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Greedy Algorithm Based Travel Route Planning under Multi-objective Decision Making

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Abstract

In this paper, greedy algorithm is used to optimize the planning of tourism routes based on multi-objective decision theory. The main goal of the research is to design the best travel route for foreign tourists by considering various factors such as time, cost and number of attractions. Firstly, this paper establishes a dataset including information of cities, attraction ratings, transportation time and cost through data integration and processing. Secondly, this paper used hierarchical analysis to evaluate 352 cities in multiple dimensions and identified the 50 cities that are most desirable to foreign tourists. Finally, combined with the greedy algorithm, this paper designed multiple optimization strategies under different constraints. The greedy algorithm used in the study can quickly provide tourist routes that meet the needs of tourists under multi-objective decision-making, and at the same time provides a new way of thinking for the planning of tourist routes.

Keywords

Route Planning; Multi-objective Decision Making; Hierarchical Analysis; Greedy Algorithm.

1. Introduction

In this paper, an effective method to optimize tourism routes[1] is explored under multi-objective decision-making[1], combined with greedy algorithm[3], hierarchical analysis[4], and other computer algorithms. Firstly, 352 cities were comprehensively evaluated by hierarchical analysis, and the 50 most desirable cities for foreign tourists were selected from the dimensions of city scale, transportation convenience and climate. Then, the greedy algorithm was used to design various optimization strategies[5] for the objectives of time, cost, and number of attractions, which provided tourists with a route planning scheme to maximize the number of cities, minimize the travel cost, and optimize the number of attractions within a limited period. In addition, for tourists with special needs, such as only visiting mountain scenery, this paper provides a personalized tour plan[6] for them through the greedy algorithm and route screening strategy. The study shows that the greedy algorithm has high efficiency in multi-objective tourism route planning and can quickly come up with the best route that meets the needs of tourists.

2. Top Rated Attractions Explored

2.1. Data Preprocessing

First of all, the data of tourist attractions are processed, and the data set of 35,200 attractions in 352 cities are integrated, and in the integration, this paper found that there are a large number of blank values and anomalies in the data, and for the integrated data, we delete the

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rows containing blank values, 0 and -- that appear in the scoring columns, and the remaining attractions after processing are 14,860 places.

2.2. Data Analysis

Using the cleaned dataset as described above, it was programmed and processed to produce the results shown in Table 1.

Table 1. Attractions Data

Highest national rating (BS)	5.0
Number of top-rated attractions in the country	2381
Cities with the most Top Rated (BS) attractions rated	Yuxi (21)
Top 10 Cities with the Highest Rated (BS) Attractions	Yuxi (21) Yiyang (20)
	Daxing'anling (18)
	Weifang (18)
	Yantai (18)
	Zhoukou (16)
	Zigong (16)
	Xingtai (16)
	Baoding (15)
	Wanning (14)

The top 10 cities in terms of the number of highest rated (BS) attractions are visualized and the results are shown in Figure 1 below.

