

Research Article

Study on City-Level Optimization of Tourism Industry Spatial Organization Nodes and Organization Mode for Tourist Destinations

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Reasonable spatial organization of the tourism industry can improve the utilization efficiency of regional tourism industry elements. Taking Dalian City in China as an example, this paper collects various types of tourism industry data and introduces GIS network analysis technology into tourism studies to determine the location, scale, and number of tourism nodes in Dalian and optimize the spatial organization nodes and organization models of the tourism industry. This will help ease the pressure on tourism reception in the southern area of Dalian and promote better development and utilization of tourism resources and tourism facilities in the central and northern regions. The results show that (1) when using the “minimizing facility points” model, a total of 17 second-level tourism nodes and 5 first-level tourism nodes are obtained after optimization. The location of these nodes is highly correlated with the level of tourist scenic spots, while tourist scenic spots play a significant role in leading and driving tourism nodes. (2) Using the “maximum coverage” model for optimization, 3138 tourism enterprises are connected with tourism nodes, thus realizing the shortest traffic path between tourism enterprises and tourism nodes, which minimizes the total cost of network services. Compared with suburban areas, enterprises in urban tourism areas are densely distributed, meaning that a smaller service radius of tourism nodes can cover more enterprises. (3) A total of 10 first-level tourism channels and 12 second-level tourism channels are optimized using the “nearest facility” model. The first-level tourism channels are mainly distributed in the central and southern areas of Dalian. These channels connect nodes mainly through national and provincial roads. The second-level tourism channels are mainly distributed in the central and northern areas of Dalian. (4) This study aims to analyze the evolution process of the spatial organization mode of Dalian’s tourism industry and construct a hub-spoke network tourism industry spatial organization mode composed of 17 hubs, 22 spokes, and 22 tourism domains. The analysis and construction are designed according to the optimization results of tourism nodes and tourism channels. The research results enrich the theories and technical means of tourism industry spatial organization and provide references and suggestions for local governments or tourism planning decision-makers; they also provide a scientific basis for the rational allocation of tourism industry elements and promote the rational distribution of tourism industry.

1. Introduction

The spatial layout and optimal design of industries are the core of industrial spatial organization research [1]. The spatial organization of the tourism industry is a process of

organizing elements of the tourism industry rationally as well as forming tourism products and effective services in a certain geographical space. The aim of this organization is to identify the optimal allocation scheme of industrial elements and realize the balanced development of regional tourism

industries. Based on the spatial interactions among tourism industry elements, a number of tourist cities and towns that are economically developed and have strong radiation and agglomeration effects on the tourism industry, as well as dense traffic networks and high-level tourist attractions, are determined to be the organization centers within the tourism destination. The tourism industry spatial organization nodes (i.e., tourism nodes) are therefore formed with these as the strongholds. Tourists are attracted to and gather in high-level tourism nodes and are then transported from these high-level tourism nodes to lower-level tourism nodes, experiencing tourism enterprises through tourism channels. In order to build a reasonable spatial organization mode for the tourism industry and improve the efficiency of tourism resource and facility utilization by connecting series of tourism enterprises through tourism nodes and tourism channels, tourism nodes, channels, and areas must be optimized in order to classify them according to their scales and functions and then determine the organization levels and development orders of tourism industry elements.

The provincial tourism industry presents a layout with cities as tourist distribution centers. At the city scale, three problems need to be solved: determining the locations and number of tourism nodes; determining their service scopes and scales; and determining the technical methods and steps for optimizing these nodes and channels. In this regard, the spatial distribution characteristics and optimization of tourism resources [2–7], spatial structure of tourist destinations [8–14], planning of tourist distribution centers, index system, and influencing factors [13–19], design of tourism channels [20–22], planning of tourism centers [23], and spatial organization mode of tourism [24–27] are investigated. Quantitative research methods such as the analytic hierarchy process [16], the GIS spatial analysis method [2–8, 14, 18, 28], the structuralism method [29], and cluster analysis [30] are introduced.

According to current research, the existing studies lack quantitative research on spatial organization nodes and organization mode of the tourism industry based on the collection of various types of tourism industry data and the comprehensive consideration of the interactions among tourism resources, service facilities, transportation, tourist towns, and other tourism industry elements. The existing studies also lack quantitative research on service scopes and scales of tourism nodes. GIS network analysis technology allows for the determination of reasonable number, locations, and service scope of facilities as well as optimization of the facility layout [31–34]. This method is widely used for optimizing site selection in public service facilities research on wholesale and retail trade, medical facilities, educational facilities, fire stations, logistics distribution center location, sports facilities, and other fields [35–46] but is almost never involved in the research of tourism nodes location. The city level undertakes tourism industry development at the provincial and county levels. Studying the problem of utilization efficiency of tourism industry elements in underdeveloped regions of tourist destinations in cities is therefore conducive to forming a realistic basis for optimizing the layout strategy of the tourism industry. This paper defines

city-level tourist destinations as the background of the study and optimizes the spatial organization nodes and organization mode of Dalian's tourism industry using GIS network analysis technology, which enriches the theories and technical means of spatial organization of the tourism industry and provides a reference for solving similar problems in comparable tourist cities. This paper focuses on (1) calculating the centrality index of tourism nodes and determining the two-level tourism nodes system with reference to the traffic principles in the central place theory; (2) using the models of minimizing facility points and maximizing coverage in the network analysis method to simulate and optimize tourism nodes and tourism channels so as to determine the locations, scales, and number of tourism nodes; and (3) optimizing the spatial organization mode of the tourism industry using the optimization results of tourism nodes and channels.

