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An Optimal Path Recommendation Algorithm for Traveling Based on Social Networks and Interest Hotspot Graphs

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ABSTRACT

In recent years, tourism has rapidly developed into a key economic sector, with travel route recommendation algorithms playing a vital role in enhancing tourists' experiences. These algorithms often utilize large amounts of travel data, social networks, and interest hotspots maps to recommend optimal routes. Social networks, as online platforms for communication and content sharing, help connect people, while interest hotspots maps visualize popular topics on social media. This paper proposes a tourism route recommendation algorithm based on social networks and interest hotspots maps, combining tourist preferences and scenic spot data. By analyzing tourist needs and scenic spot conditions, the algorithm improves route recommendations, reducing analysis time and increasing accuracy. Research results show that, before using this algorithm, tourists rated travel time, routes, and attractions at 87.25, 86.84, and 88.62 points, respectively. After using the travel route recommendation algorithm, tourists' satisfaction was 95.76 points, 96.48 points and 92.89 points respectively. These results can showed that the travel route recommendation algorithm can improve the satisfaction of tourists, and that the research of travel route recommendation algorithm based on social networks and interest hotspots map was of practical value. This also provided a new research path for tourism route recommendation technology.

Keywords: Social Network, Interest Hotspots Map, Travel Route Recommendation Algorithm, Development Stage of Social Network

1. Introduction

In recent years, the level of urbanization is getting higher and higher, and the demand for travel is getting more and more, which creates a great pressure on the comprehensive index improvement of air, railroad, and urban transportation [1-3]. At the same time, with the improvement of living

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standards, the traveler's consideration is no longer the shortest distance, but a comprehensive consideration from all aspects, so as to arrive at the best travel route. Factors considered include the traveler's purpose of travel, physical condition, safety performance, acceptable type of transportation, cost, fuel consumption, preference, time urgency, minimum walking distance, the number of transfers, the number of people travelling together, the current road conditions, traffic conditions, whether it is a holiday, personalized needs, etc. [4-7]. It is obvious that the shortest route is not equal to the best route. The optimal route problem is the most basic and critical problem in GIS spatial analysis [8]. For different application environments, the optimal path can represent a variety of meanings. Generally speaking, it mainly refers to three meanings. First, the shortest path in the sense of pure distance, referring to the actual mileage; second, the shortest path in the sense of economic distance, i.e., the least cost; third, the shortest path in the sense of time distance, i.e., the least amount of time spent in the urban transportation, the common modes of transportation, including buses, cabs, private cars, motorcycles, and bicycles, the choice of different modes of transportation, travel time (time distance), travel distance (pure distance), the degree of congestion The time of travel (time distance), distance traveled (pure distance), congestion, cost of travel (economic distance) and level of service differ between the different modes of transportation chosen [9-11]. Based on the many factors considered for optimal routes, it is necessary to select appropriate analytical methods and algorithms for planning.

Social network analysis is a method for studying social structures and relationships, which reveals patterns and patterns in social networks by analyzing the connections and interactions between individuals [12]. It can help people carry out simulation and prediction of network dynamics. By building network evolution models, it can simulate the interaction and relationship changes between individuals in the network and predict the development trend and evolution law of the network [13]. Social network analysis can also help people to reveal the information dissemination in the social network, influence to show the diffusion path and influence range of information in the network, to help people better understand the mechanism and law of information dissemination, and through the analysis of the network of individuals in the degree of centrality, the degree of authority and other indicators, it can be revealed in the network of the transmission, the structure of power and other important features [14-15]. In order to better understand the multidimensional situation of travelers and give reliable travel reference routes. And hotspot map as a chart with different colors or different brightness to indicate the density of data, it can intuitively show the distribution of data and heat distribution [16]. It can visualize the distribution of travelers' interests and preferences, etc., and satisfy the travelers' experience to the greatest extent.

With the prosperity of the economy and the increase in the number of trips taken by residents, improving the efficiency of transportation resource utilization has become an important means of alleviating traffic congestion, and the best way to improve the efficiency of transportation resource utilization is to improve the travel efficiency by public transportation and other means of transportation, reduce the number of transfers, travel time and cost [17-19]. Therefore, the most simple and effective optimal path algorithm has become a hot issue in many people's research [20]. Since there are many kinds of “optimal” indicators, researchers can choose different algorithms from different perspectives.

2. Overview

There are many travel purposes, such as tourism, logistics and transportation, general travel, and rescue travel. In tourism travel, literature [21], after constructing a data model of travelers' travel history and preferences, used deep learning to match these information data with destination geolocation information and performed a hierarchical analysis of travelers and destinations to obtain an optimal route algorithm. Literature [22] used an enhanced genetic algorithm to design optimal travel routes to multiple tourist attractions taking into account physical exertion and planned detailed travel arrangements based on the number of travel days. Literature [23] proposed a novel graph search algorithm supported by the output of a large language model, which integrates the traveler's starting and ending points, attractions of interest in the trip, the hotness of the attractions, and the time distance, in order to recommend the best travel route. Literature [24] uses an improved ant colony optimization algorithm for experience-enhanced travel path planning taking into account the weather, comfort, and other information of the attractions. And literature [25] proposed the optimal travel route by balancing the flow of scenic spots with the carrying capacity of the destination under the improved ant colony optimization algorithm. Literature [26] predicted the optimal route recommendation mechanism for scenic spots using neural network algorithm and realized the optimal path recommendation under particle swarm algorithm, in which five dimensions, namely, traveler preference, to cite one example, road condition, weather, and route heat, were considered. Literature [27] first constructed a core scenic area priority model through the best-worst method, and then used genetic algorithms to plan the core scenic area's travel routes, and obtained the best travel routes for multiple core scenic areas under the reduction of costs and the improvement of experience happiness.