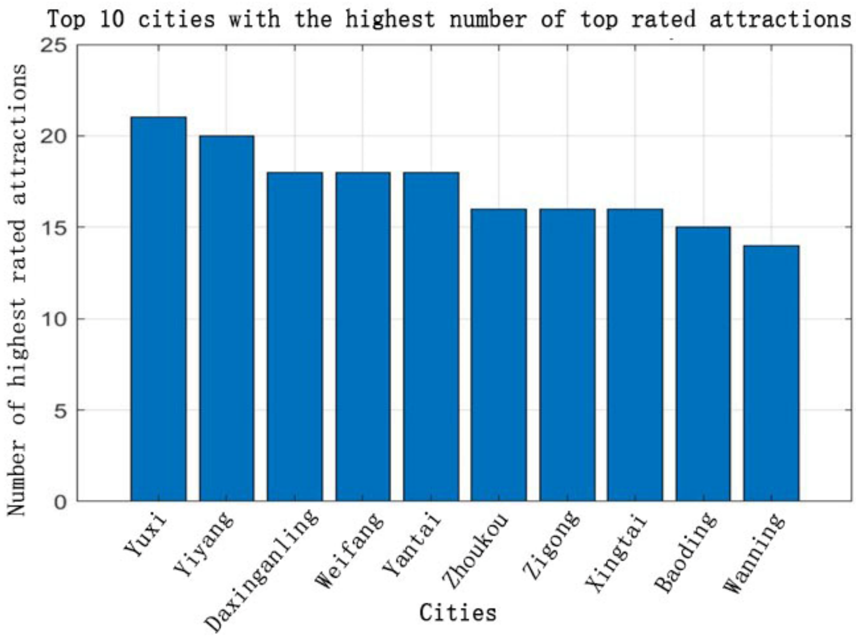

Figure 1. Cities with the highest number of top-rated attractions top 10

In this section, the cities with the highest number of top rated attractions are ranked in reverse order, and the top 10 cities, from highest to lowest, are: Yuxi, Yiyang, Daxinganling, Huafang, Yantai, Zhoukou, Zigong, Xingtai, Baoding, and Wanning, with Yuxi having the most top rated attractions with 21 top rated attractions, making it the city with the highest number of top rated (BS) attractions.

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3. Assessment of the 50 Most Desirable Cities for Foreign Tourists

3.1. Evaluation System Construction

For this section, since it is necessary to follow the "principle of visiting the best attractions in the city", i.e., each city chooses its highest rated attractions to visit, then the "number of attractions to visit" can be simplified to the "number of cities to visit", which can greatly reduce the amount of data, i.e., from 30,000 + to 300 + data volume. At this time, we can establish a multi-indicator evaluation model by processing the indicators of these 300 + cities, and finally make a comprehensive scoring of the cities according to their respective weights and select the "50 most desirable cities for foreign tourists".

For the selection of judging indicators, we mainly start from these aspects:

(1) Environmental protection (including air quality, green coverage, wastewater and gas treatment rate, and garbage classification and disposal rate).

(2) Cultural heritage (including the number of historical sites, the number of museums, the number of cultural facilities, the frequency of cultural activities).

(3) Transportation convenience (including public transportation coverage, mileage of highways, number of airport flights).

(4) Climate (including average annual temperature, annual precipitation, number of days suitable for tourism).

(5) Gastronomy (including number of specialties, frequency of gastronomic events, number of restaurants).

Since the number of playable attractions in each city is large and the number is not very different, it can be considered that the city size is in the same situation, so this paper does not take the city size as a judging index.

3.2. Scoring Methods

(1) Normalization

Due to the different scales of the indicators, the first thing to do is to normalize these different scales of data to make them the same quantitative indicator, specifically using the method of using a single data divided by the square of all the data and the open root sign, i.e.:

$$C_{ij}^{*} = \frac{C_{ij}}{\sqrt{C_{11}^{2}+C_{12}^{2}+\cdots+C_{ab}^{2}}}(1 \leq i \leq a, 1 \leq j \leq b) \quad (1)$$

(2) Weight Allocation

As foreigners do not know much about our country, they know very little about each place, and their evaluation is more objective. Therefore, the evaluation of each place needs to be a combination of various aspects, not to emphasize a prominent aspect, but to consider all aspects in a balanced way, thus in this paper, the weight of each indicator is set equal, balancing the comprehensive situation of each place for scoring. The specific calculation method of weight is:

$$W = \frac{1}{n}(\text{n is the number of indicators to be evaluated}) \quad (2)$$

The final calculated unified weight is 0.0556.

(3) Weighting the Indexes

The weighted data can be obtained by multiplying the data in step 1 with the weights obtained in step 2:

$$Ws_{ij} = W * C_{ij}^{*} \quad (3)$$

(4) Determine the Positive and Negative Ideal Solutions

Find the maximum and minimum values in the weighted metrics, which are the positive and negative ideal solutions:

$$A_{+} = Ws_{\max} \tag{4}$$

$$A_{-} = Ws_{\min} \tag{5}$$

(5) Calculate the Maximum and Minimum Distance

Sum each of the weighted data by differing and squaring them with the positive and negative ideal solutions respectively, after which it is sufficient to open the root sign:

$$L_{\max} = \sqrt{\sum_i^a \sum_j^b \left(Ws_{ij} - A_{+}\right)^2} \tag{6}$$

$$L_{\min} = \sqrt{\sum_i^a \sum_j^b \left(Ws_{ij} - A_{-}\right)^2} \tag{7}$$

(6) Calculation of Relative Proximity

By calculating the relative proximity, this can be used as the final city composite score. The calculation method is as follows:

$$P = \frac{L_{\min}}{L_{\max} + L_{\min}} \tag{8}$$

Through the above steps, the overall score of each city can be calculated, which can be used as the ranking of the "50 Most Desirable Cities for Foreign Tourists".

