Tourism Route Planning Based on 0-1 Algorithm and Multi-Traveler Modeling--A Case Study of Sichuan Province

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Abstract. With the booming development of tourism market, how to efficiently plan tourism routes has become a common concern of travelers and tourism departments. In this paper, the TSP model and multi-traveler model for tourism route planning are established for the Sichuan tourism problem by using mathematical modeling techniques such as 0-1 planning and minimum spanning tree method, combined with equilibrium function. By studying the approximate optimal solution of the NP-hard problem, it provides tourists with an economical and efficient tourism route planning scheme. The research results show that the model proposed in this paper can effectively solve the tourism route planning problem and provide decision support for tourists and tourism departments.

Keywords: TSP model, Multi-traveler problem, 0-1 planning, Minimum spanning tree method, Route planning

1 INTRODUCTION

1.1 A Subsection Sample

Tourism route design is an important part of the smooth implementation of tourism activities. In order to obtain a satisfactory tourism route plan, tourists need to collect a large amount of information before starting tourism activities, which not only consumes a lot of time and energy, but also makes it difficult for tourists to make the best tourism route decision in the face of various conflicting goals[1]. Therefore, the study of tourism route design is particularly important for improving tourists' travel satisfaction and enhancing the service quality of scenic spots.

Sichuan, abbreviated as “Sichuan” or “Shu”, with its capital Chengdu, is located in the southwest hinterland of mainland China, and has been known as the “Land of Heavenly Capital” since ancient times, the gateway to western China and the hometown of giant pandas. Sichuan now and Chongqing, Guizhou, Yunnan, Tibet, Qinghai, Gansu, Shaanxi provinces and municipalities border. The eastern part of Sichuan is the Parallel Ridge Valley in eastern Sichuan and the hills in central Sichuan, the central part is the Chengdu Plain, and the western part is the western Si-

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chuan Plateau. Sichuan has a long history, splendid culture and colorful natural scenery, including Jiuzhaigou, Huanglong, Dujiangyan, Mount Qingcheng, Leshan Giant Buddha, Mount Emei, Sanxingdui, Jinsha Ruins, Wuhou Ancestral Temple, Dufu Cao Tang, Kuanzhi Alley, Langzhong Ancient City, Hailougou, Mount Siguniang, and Inagashiyadin, and other tourist attractions which are famous both at home and abroad[2].

In tourism management, tourism route design is one of the core contents, which involves how to plan the optimal tourism experience according to tourists' needs, time, budget, and the characteristics of the attractions, of which the most important ones are the following three categories: centralized time tour design, inter-period decentralized tour design, and time-specific diversion tour design[3]. “Focused time tour design aims to create a route for tourists to visit as many attractions as possible in a limited period of time, such as a month-long summer vacation. This design belongs to the maximized coverage design or intensive route design, and its core objective is to maximize the tourism experience within a given period of time. Secondly, the “inter-period dispersed tour design” is aimed at tourists who need to complete their travel plans in multiple time periods, such as two years between summer vacations[4]. This design is a manifestation of the long-term planning route design or phased tour design, which requires effective allocation of tourism resources in different time periods to maximize cost-effectiveness. Finally, the “time-specific diversion tour design” is specifically designed for peak periods such as the “11th Golden Week”, which improves the quality of hospitality by designing multiple tour routes to spread out the flow of tourists[5]. This type of design is known as holiday peak diversion design or time-specific route design, and it aims to enhance the tourist experience and optimize service levels by providing a variety of route options.

2 MODELS

2.1 Concentrated Time Tour Design: Development of a Classical TSP Model Based on 0-1 Planning

Firstly, the latitude and longitude information of 15 major attractions in Sichuan is collected and mapped to construct the distance matrix between two by two of the 15 attractions and transform it into a practice matrix.

The assignment graph is denoted as G=(V,E),V is the set of vertices, E is the set of edges, and the distance between vertices is known. If (i, j) is on the loop path, then x_{ij} takes 1, otherwise it takes 0.

$$\max \omega=\sum_{i=1}^{15}\sum_{j=1}^{15} x_{ij}$$

$$\text{s.t.}\begin{cases}\sum_{i=1}^{15} x_{ij} = 1, and\ \sum_{j=1}^{15} x_{ij} = 1\\ \sum_{i=1}^{15}\sum_{j=1}^{15}\big(T(i) + D(i,j)\big) * x_{ij} \le 30\end{cases}$$

The objective is to solve for the maximum number of classics, with the first of the constraints indicating that each attraction is passed through only once, and the second of the constraints indicating that the duration of the tour is less than or equal to 30 days. T(i) denotes the time spent at i, D(i,j), denotes the travel time from i to j.

