Research on Optimization of Tourism Route Based on Genetic Algorithm

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Abstract. This paper aims at the tourist route planning of 47 scenic spots faced by tourists when traveling in Chongqing. The route distance and transportation cost of tourists during travel are taken into account and the optimal planning of tourist routes are recommended to meet their personal needs. First, the coordinates of longitude and latitude of each attraction and the transportation costs between the attractions are collected. Second, the distance target and transportation cost target are combined into a combined target by using the weighting coefficient method. Finally, the optimal solution of the combined target was solved by the genetic algorithm. The result obtained is that when only the cost is considered, the distance of 47 attractions is 2257.76 kilometers and the transportation cost is 2866.2 yuan. While only the distance is analyzed, the above two values are 1426.68 kilometers and 4931.18 yuan, respectively.

1. Introduction
The development strategy of global tourism has broken through the concept of resources in traditional scenic spots and the scenic spots extend to farming folk customs and industrial heritage such as social resources [1-2]. However, with the sharp increase in the number of available locations, how to help users quickly plan travel routes according to the needs of tourists has become a difficult problem to be solved in global tourism, which makes the research of related travel route planning methods be the current research front in the tourism field [3-6].

At present, although tourists can conveniently view relevant information on the Internet when planning their trips, it still requires a lot of time and effort. Therefore, in order to solve the tourist route planning problems faced by tourists when traveling, this paper uses the idea of multi-objective conversion and genetic algorithm to establish a mathematical model for the tourist route planning, which comprehensively considers the needs of route distances and transportation costs during the user travel. Finally the planning of tourist routes and recommend tourist routes that meet their personal needs are obtained.

2. Route Optimization

2.1. Multi-Objective Function into a Single Objective Function
Evaluating the advantages and disadvantages of a route is mainly determined by the total distance between the attractions and the total transportation cost. The distance is determined by the distance between each city and the distance objective function obtained is
\[ f_i(X) = \sum_{i,j}^{} d_{ij}, i \neq j, \]  
\[ f_z(X) = \sum_{i,j}^{} s_{ij}, i \neq j. \]

Where \( d_{ij} \) shows the distance from the attraction \( i \) to attraction \( j \).

The objective function \([7-9]\) of the total transportation cost for each route is

\[ f_z(X) = \sum_{i,j}^{} s_{ij}, i \neq j. \]

In (2), the total transportation cost of each route can be obtained.

Using the weighted combination method, the distance objective function and the transportation cost objective function can be converted into a single objective function, and the combined objective function is solved to obtain optimal solution as

\[ f(x) = \lambda \sum_{i,j}^{} d_{ij} + (1 - \lambda) \sum_{i,j}^{} s_{ij}, i \neq j, \]

Where \( \lambda \) is the weight factor and its range is \( 0 \leq \lambda \leq 1 \). When \( \lambda = 0 \), it means that it only takes the transportation cost into consideration for the tourist route. While \( \lambda = 1 \), it means that only the distance is considered.

2.2. Data Normalization

Because the difference between the distance and the cost numerical dimension is large, then the data must be dimensionless \([10]\).

The latitude and longitude data for each attraction are as follows:

| Attraction Name            | Latitude | Longitude |
|---------------------------|----------|-----------|
| Dazu Rock Carving         | 29.7131  | 105.7284  |
| Qinglong Lake             | 29.7131  | 106.1734  |
| Liberation Monument       | 29.5661  | 106.5861  |

As shown in Table 1, the longitude and latitude of each attraction are not much different, and the normalization is more conducive to the differentiation of the location of each attraction. The normalized result is

| Attraction Name            | Longitude | Dimension |
|---------------------------|-----------|-----------|
| Dazu Rock Carving         | 0.0000    | 0.3752    |
| Hongchiba                 | 0.7964    | 1.0000    |
| Great Hall of the People  | 0.1998    | 0.3258    |

As shown in Table 2, the differences in latitude and longitude of each attraction's location after normalization are more obvious.