In other trips, literature [28] designed a logistics optimal travel route planning system, route search through Google Maps and its multiple destinations, identifying the best route with Dijkstra's algorithm, and considering the previous traffic conditions, travel time, speed, and destinations, which ultimately improves the efficiency of the trip and operator monitoring. Literature [29] developed a popular route planning system including popular wire maps, travel cost models, and efficient route planning algorithms based on optimal route combinations of start locations and start times, which performs friendly to travelers unfamiliar with the road network. In particular, literature [30] designed a route planning method for low-exposure trips considering physical characteristics such as air pollution conditions, trip purpose, and traveler's age, but the route planning scheme may have detours and different exposure times for different age groups under the same route. Similarly, literature [31] developed a travel route model for avoiding COVID-19 hotspot areas, which contains two models, static and dynamic, the former considers the shortest route planning for avoiding hotspot areas, and the latter takes into account the real-time change information of the hotspot areas, which are used in different pandemic scenarios but can be used in conjunction with each other to plan the optimal routes that are safe at the planning office. Literature [32] builds a deep reinforcement learning-supported carpooling route planning system that can shorten travel time while protecting privacy. Literature [33] designed a stochastic Monte Carlo tree search in a multi-objective environment to optimize the search cost and efficiency and gave the Pareto-optimal bus routes. Literature [34] set up a traffic-aware road network and a set of travel queries, and used greedy algorithm and e-refinement algorithm to solve the algorithmic computational difficulty of the optimal route planning in accounting for the traffic flow, preventing congestion during peak hours, etc., in order to achieve the optimal paths for large-scale travel. Literature [35] proposed a method using GIS tools to plan the optimal route for traffic jams due to earthquakes taking into account the cost and the condition of the buildings. Literature [36] developed an intelligent optimal route recommendation system with three modules: personality search, optimal budget allocation implemented by genetic algorithm, and optimal route planning improved to mimic the ant colony method.

3. Social Network and Travel Route Recommendation Algorithm

3.1. Concept of Social Network and Development Stage

Social network is a kind of electronic media platform that allows users to create personal data and establish relationships with other users. Users can post messages, share links, images and videos on social networks. Users can also use social networks to communicate with other users and share information and views. In the development process of social network, it is mainly divided into four stages.

1) Primary stage. In the early stages, social networks were email-based platforms like Yahoo Groups and MSN Groups, allowing users to create communities for sharing information and discussions on specific topics. Although user numbers were small, these platforms laid the foundation for future social network development by offering new ways to establish contacts and share content.
2) Web-based stage. In the web-based stage, social networks like MySpace and LinkedIn allowed users to create personal homepages and connect with others. These networks expanded beyond basic chat and information sharing, adding features and privacy settings to protect personal data. As internet technology advanced, social networks evolved into mobile-based platforms, with web-based social media remaining a key form, though not the only one.
3) Mobile social network stage. The mobile social network stage allows users to access social networks anytime, anywhere via smartphones or tablets, revolutionizing communication and interaction. Users can update statuses, share content, and view updates through mobile apps, with location-based features like sharing locations and discovering nearby people or places. This shift has created new communication and marketing opportunities but also raised issues like privacy protection and false information. Users must be cautious about their privacy and critically assess the authenticity of information on mobile social networks.
4) Diversified development stage. The stage of diversified development of social networks refers to the stage of simultaneous development of social networks in multiple fields. At this stage, social network is not only a pure social platform, but also extends in different fields, covering more content and functions. The diversified development of social networks is mainly reflected in the following aspects. Content diversification: social networks not only provide pure social functions, but also provide information, entertainment, education and other content. Diversified functions: social networks not only provide pure communication functions, but also provide shopping, payment, games and other functions. For example, some social networks would provide e-commerce platforms, online payment, games and other functions. Some social networks also provide live video, short video sharing and other functions. Domain diversification: social networks not only develop in social fields, but also involve more fields, such as education, medical care, finance, etc. For example, some social networks would provide online courses, community learning and other educational functions. Some social networks would provide health consultation, online doctors and other medical functions. Some social networks would provide financial functions such as financial consultation and online payment.

The development stage of social network is shown in Figure 1.

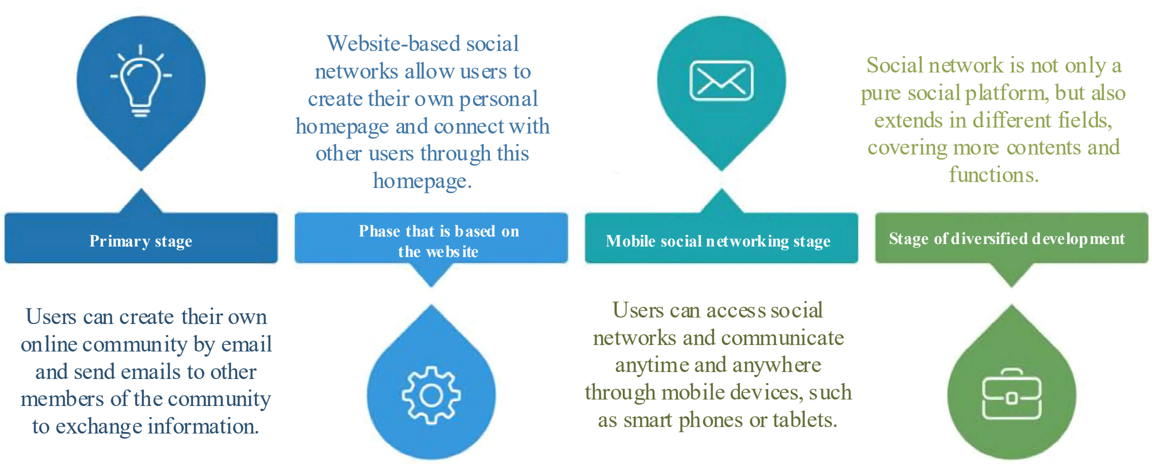


Fig. 1. Development stage of social network

3.2. Main Categories of Social Network Applications

Social network applications refer to software or websites that combine the Internet and social elements. They usually allow users to create profiles, upload photos, connect with other users and exchange information. Users can use them to keep in touch with friends and family, or to exchange and share information with new people. In social networks, they are mainly divided into four categories.