Assuming that the next 15 attractions can be fully completed in one month, in order to study the best route to play, looking for the route that can play the most attractions in a short period of time and this route as the best route, so the calculation of the route in the drive were 24 hours, 12 hours, 6 hours to complete the most attractions of the route plotted in the cumulative distance traveled on each route line graphs shown in Fig. 1.

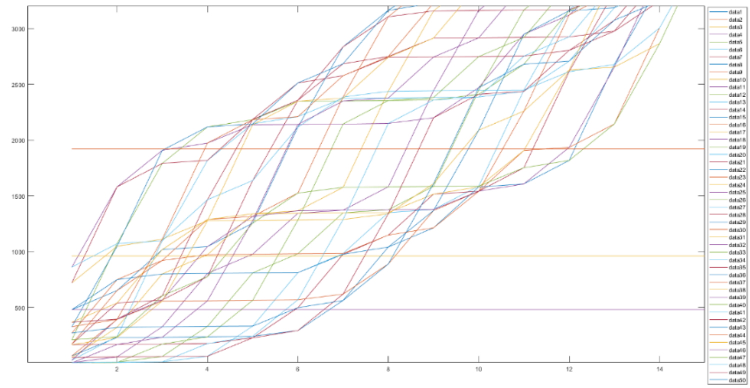

Fig. 1. Line graph of cumulative distance traveled for each route

Calculated the recommended route with suitable intensity: Hailuogou --> Emei Mountain --> Leshan Giant Buddha --> Broad and Narrow Alley --> Wuhou Ancestral Temple --> Dufu Cao Tang --> Jinsha Ruins --> Sanxingdui --> Langzhong Ancient City

2.2 Inter-Period Decentralized Tour Design: Integrating the Multi-Traveler Model Formed by the Traveler Model

15 attractions are divided into two tours, in order to achieve the purpose of time, transportation costs as much as possible to save, and strive to two tour routes balanced, the balance of the two travel routes measured by the time equilibrium function, when B ≤ 0.1, it can be considered that the results have reached an approximate balance of the

$$B=\frac{maxT_i - minT_I}{maxT_i}$$

The most densely packed attraction in the surrounding area is regarded as the root of the tree, and the attractions closest to the root are regarded as the trunk of the tree, and so on as the branches of the tree.

The trunk, and so on as branches of the tree, divides the tree into two partitions, and applies the classical TSP model based on 0-1 planning established in Problem 1 to each partition to obtain the total time and total spending, and then combines the two to arrive at the final travel planning scheme.

$$\max \omega = x_{ij} * DT_{ij} + \frac{x_{ij} * (T_i + T_j)}{2}$$

$$\text{s.t.} f(x) = \begin{cases} \sum_{i=1}^{15} x_{ij} = 1 \quad \sum_{j=1}^{15} x_{ij} = 1 \\ u_i - u_j + n x_{ij} \le n - 1, 1 \le i \ne j \le n \end{cases}$$

In this study, we propose an algorithmic framework designed to optimize tourist route planning. The algorithm first utilizes the minimum spanning tree method to divide all attractions into two regions, which ensures the solvability of the problem. Subsequently, for each region, we constructed complete graphs and applied a pre-established model to solve the shortest tour route, thus avoiding repeated visits to either attraction in the route. In addition, we introduced a time-equilibrium function to test whether the time allocation of the resulting routes is balanced in order to prevent the phenomenon of multiple circuits. The test result of this function determines the iterative process of the algorithm: if the test passes, the algorithm is terminated and the optimal route is outputted; if it does not pass, the route optimization is repeated. Through this iterative optimization process, we are able to ensure that the designed tourist routes are both efficient and economical, meeting the needs of tourists to visit more attractions in a limited time.

First time route: Dufu Cao Tang-->Jinsha Ruins-->Langzhong Ancient City-->Jiuzhaigou-->Huanglong-->Siguniangshan-->Dujiangyan-->Qingcheng Mountain-->Dufu Cao Tang

Second time route: Dufu Qiaotang-->KuanNarrow Alley-->Wuhou Ancestral Temple-->Leshan Buddha-->Mount Emei-->Inacheng Yading-->Hailuogou-->Dufu Qiaotang

2.3 Minimum Spanning Tree Algorithm: Specific Time Period Diversion Tour Design

In the face of a surge in the number of tourists during peak travel periods, such as holidays, this study proposes an innovative approach to tourism route planning, aiming to alleviate crowd density and optimize tourists' travel experience through multi-route diversion. In order to achieve this goal, we carefully selected 11 popular attractions from many tourist attractions in Sichuan, including the famous Jiuzhaigou, Huanglong, Dujiangyan, Qingchengshan, Leshan Giant Buddha, etc., and numbered them sequentially as Node1 to Node11 for subsequent algorithmic processing.