The transportation cost data between various attractions is as follows:

| Attraction Name            | Tea and Bamboo Forest | Ciqikou ancient town | Happy Valley |
|---------------------------|-----------------------|----------------------|--------------|
| Tea and Bamboo Forest     | 0.00                  | 133.60               | 162.20       |
| Ciqikou ancient town      | 139.13                | 113.60               | 98.80        |
| Happy Valley              | 162.60                | 229.60               | 248.80       |
As shown in Table 3, the transportation costs of various attractions vary greatly and the dimension of the distance value is relatively large. Consequently, the method of normalization can eliminate the dimensional impact of distance and transportation cost and the normalized result is

Table 4. Transport costs between some attractions after normalization

|                          | Tea and bamboo Forest | Ciqikou ancient town | Happy Valley |
|--------------------------|-----------------------|----------------------|--------------|
| Tea and Bamboo Forest    | 0                     | 0.1218               | 0.1424       |
| Ciqikou ancient town    | 0.1218                | 0                    | 0.2011       |
| Happy Valley            | 0.1424                | 0.2011               | 0            |

As shown in Table 4, the normalized transportation costs between various attractions are more reasonable.

2.3. Optimal Route Using Genetic Algorithm

Collected the relevant information of 47 scenic spots in Chongqing and the 47 cities are as follows:

Table 5. The table of scenic spots

| number | scenic spot                      | number | scenic spot                      |
|--------|----------------------------------|--------|----------------------------------|
| 0      | Dazu Rock Carvings               | 24     | Three natural bridges            |
| 1      | Tea and Bamboo Forest            | 25     | Fairy mountain                   |
| 2      | Qinglong Lake                    | 26     | Snow Jade Cave                   |
| 3      | Hechuan fishing city             | 27     | Huatian Valley                   |
| 4      | The Four Sided Mountain          | 28     | Ayi river rafting                |
| 5      | Ciqikou ancient town             | 29     | Yushan ancient town              |
| 6      | Happy Valley                     | 30     | Wujiang Gallery                  |
| 7      | Guanyinqiao pedestrian street    | 31     | Zhou’ Stockade                   |
| 8      | Old town of anziba               | 32     | Gong Tan ancient town            |
| 9      | Great Hall of the People         | 33     | Taibaiyan Park                   |
| 10     | Arhat Temple                     | 34     | Waterfall group tourist area     |
| 11     | Hongya cave                      | 35     | Ancient town of Luotian          |
| 12     | Liberation Monument              | 36     | Gaoyang Ping Lake                |
| 13     | ChaoTianmen Square               | 37     | Three Gorges Cultural Relics Park|
| 14     | Foreigner's Street               | 38     | The Peach Garden                 |
| 15     | Golden knife Gorge               | 39     | Longtang Geopark                 |
| 16     | A tree viewing platform          | 40     | Hongchiba                        |
| 17     | Foying gorge                     | 41     | Shidi ancient town               |
| 18     | Liangjiang Movie City            | 42     | Xiaozhai Tiankeng                |
| 19     | Wansheng Stone Forest            | 43     | Wuxi Lingwu cave                 |
| 20     | Black Valley                     | 44     | Wushan Goddess Heaven Road       |
| 21     | Mount Putuo                      | 45     | Small Three Gorges               |
| 22     | Big wood Flower Valley           | 46     | Tong Jing hot spring             |
| 23     | Baiheliang underwater Museum     |        |                                  |

Using Genetic Algorithm [11-13] to solve the optimal solution of the combined objective function, we can get the most suitable tourist route. Through experiments, i.e. the weight value of $\lambda$ is 0, 0.2, 0.4, 0.6, 0.8 and 1, respectively, the results of distance, traffic cost and combined objective function values are as follows:
Table 6. The table of experimental result

| λ  | distance | cost   | value |
|----|----------|--------|-------|
| 0  | 23.16    | 2686.2 | 2.353 |
| 0.2| 19.8581  | 2947.04| 3.1591|
| 0.4| 15.9275  | 3334.51| 3.5041|
| 0.6| 14.8663  | 3035.8 | 3.5464|
| 0.8| 13.458   | 3816.06| 3.6988|
| 1  | 12.853   | 4931.18| 3.5638|

As shown in Table 6, when only considering the transportation cost, the distance to complete 47 scenic spots is 2570.76 kilometers, and the transportation cost is 2686.2 yuan; when only considering the distance, the distance to complete 47 scenic spots is 1426.68km, and the transportation cost is 4931.18 yuan. When the value of $\lambda$ increases, the distance decreases gradually, and the traffic cost increases as a whole; when the value of $\lambda$ is about 0.4, the traffic cost changes less.