1) Community forum. A social network community forum is an online platform where users can post information, participate in discussions, and exchange ideas. Organized into thematic sections, forums help users connect, share information, and build social relationships. However, issues like spam, harassment, and inappropriate speech can arise, impacting the forum's effectiveness. These platforms are valuable for communication and information gathering but require moderation.

2) Instant messaging application. Instant messaging applications allow real-time communication through text, voice, or video, with features like group chat, file transfer, and video calls. These apps are popular for keeping in touch anytime, anywhere, but may pose privacy risks, spam, and fraud. Users should protect their privacy and follow usage guidelines to ensure safe communication.

3) Content social application. Content social applications allow users to share and interact with videos, pictures, music, or articles. They offer features like personalized recommendations, user accounts, subscriptions, and social interactions (comments, likes, sharing). Accessible on smartphones, tablets, or browsers, these apps help users discover new content, track activities, and stay updated with notifications. They enhance social engagement while enabling content creation and sharing within a community.

4) Strange friends application. Strange dating application is a social network application that allows users to find new friends, pair or date. These applications usually ask users to fill in personal information, provide some matching criteria, and then provide users with potential matching or appointment suggestions. These applications may use various methods to determine the match, such as interest, goal, lifestyle or geographical location. Strange dating applications can usually be used on smart phones or tablets, and can also be accessed through web browsers. Its core functions need to include chat, intelligent matching, short video live broadcast and dynamic plaza. Focusing on the design concept of classification aggregation, the product architecture needs to display the core functions together on the home page, such as online intelligent speed matching, live chat, video matching and other forms of play functions. This allows users to quickly build a bridge between information transmission and interaction to meet the needs of social matching.

The main categories of social network applications are shown in Figure 2.

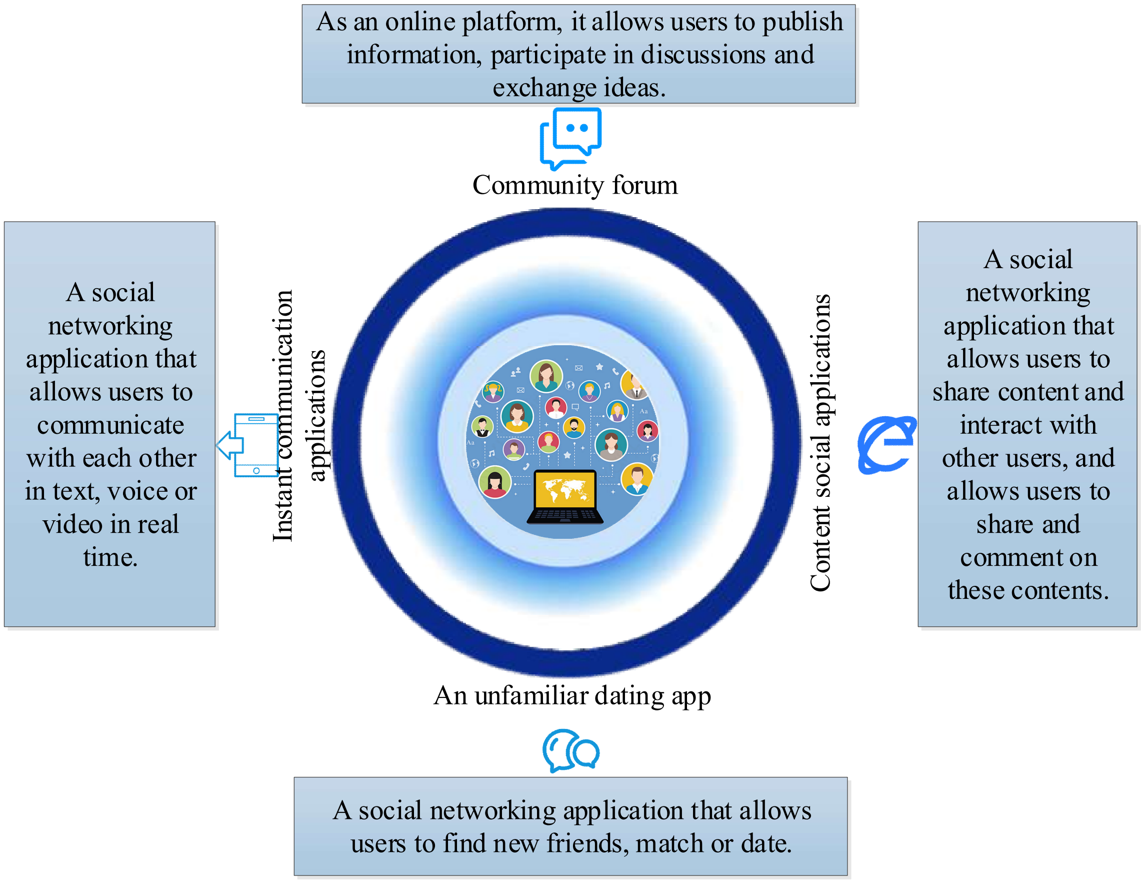


Fig. 2. Main categories of social network applications

3.3. *General Process of the Travel Route Recommendation Algorithm*

The travel route recommendation algorithm is a technology that can help tourists plan their travel routes. It usually uses machine learning algorithms to simulate people's way of thinking, and recommends appropriate travel routes based on tourists' needs and preferences. The general process of the travel route recommendation algorithm is as follows.

1) Tourist input demand. In tourism route recommendation algorithms, tourists provide input information used to generate personalized recommendations. Natural language processing (e.g., word segmentation and part-of-speech tagging) identifies key details from tourists' input, while machine learning models, trained on large datasets, predict routes based on tourist preferences, behaviors, and attributes.

