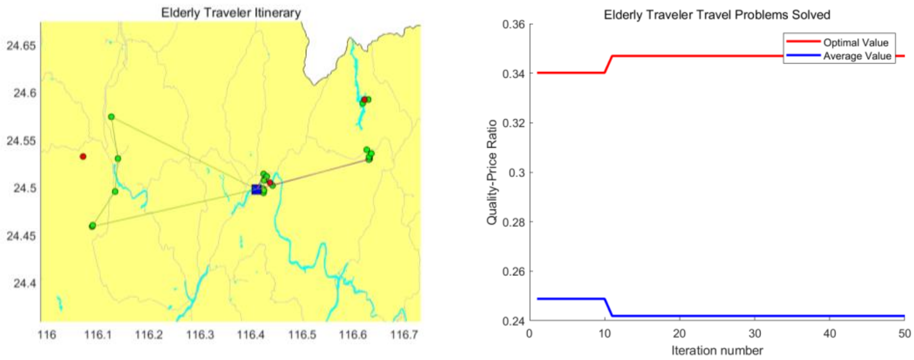

Figure 10: ElderlyTraveler path planning results and shortest distance vs. average distance

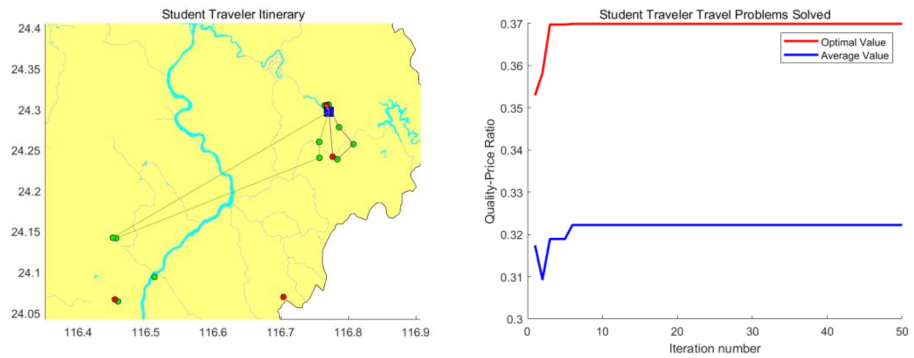

Figure 11: Student Traveler path planning results and shortest distance vs. average distance

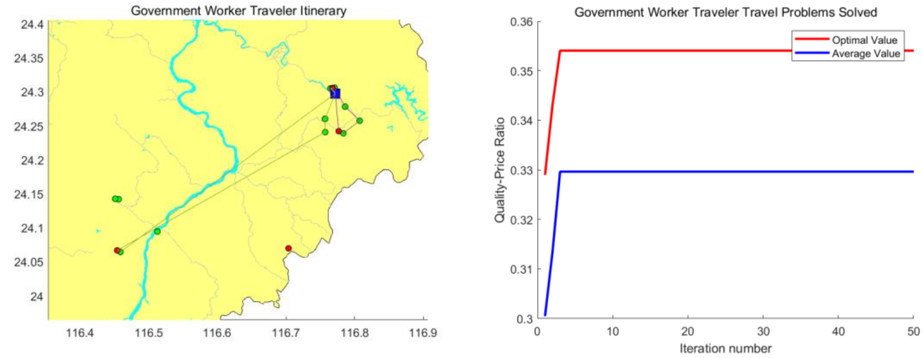

Figure 12: Government Worker Travelerpath planning results and shortest distance vs. average distance

TableIII: Specific path planning

	Day 1	*Day 2*	*Day 3*
Family Traveler	Ruixin Business Hotel (TaiPo Avenue)→Jiu Pod Ancestral Hall→Yang Clan Ancestral Hall, the former site of Zhu De's revolutionary activities→Ru Zong Yan Qing→Zhou Sima Di→Qu Heng→Ruixin Business Hotel (TaiPo Avenue)	Ruixin Business Hotel (TaiPo Avenue) →Jiu Da Tang→Jiulong Pavilion→Lian Guan's Former Residence→Lui Fang Tang (Fifth Ancestral Hall) →Guan Clan's Zhongshi Ancestral Hall→Ruixin Business Hotel (TaiPo Avenue)	Ruixin Business Hotel (TaiPo Avenue)→Glass Rafting→Glass Bridge→Millennium Bogong Tree→Celadon Porcelain→Riverside Family Red Tourism Resort→Ruixin Business Hotel (TaiPo Avenue)
Elderly Traveler	An Yu Hotel Meizhou→Songkou Buddhist Monastery→Kuangjunzhuang→ Zhang Rongxuan Memorial Hall→Shide Hall (under renovation) →Ronglu Di→An Yu Hotel Meizhou	Meizhou An Yu Hotel→Fu's Nian Er Gong Ancestral Hall Jinyutang→Yuankui Pagoda, the former site of the founding of the Song Anti-Japanese Education Association Pamphlet Hall, the former site of the Central Red Transportation Line Tai Po Central Station Dobaokeng Small Station, the former site of the Central Red Transportation Line→Yuankui Pagoda→Glass Bridge→Glass Rafting→Meizhou An Yu Hotel	Meizhou Anyu Hotel→Jiuling Windmill Corridor→Shangxinya Tingxuangong Ancestral Hall→Huilong Guzu→Huanguangju→Rongkilu→Meizhou Anyu Hotel
Student Traveler	Taipo See Hanlin B&B→State Sima Di→Ru Zong Yan Qing→Qu Heng→Jiubao Ancestral Hall→Yang Clan Ancestral Hall, the former site of Zhu De's revolutionary activities→Taipo See Hanlin B&B	Tai Po Hanlin B&B→Jiu Da Tang→Jiulong Pavilion→Wei Xin Building→Min Yue Gan Border Region Revolutionary History Exhibition Hall→Organization of the Southern Working Committee of the Communist Party of China (September 1941-June 1942) →TaiPo Hanlin B&B	TaiPo See Hanlin B&B→Guan Zhongshi Ancestral Hall→Lui Fong Tong (Fifth Ancestral Hall) →Lian Guan's Former Residence→Monument→ Bauhinia Wai→TaiPo See Hanlin B&B