When $\lambda=1$ in the process of population evolution, the curve change of the minimum and average value of the combination objective function of the population is as follows:

![Figure 1. The curve of Algorithm evolution](image)

In Figure 1, it can be seen that the value of the optimal solution of the population is less than the average value of the population in the first 100 evolutions. While the evolution reaches 450 iteration steps, the value of the optimal solution is basically equal to the average value, which indicates that the algorithm is convergence.
It can be seen from Figure 2, tourists start from Hongchiba in Wuxi and finally arrive at Shidi ancient town in Xiushan with the shortest distance. The detailed route is 40->43->45->44->42->39->36->34->33->35->27->26->23->21->18->46->15->3->2->0->1->5->6->14->7->8->9->10->12->11->13->16->17->4->19->20->24->25->29->28->30->31->32->38->41.

As shown in Figure 3, tourists start from Hongchiba in Wuxi and finally arrive at the old city of anziba with short route distance and less transportation cost. The detailed route is 40->43->45->44->42->39->37->36->33->34->35->27->26->25->29->31->32->41->38->30->28->24->23->22->21->17->20->19->4->1->0->3->15->46->18->6->2->5->7->9->11->13->12->10->16->14->8.

As shown in Figure 4, tourists start from Luotian ancient town and finally arrive at the tea mountain and bamboo sea in Yongchuan with the lowest transportation cost. The detailed route is 35->26->23->22->25->24->27->8->33->34->37->36->40->43->42->44->45->39->28->38->30->41.
From Figure 2-4, it can be seen that the weight of traffic cost is larger, then the crossing degree of the planned route is heavier. While, the weights of the route distance and traffic cost are little difference, then the crossing degree of the planned route is less.

3. Conclusion

This paper not only considers the distance, but also fully analyses the factor of transportation cost. The multiple factors are integrated into an objective function to make the problem simple and meet the requirements of tourists. The genetic algorithm is used to find the best route more quickly. Through adjusting the importance of various factors according to their own situation, the route of tourists' satisfaction is planned with good scalability.

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5. References

[1] Chen Xiang, Yang Jianlong. Research on the current situation of China's tourism development. Value engineering, 2016, 35 (06): 219-222.
[2] Gao Rui. On the current situation and development trend of China's tourism industry. Tourism overview (industry Edition), 2012 (05): 82.
[3] Xiaohui Qian, Xiaopeng Zhong. Optimal individualized multimedia tourism route planning based on ant colony algorithms and large data hidden mining. Multimedia Tools and Applications, 2019, 78(15).
[4] Kenneth C. Gilbert, Ruth B. Hofstra. A New Multiperiod Multiple Traveling Salesman Problem with Heuristic and Application to a Scheduling Problem. Decision Sciences, 1992, 23 (1): 250-259.
[5] Xiong Y, Schneider J B. Shortest Path within Polygon and Best Path around or through Barriers. Journal of Urban Planning & Development, 1992, 118 (2): 65-79.
[6] Alhanjouri M, Alfarra B. Ant Colony versus Genetic Algorithm based on Travelling Salesman Problem. International Journal of Computer Technology, &Applications, 2011, 02 (03): 570-578.
[7] Wang Jigang, Hu Yonghui, he Zhemin, Yang Haiyan, Hou Juan. Application of linear weighted combination Kalman filter in clock difference prediction. Tian Wenxue Bao, 2012, 53 (03): 213-221.
[8] Du Minhua, Tian Long. Optimization of vacuum freeze drying process of strawberry pulp by linear weighted combination method. Food industry, 2007 (04): 15-17.
[9] Bai Xuemei. Discussion on linear weighted combination weighting method. Statistics and information, 1998 (03): 5-6.
[10] Ji Xiaojiang, Du Sanbao, Wang Guandong. Determination of regional economic growth difference by min max standardized analysis method -- Taking Yulin area of Shaanxi Province as an example. Economy and management, 2016, 30 (03): 54-56 [11] Holland J.H. Outline for a logical theory of adaptive systems. Journal of the Association for Computing Machinery, 1962, 9 (3): 297-314.
[11] Pei Jiaming, Zhou Bin, Li Li. TSP algorithm based on genetic algorithm to solve the shortest journey of 20 major cities. Computer knowledge and technology, 2019, 15 (16): 194-195.
[12] Zeng Wenfei, Zhang Yingjie, Yan Ling. Basic principles and application of genetic algorithm. Software guide, 2009, 8 (09): 54-56.