2) Data collection. In travel route recommendation algorithms, key factors like travel time, distance, road conditions, and costs are crucial for providing personalized suggestions. Travel time helps the algorithm consider tourists' time constraints, while distance determines their willingness for long trips. Road conditions (weather and traffic) ensure safety and convenience, and tourism expenditure helps set budget limits. By analyzing and comparing these factors, the algorithm can optimize and recommend the best routes, using iterative calculations to continuously refine the results.

3) Route optimization. In tourism route recommendation algorithms, route optimization involves time, distance, cost, and preference adjustments to better meet tourists' needs. User feedback after the tour helps refine the algorithm's accuracy. Additionally, if tourists' preferences change, the algorithm can re-plan and optimize routes accordingly.

The general flow of the travel route recommendation algorithm is shown in Figure 3.

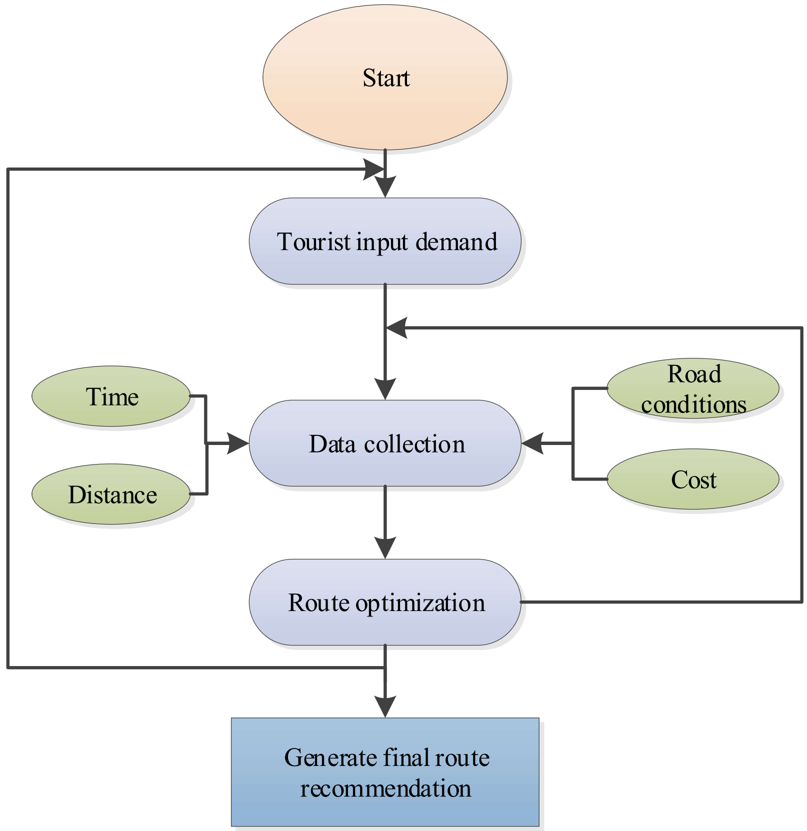


Fig. 3. Approximate flow chart of travel route recommendation algorithm

4. Social Networks and Hotspots Technologies

4.1. Hotspots Map

Interest hotspots help identify public opinion, popular trends, and differences between groups on social media. They are useful for market research, public opinion monitoring, and business analysis, helping businesses adjust strategies. In tourism route recommendation, interest hotspots can analyze tourists' preferences for destinations by examining social media and review sites, identifying popular spots, top-rated places, and trending activities. This data enables travel agencies to create tailored route recommendations and personalized tourism products, enhancing the overall travel experience by focusing on tourists' interests in cultural, outdoor, food, or shopping activities.

4.2. Travel Route Recommendation Algorithm Based on Social Network

To build a travel route recommendation algorithm through social networks, first of all, people need to build a dictionary to capture user comments from social networks. It then carries out word filtering, part of speech filtering, stem extraction and other preprocessing operations, and then sorts the words in all comments according to word frequency. Finally, it intercepts the sorted words as a dictionary.

$$D = (d_1, d_2, \ldots, d_n) \tag{1}$$

In the formula, D represents the dictionary and d_i $(i = 1, \ldots, n)$ represents the i-th dimension value of dictionary D.

Then, feature extraction of scenic spots is performed. Take the comment information of the scenic spot as the document of the scenic spot. First, collect all the comment information under the scenic spot into a document, and then process the scenic spot document. Then the feature vectors of scenic spots are obtained by word frequency - inverse document frequency, and then these feature vectors are mapped on the constructed dictionary.

$$P_l = (P_{l_1}, P_{l_2}, \ldots, P_{l_n}) \tag{2}$$

P_l represents the characteristics of the scenic spot.

P_{l_i} in the formula represents the ith characteristic value of the scenic spot feature. Its expression is as follows:

$$P_{l_i} = \begin{cases} v_{d_i}\left(d_i \in D\right) \\ 0\left(d_i \notin D\right) \end{cases} \tag{3}$$

v_{d_i} represents the value of d_i in the eigenvector.

After that, user feature information is extracted. Through the user's historical scenic spot records, the user's historical scenic spot features are summed to obtain the user's characteristics. It is expressed as follows:

$$P_u = \sum_l^L P_l \tag{4}$$

In the formula, P_u is the user feature, L is the attraction set, and l is the attraction.

Secondly, extract user interest information. Use user interest to model. The similarity measurement between users and scenic spots is the user's interest preference for scenic spots. The calculation formula is as follows:

$$P(l \mid h_u) = sim(P_l, P_u) = \frac{P_l * P_u}{\|P_l\| * \|P_u\|} \tag{5}$$

In the formula, h_u represents the user's historical scenic spot access record.