Government Worker Traveler	Baihou Ruyi B&B→Jiu Bao Gong Ancestral Hall→Yang Clan Ancestral Hall, the former site of Zhu De's revolutionary activities→Zhou Simadi→Ru Zong Yan Qing→Qu Heng→Baihou Ruyi B&B	Baihou Ruyi B&B→Jiudadang→Jiulong Pavilion→Weixinlou→MinYuegan Border Region Revolutionary History Exhibition Hall→Organization of the Southern Working Committee of the Communist Party of China (September 1941-June 1942) →Baihou Ruyi B&B	Baihou Ruyi B&B→Lui Fang Tang (Fifth Ancestral Hall) → Guan Zhongshi Ancestral Hall→Lian Guan's Former Residence→Li Jianzhen's Former Residence→Jianzhen Memorial Hall→ Baihou Ruyi B&B

TableIV:Optimal starting point, path number per day, length of journey per day, and combined value for money for travel planning

	Accommodation Number	*Daily Tourist Attraction Number*	*Daily Trip Length*	*Total Cost*	*Quality-Price Ratio*
Family Traveler	320	53-10-51-49-52,50-57-58-59-56,43-41-42-44-45,	[18.5560472889285,32.5028607675822,41.8847550578513]	878.8309893	0.042407684
Elderly Traveler	247	30-34-31-32-36,33-7-35-41-43, 26-28-27-29-25,	[6.53015990990591,46.6787326914700,78.1041903533105]	993.9392489	0.346946401
Student Traveler	765	49-51-52-53-10,50-57-54-55-3, 56-59-58-37-39,	[2.36411028293649,17.7263997038281,76.4543264993579]	889.6345095	0.36991145
Government Worker Traveler	1225	53-10-49-51-52,50-57-54-55-3, 59-56-58-8-40,	[2.57612257207198,17.7264914090434,84.5813212610054]	914.6518057	0.354064667

4.2 model evaluation

In this paper, the ant colony algorithm is used to analyze the scheme of minimizing the red tourism path, and systematically describes the planning scheme of combining the red attractions with other tourist attractions in Guangdong Province based on the ant colony algorithm, and takes into account the degree of difference of four different groups, namely, families, students, sunset, and government workers, as well as the limitation of tourism spending, to make the planned tourism routes more in line with the actual situation. The simulation results show that the method has good practicality and effectiveness.

There are many benefits to installing a monitoring system — some of which strongly interrelate with each other. A properly designed and installed monitoring system offers a deeper understanding of the operational parameters of the system. A close appraisal of the data generated by a monitoring system can reveal a variety of overt and subtle opportunities, including:

Environmental —better knowledge of how energy is used allows you to identify an array of prospects to improve efficiency and reduce energy consumption.

Reliability — assessment of data from the monitoring system can reveal existing or imminent issues that can adversely affect the operation and product within a facility. Historical data from monitoring systems can help locate and correct both acute and chronic problems, resulting in increased productivity.

Maintenance — Data trends can forecast and notify the appropriate people when discrete equipment parameters may be exceeded, allowing you to plan instead of facing an unscheduled shutdown.

Financial — each benefit discussed above either directly or indirectly influences a business's bottom line. In most cases, the monetary impact from even one or two benefits can quickly justify the purchase and installation of a monitoring system.

IV.SUMMARY

Red tourism and rural tourism also face some problems in the development process, such as the dispersion and lack of linkage between scenic spots. Therefore, this study aims to take Guangdong Province as an example to explore the combination of red tourism and other tourist attractions. Through planning and design, it aims to achieve close connections between benign coupling regions, improve tourism attractiveness and competitiveness, and promote the sustainable development of red tourism in Guangdong Province.

The shortcomings of this article lie in the fact that the model assumptions do not take into account more actual influencing factors; The calculation of distance between scenic spots in this article uses the Haversine formula based on spherical approximation, which may have errors in extreme distances; This study focuses on using ant colony algorithm for problem solving. It should be noted that ant colony algorithm has some limitations in practical applications, which may lead to solution results approaching the optimal rather than absolute optimal. Consider using a mixed programming method with multiple algorithms, which may improve the solution effect.

ACKNOWLEDGMENTS

This work was supported by2022 Guangdong Undergraduate Innovation and Entrepreneurship Training Program and Zhujiang College of South China Agricultural UniversityFunding Project (No.S202212623021),and 2021 School level Education and Teaching Reform Project of Zhujiang College of South China Agricultural University "Research and Practice of Online and Offline Integrated Teaching Mode of Linear Algebra", and 2022 School level Education and Teaching Reform Project of Zhujiang College of South China Agricultural University "Mathematics and Interdisciplinary Second Classroom Teaching Practice"(No.2022ZJZLGC15).

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