Based on the construction principle of minimum spanning tree, we formulated three grouping principles: first, dividing the attractions on the same branch within the same group as far as possible to maintain geographic continuity; second, assigning neighboring stem and branch attractions to the same group to reduce the tourists' transfer time between different attractions; and lastly, ensuring that the total touring time of each group ranges between 5 and 10 days to accommodate the different tourists' schedules and preferences.

In the assumption of the source of tourists, we mainly considered tourists from outside Sichuan Province, considering that they may need to cross a longer distance to reach the first attraction, we assumed that the average distance is 800 kilometers, and the round trip time is about 20 hours. Based on this assumption, we projected that each group of routes should contain at least 4 attractions and at most 9 attractions to achieve effective diversification of passenger flow. To further improve the diversion effect, we try to choose different starting points for each group of routes.

Through this strategy, we successfully divided the 11 attractions into five groups, which greatly dispersed the flow of visitors and at the same time ensured that each group of routes was optimized in terms of distance. In addition, we estimated the corresponding costs for each group of routes, which were $4,023.6, $5,031.0, $4,617.3, $4,636.9, and $5,231.3, respectively, which provided important reference data for the tourism sector when formulating tour packages. In the end, we designed six distinctive tour routes, which not only meet the tourists' travel demand during the peak period, but also provide a new strategy and tool for tourism management.

Route 1: The itinerary includes visits to Huanglong, Dujiangyan, Sanxingdui, Du Fu Cao Tang, and ends at Kuan Narrow Alley, with a planned tour duration of six days. The total cost is approximately $719.57.

Route 2: This route covers Jiuzhaigou, Huanglong, Dujiangyan, and Mount Qingcheng, with a planned tour duration of five days. The estimated cost is about $618.23.

Route 3: Commencing from Kuanzhaigou, the route proceeds through Emei Mountain, Sanxingdui, Dujiangyan, and Huanglong, concluding at Jiuzhaigou, encompassing a 7-day journey. The total cost amounts to roughly $773.08.

Route 4: Beginning at Leshan Buddha, this route includes visits to Jinsha Ruins, Wuhou Temple, Sanxingdui, Dujiangyan, and Mount Qingcheng, also spanning 7 days. The total cost is around $710.02.

Route 5: Starting at Dufu Cao Tang, the route continues through Jinsha Ruins, Wuhou Temple, Sanxingdui, Emei Mountain, and concludes at Kuan Narrow Alley, also lasting for 7 days. The estimated cost is approximately $714.86.

Route 6: The final route initiates at Jiuzhaigou, traverses Huanglong, Dujiangyan, Sanxingdui, Wuhou Temple, Jinsha Ruins, and culminates at Dufu Cao Tang, with a duration of 8 days. The total cost is about $805.58.

3 DISCUSSION

The study's findings underscore the potential for policy-driven enhancements in tourism route planning within Sichuan Province. By adopting the proposed 0-1 planning and multi-traveler modeling techniques, local authorities can strategically optimize routes to alleviate peak season congestion, ensuring a more sustainable and enjoyable experience for tourists. The model's emphasis on cost-effectiveness and time balance provides a framework for policymakers to allocate resources efficiently and to develop long-term tourism strategies that are both economically viable and environmentally considerate. The study's findings underscore the importance of a data-driven and strategic approach to tourism management. By applying mathematical modeling techniques, the proposed framework can optimize the allocation of tourism resources, reduce congestion during peak travel periods, and ensure a sustainable tourism experience. The recommended routes and the algorithmic framework for iterative optimization provide a solid foundation for future research and practical application in the tourism industry, offering a valuable tool for policymakers and tourism authorities to manage and enhance the tourism experience in Sichuan and beyond.

4 CONCLUSION

The paper proposes a data-driven tourism route planning method for Sichuan, utilizing the TSP model and multi-traveler analysis. It benefits tourists with cost-effective routes and supports tourism departments with strategic decision-making, improving satisfaction and service quality. The approach optimizes resource allocation, mitigates peak travel issues, and promotes sustainable tourism, laying groundwork for future research and practical use as a policy tool for enhancing tourism in Sichuan and beyond.

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