Finally, the route of tourist attractions is generated through user interest.

$$P(l_t \mid l_{t\text{-}1}, h_u) = P(l_t \mid l_{t\text{-}1}) * \frac{P(l_t \mid h_u)}{P(l_t)} \tag{6}$$

In the formula, l_t represents the scenic spots visited at time t, and $l_{t\text{-}1}$ represents the scenic spots visited at time $t-1$.

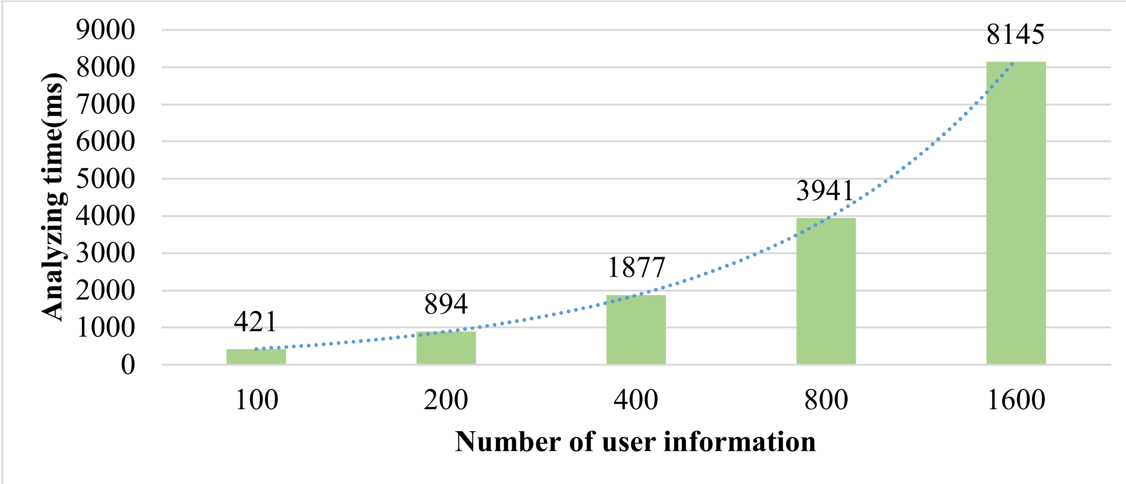
This is the general step of the tourist route recommendation algorithm. Through this algorithm, tourists' interest information and feature information can be extracted from social networking sites, and combined with the feature information of scenic spots, tourism route planning can be carried out, and finally the route of tourist attractions can be generated. The algorithm can reduce the travel route cost of tourists, recommend better travel routes for tourists, and improve the travel experience of tourists.

5. Implementation and Test of Travel Route Recommendation Algorithm Based on Social Network

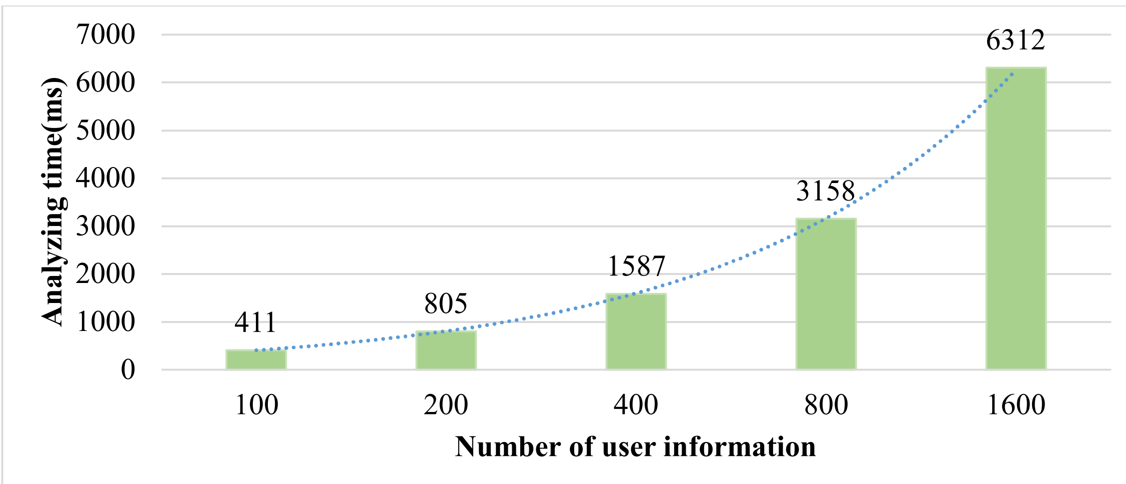
5.1. Test of Travel Route Recommendation Algorithm Based on Social Network

After putting forward the travel route recommendation algorithm based on social network, people should not only rely on theory, but also test the performance of the algorithm in actual use. This experiment would test the performance of traditional travel route recommendation algorithm and travel route recommendation algorithm based on social network. The analysis time and analysis accuracy are the two performance indicators.

First, this paper tested the analysis time of the algorithm, and observed the change of the analysis time by adjusting the number of user information. The results are shown in Figure 4.