4. Tour Route Planning

For this section, the foreign tourists' tour objective is to visit as many cities as possible and to have the best comprehensive tour experience, and there are three requirements in this section:

(1) Follow the principle of visiting the best attractions in the cities.

(2) Choose only high-speed rail for transportation between cities.

(3) Only choose the cities to visit from the "50 most desirable cities for foreign tourists".

For requirement (1), attractions can be converted into cities, which can greatly reduce the amount of data, thus ensuring the accuracy of the results. For requirements (2) and (3), the high-speed rail information of 50 cities can be queried to determine whether the high-speed rail is available in this place, so that a certain number of cities can be filtered out to achieve simplicity.

After some simplification, it is considered that this section belongs to optimal path planning, i.e., selecting some number of optimal solutions for path planning among multiple objectives, and since conditions such as the total time spent, the total cost of tickets and transportation, and the number of attractions that can be visited are given, it can be assumed that from these aspects, it is necessary to reach the most number of attractions (cities) to visit in a certain time (144h), then A path and cost optimization model can be built for this. In this model, to achieve the maximum utilization of time and the greatest number of attractions to play, the objective function can be established as follows:

$$\begin{cases} \max \sum_i^k \sum_j^l T_i + t_{ij} (k, l < 50) \\ \max M_i \end{cases} \tag{9}$$

Where: T_i, M_i and t_{ij} represent the playing time in each city, the number of cities and the transportation time between each city, respectively.

For this objective function the constraints are:

$$\begin{cases} 0 \leq T_i + t_{ij} \leq 144 \\ 0 \leq M_i \leq 50 \end{cases} \tag{10}$$

That is, the sum of transportation time and playing time is less than 144 h, and the number of playing cities is among the “50 most desirable cities for foreign tourists”.

For this model, the greedy algorithm is used to select the nearest unvisited city as much as possible, and by doing so, the program with the largest time and the largest number of cities to visit can be selected, and the tour route is planned accordingly, and the optimal program is finally obtained.

Finally, the tour route is obtained as follows: Guangzhou → Zhongshan → Zhuhai → Xianning → Qianjiang → Yichang → Enshi, with a total time spent of 132.65 hours, and a total ticket and transportation cost of 3578.09 yuan, which can be used to play a total of 7 BS attractions.

The obtained results are summarized in Table 2 below.

Table 2. Summary of Results

Projects	Results
Total time spent	132.65 h
Total cost of admission and transportation	3587.09 yuan
Number of attractions you can visit	7
Itinerary	Guangzhou → Zhongshan → Zhuhai → Xianning → Qianjiang → Yichang → Enshi

5. Route Optimization based on the Number of Cities Visited and the Cost

The objective of the tour plan in this section is to visit as many cities as possible while keeping the total cost of tickets and transportation as low as possible.

Since this section gives the requirement to reduce the cost and visit as many attractions as possible, the objective function can be created as follows:

$$\begin{cases} \max \sum_i^k \sum_j^l T_i + t_{ij} \\ \max M_i \\ \min \sum_i^k \sum_j^l H_i + h_{ij} \end{cases} \tag{11}$$

Where: $T_i, M_i, H_i, h_{ij}, t_{ij}$ represent the time spent in each city, the number of cities, the cost of tickets in each city, and the cost of travel between cities.

For this objective function the constraints are:

$$\begin{cases} 0 \leq T_i + t_{ij} \leq 144 \\ 0 \leq M_i \leq 50 \end{cases} \tag{12}$$

For this model, through the greedy algorithm to consider the time and cost as much as possible to choose the route to play, through such a choice, can be selected to minimize the cost expenditure and play the most goals of the program, as well as play the corresponding planning of the tour route, and ultimately come up with the optimal program.

The final tour route is: Guangzhou → Jiayuguan → Tonghua, the total time spent is 140.0 hours, the total cost of tickets and transportation is 1146.59 yuan, and a total of 3 BS attractions can be played.

6. Tour Route Planning for Mountain View City under Multi-Objective

For this section, the tour objectives for foreign tourists are to visit as many cities as possible and to have the best combined tour experience, and there are three requirements in this section:

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(1) Only one of the highest rated mountains will be visited in each city.

(2) Only high-speed trains are used for transportation between cities;

(3) The cities to be visited are not limited to the “50 most desirable cities for foreign tourists” but are expanded to 352 cities.