(a). User information quantity and analysis time of traditional algorithm

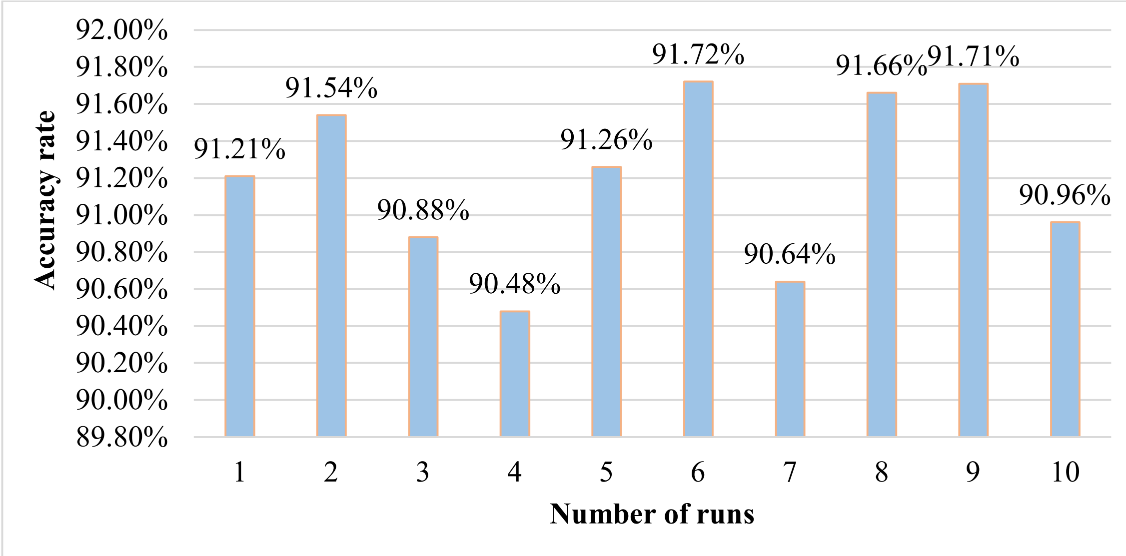


(b). User information quantity and analysis time based on social network algorithm

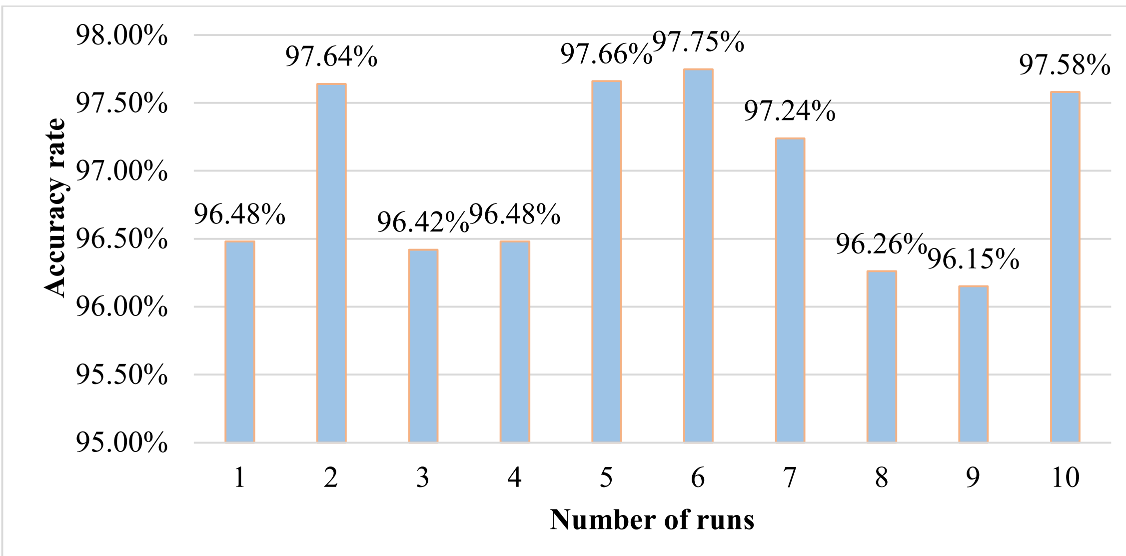
Fig. 4. User information quantity and analysis time of the two algorithms

According to the data results in Figure 4, when the number of user information was 100, the analysis time of traditional travel route recommendation algorithm and travel route recommendation algorithm based on social network was 421ms and 411ms respectively. The difference in analysis time between the two algorithms was relatively small. However, when the number of user information was 1600, the analysis time of these two algorithms was 8145ms and 6312ms respectively. It can be seen that at this time, the analysis time of the travel route recommendation algorithm based on social network was far shorter than the traditional algorithm.

Then, this paper studied the accuracy of the travel route analysis of the two algorithms. Through 10 experiments on the two algorithms, the accuracy of the analysis was collected and counted. The results are shown in Figure 5.



(a). Graph of running times and accuracy of traditional algorithm



(b). Graph of running times and accuracy based on social network algorithm

Fig. 5. Comparison of running times and accuracy of the two algorithms

After analyzing the experimental data in Figure 5, the average accuracy of the two algorithms can be calculated separately after statistics and calculation. The average analysis accuracy of traditional travel route recommendation algorithm and travel route recommendation algorithm based on social network were 91.21% and 96.97% respectively. Obviously, the average analysis accuracy of the travel route recommendation algorithm based on social networks was higher, which can show that the algorithm has more powerful analysis ability.

5.2. Experiment of Tourism Route Recommendation Algorithm

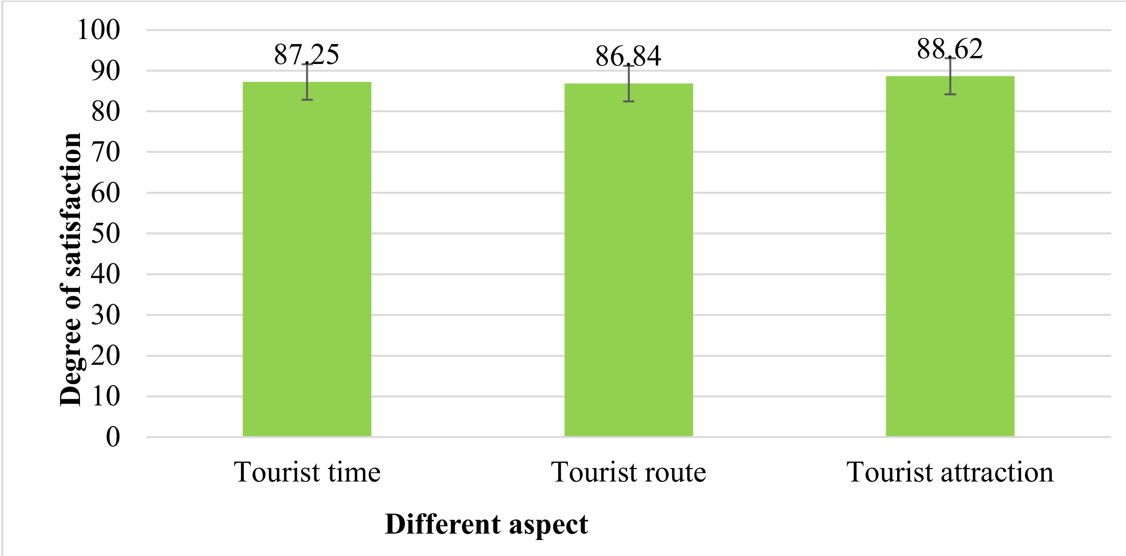
In the experiment part of this research, the actual use effect of the travel route recommendation algorithm based on social network would be tested. In the experimental investigation, this paper first selected a scenic spot as the experimental site, and first collected and counted the basic information of tourists in the scenic spot. The statistical results are shown in Table 1.

Table 1. Basic information of tourists

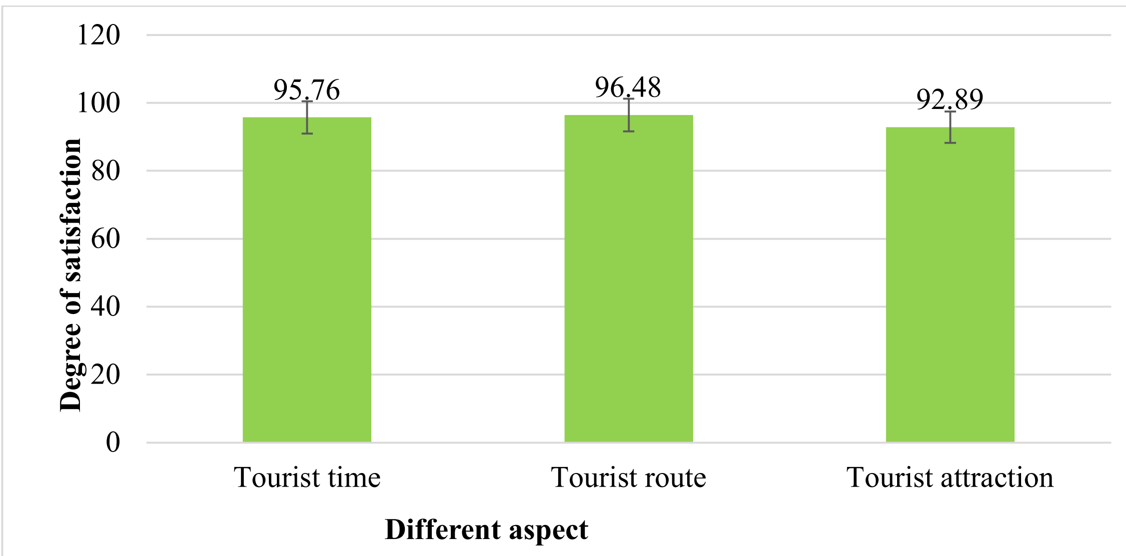
		Age			Gender	
		Age≤25	25<Age≤50	50<Age	Male	Female
		33.44%	30.23%	36.33%	49.63%	50.37%
Use a travel recommendation app	Do not use	47.47%	50.45%	51.36%	53.22%	52.44%
	Use	52.53%	49.55%	48.64%	46.78%	47.56%
The number of travel	Number≤5	35.78%	31.45%	30.22%	31.64%	33.73%
	5<Number≤10	32.24%	35.36%	33.61%	32.89%	34.52%
	10<Number	31.98%	33.19%	36.17%	35.47%	31.75%

According to the tourist information in Table 1, it can be seen that the majority of tourists in this scenic spot were over 50 years old, and the sex ratio of tourists was relatively average. In addition, it can be seen that tourists aged over 50 also travel more frequently. In addition, people can know that the proportion of tourists using travel recommendation applications is also relatively average.

In the experimental survey, this paper first distributed a questionnaire to tourists to investigate their satisfaction before and after using the travel route recommendation algorithm based on social networks. The total satisfaction score of each item was 100. The survey results are shown in Figure 6.