For requirement (3), the first dataset can be built by converting mountains into cities, which can greatly reduce the amount of data and thus ensure the quality of the data.

This will greatly reduce the amount of data and ensure the accuracy of the results. For requirements (1) and (2), the high-speed rail information of the cities contained in the first dataset can be queried to determine whether the high-speed rail is available in this place, so that a certain number of cities can be filtered out to achieve simplicity.

A path and cost optimization model are developed for this section. In this model, to achieve the least cost and the most attractions to visit, the objective function can be established as follows:

$$\begin{cases} \max \sum_i^k \sum_j^l T_i + t_{ij} (k, l < 50) \\ \max M_i \end{cases} \tag{13}$$

Where: T_i , M_i and t_{ij} represent the playing time in each city, the number of cities and the transportation time between each city, respectively.

For this objective function the constraints are:

$$\begin{cases} 0 \le T_i + t_{ij} \le 144 \\ \quad 0 \le M_i \le 352 \end{cases} \tag{14}$$

Finally, the obtained results are summarized in Table 3 below.

Table 3. Summary of results

Projects	Result
Optimal starting city	Nanshan National Forest Park
Total time spent	143.79 h
Total cost of admission and transportation	3087.98 yuan
Number of attractions you can visit	12
Itinerary	Nanshan National Forest Park → Five Fingers Peak Scenic Area → Shanxi Wangjia compound → Funiushan Geological Park → Siming Mountain Staff Tin Scenic Area → Jiangxi Wugong Mountain National Scenic Spot → Shugang Xifeng Ecological Park → Yichang Dongshan Park → Linzhou Taihang Huanghuashan → Shaoshi Mountain → Xiaoheishan Forest Park → Beihai Guantuling Dive Base

7. Conclusion

Using multi-objective decision theory, combined with greedy algorithm and hierarchical analysis method, this paper proposes an effective method to optimize travel routes, aiming to provide foreign tourists with the best travel planning scheme. By constructing a dataset containing multi-dimensional information such as cities, attraction ratings, transportation time and cost, this paper used hierarchical analysis to comprehensively evaluate 352 cities and selected the 50 cities most favored by foreign tourists. Subsequently, the greedy algorithm was applied to design several tourist routes for different optimization objectives (e.g., time, cost, and number of attractions). The results show that the greedy algorithm has high computational efficiency under multiple objectives and can quickly provide the optimal route that meets the needs of tourists. By accurately calculating factors such as transportation time, cost, and the number of attractions, it can effectively design both economical and efficient tourist routes for tourists and improve the intelligence level of tourism planning. Especially under special needs, the greedy algorithm provides the feasibility of personalized and customized tourism solutions.

References

[1] Li Ting. Modeling and optimization of tourist-oriented travel route planning problem[D]. Northeastern University, 2022.DOI: 10.27007/d.cnki.gdbeu.2022.000572.

[2] Le Meilong, Huang Cuiping. Research on multi-objective decision making for airplane routes[J]. Journal of Wuhan University of Technology (Information and Management Engineering Edition), 2014, 36(04):546-549.

[3] Yuan Jiangshu, Feng Zhenyu, Zhu Tianle, et al. Optimization design of tourism routes in Huangshan scenic area based on greedy algorithm[J]. Modern Commerce Industry,2020,41(20): 32-33.DOI: 10. 19311/j.cnki.1672-3198.2020.20.016.

[4] Ma Hui, Liu Bin. Highway route comparison method based on improved fuzzy hierarchical analysis [J]. Highway Traffic Technology,2022,38(04): 41-47.DOI: 10.13607/j. cnki. gljt. 2022. 04.007.

[5] Sun Haodong, Wang Rui, Liu Siyang, et al. Research on tourism route planning based on multi-objective optimization model[C]//Professional Committee on Urban Transportation Planning, China Society of Urban Planning. Green Numerical Intelligence: Enhancing Quality and Efficiency - Proceedings of the 2024 Annual Conference on Urban Transportation Planning in China. Beijing Institute of Urban Planning and Design; Changsha University of Science and Technology; Beijing Institute of Technology;2024: 13.DOI: 10.26914/c.cnkihy.2024.038591.

[6] Zhang Hengxun. Research and implementation of personalized travel route recommendation technology[D]. Huazhong University of Science and Technology, 2023. DOI: 10. 27157/ d. cnki. ghzku. 2023. 001069.