(a). Tourist satisfaction before use

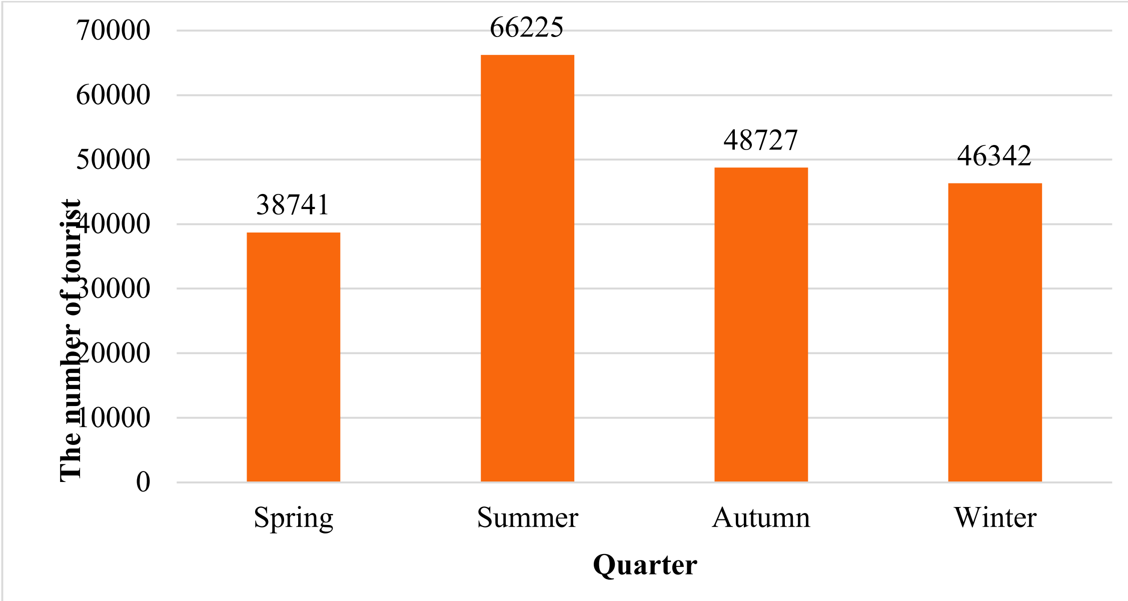


(b). Tourist satisfaction after use

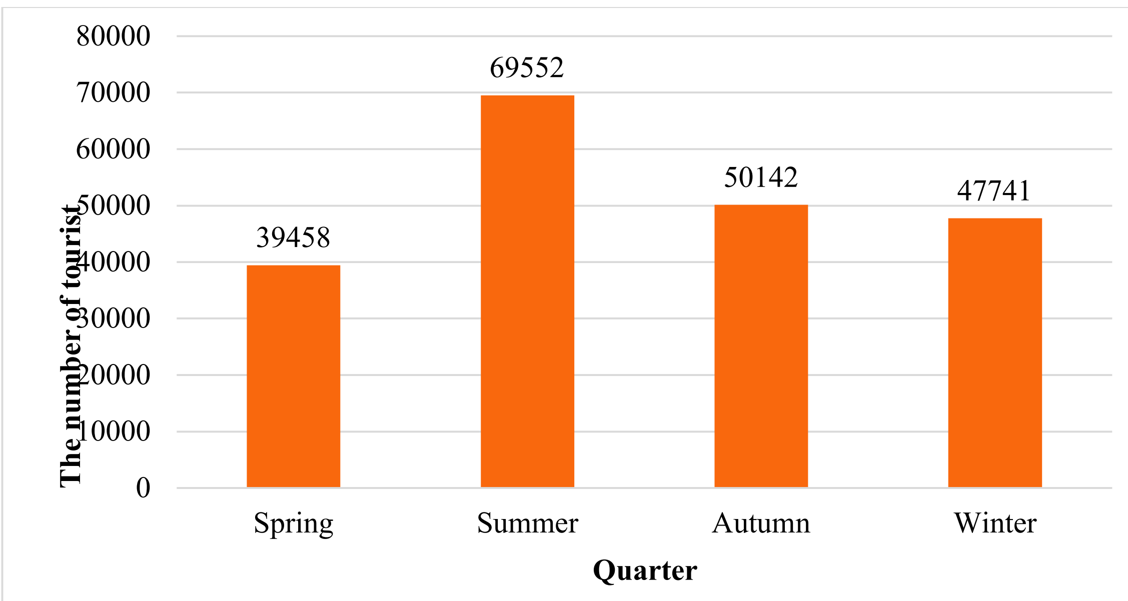
Fig. 6. Tourist satisfaction before and after use

According to the data in Figure 6, it can be analyzed that before using the travel route recommendation algorithm based on social network, tourists' satisfaction with travel time, travel route and tourism attraction was 87.25 points, 86.84 points and 88.62 points respectively. After using the travel route recommendation algorithm, tourists' satisfaction with travel time, travel route and tourist attraction was 95.76 points, 96.48 points and 92.89 points respectively. It can be seen that after using the travel route recommendation algorithm, tourists' satisfaction has improved. Among them, tourists' satisfaction with travel time and route was higher.

Then, people need to investigate the change of the number of tourists in the scenic spot before and after the use of the travel route recommendation algorithm based on social networks. The survey results are shown in Figure 7.



(a). Number of tourists before use



(b). Number of tourists after use

Fig. 7. Number of tourists before and after use

After analyzing Figure 7, people know that before using the travel route recommendation algorithm based on social networks, the number of tourists in the scenic spot in spring, summer, autumn and winter was 38741, 66225, and 48727 for 46342. After using the travel route recommendation algorithm, the number of tourists was 39458, 69552, 50142 and 47741 respectively. Obviously, people can know that the tourist route recommendation algorithm can attract tourists, increase the popularity of the scenic spot, and bring better benefits to the scenic spot.

6. Conclusions

Social network and interest hotspots map are two important factors in the travel route recommendation algorithm. Combining these two factors can better meet the needs of users. Social network data can provide information about user interests and social relationships, and can be used to build models of user interests and social relationships. Interest hotspots map data can provide information about popularity and interest of scenic spots, and can be used to build interest models of scenic spots. Through the interest hotspots map, people can better understand the interest similarity and popularity among the scenic spots, so as to provide tourism route suggestions that are more in line with the interests of users. Among them, the test of the travel route recommendation algorithm based on social network played a very important role in this paper, and it showed excellent performance in the test. In the research experiment of the travel route recommendation algorithm, according to the experimental results, it showed that after using the travel route recommendation algorithm, tourists' satisfaction with travel time, travel route and tourism attraction has been improved. In addition, the number of tourists in the scenic spot has also increased a lot, which has improved the income of the scenic spot. Finally, the development prospect of tourism route recommendation algorithm was very broad. With the continuous development of science and technology and the popularity of the Internet, the travel route recommendation algorithm can be better supported. On the one hand, with the development of big data and artificial intelligence technology, the travel route recommendation algorithm can better process and analyze a large number of travel data and provide more personalized and accurate travel suggestions. On the other hand, with the development of mobile Internet and social networks, tourists can more easily query travel information and share travel experience, which provides more effective data sources for the travel route recommendation algorithm. Therefore, it can be said that the travel route recommendation algorithm would play an increasingly important role in the future, and its application prospects are very broad.

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