2. Methods

2.1. The Model of Minimizing Facility Points. This model is applied to determine the number and locations of tourism nodes (i.e., facility points). The unbalanced space of tourism industry elements makes it difficult to determine the number and location of tourism nodes, and the service radius of different levels of tourism nodes is different. Using this model to set the impedance cutoff value of tourism nodes, the tourism nodes that meet the requirements according to the distribution of tourism enterprises (i.e., request points) will be selected, and the tourism enterprises located in the tourism nodes impedance cutoff will allocate all of their request weights to the tourism nodes, so that as many tourism enterprises as possible are located within the impedance radius of tourism nodes, thus minimizing the number of tourism nodes covering tourism enterprises. The formulas [47] are

$$\text{Min } z = \sum_{j \in J} X_j, \quad (1)$$

$$\text{s.t. } \sum_{j \in Ni} X_j \geq 1, \quad \forall i \in I, \quad (2)$$

$$X_j \in \{0, 1\}, \quad \forall i \in J. \quad (3)$$

In formulas (1) to (3), i represents a set of demand points, and J represents a set of candidate facility points; if the candidate facility point j is selected, then $X_j = 1$, and if it is not selected, then $X_j = 0$. Formula (1) minimizes the total number of facilities; formula (2) ensures that the demand points are covered at least once by service facilities; and formula (3) ensures that the decision variable is 0-1. If d_{ij} is used to represent the distance from the demand point i to the facility point j and D_c is used to represent the coverage distance, then $Ni = \{j \in J \mid d_{ij} \leq D_c\}$ represents the set of facilities that can cover the demand point i .

2.2. The Model of Maximizing Coverage. This model is applied to determine the service scope and scales of tourism nodes. The central guidance and radiation effect of tourism

nodes encourage tourism enterprises to seek services from the nearest nodes. Using this model to obtain services from the nearest nodes therefore serves to minimize the total cost of network services [48]. The number of tourism enterprises served by each node is the scale of the tourism node, and the spatial distribution scope of the tourism enterprises served is the service scope of the tourism node. The service scope is calculated based on the average distance from the tourism node to the tourism enterprise. To prevent individual demand points from falling outside the coverage of facilities, the improved model is adopted, and the formulas [49] are

$$\begin{aligned} \max &= \sum_{a=1}^n Q_a Y_b, & (4) \\ \text{Q.T.} & \begin{cases} \sum_{a=1}^m C_{ab} X_a - Y_b \geq 0, \\ \sum_{a=1}^m X_a = D, \\ X_a Y_b = 0 \text{ or } 1 \quad (a = 1, 2, \dots, n, \quad b = 1, 2, \dots, m). \end{cases} & (5) \end{aligned}$$

In formulas (4) and (5), X_a and Y_b are decision variables. If $X_a = 1$, then the facility is configured at request point a ; otherwise, $X_a = 0$; if $Y_b = 1$, then the request point b is covered within the effective service radius of the facility; otherwise, $Y_b = 0$; Q_a represents the comprehensive layout index from the request point to the facility point; C_{ab} is a binary value coefficient. When the distance L_{ab} from the request point a to the facility point b is within the effective service radius R , then $C_{ab} = 1$; otherwise, $C_{ab} = 0$; D is the specified number of facilities to be deployed.

3. Data

3.1. Research Area. Dalian City consists of 10 administrative units: Zhongshan District, Xigang District, Shahekou District, Ganjingzi District, Lüshunkou District, Jinzhou District, Pulandian District, Zhuanghe City, Wafangdian City, and Changhai County (Figure 1). Its jurisdiction covers 162 townships and subdistricts. Dalian was one of the first locations to be awarded the designation of best tourist city in China and is also a famous tourist destination. The development of its tourism industry has achieved remarkable results but has highlighted the contradiction between supply and demand within the leisure industry as well as the backward organization mode of the tourism industry, both of which affect the industry's sustainable development. Therefore, using the GIS network analysis method, this paper puts forward the calculation steps for optimizing the spatial organization nodes and channels of the tourism industry. The spatial organization mode of the tourism industry is constructed on this basis, and its essential elements are scientifically organized to provide reference for development planning and policy formulation for Dalian's tourism industry.

3.2. Data Sources

3.2.1. Establishment of the Traffic Network Dataset. It is important to ensure that the travel time between the tourism nodes (or tourism attractions) is short; at the same time, tourist activities require minimization of transportation costs, selection of other types of transportation instead of expressways, consideration of the appropriate advancement of tourism node optimization, and establishment of a traffic network dataset including national roads, provincial roads, planned new roads, county roads, and township roads. Two types of transportation, highway and waterway, are also involved. With reference to the relevant provisions of traffic laws and considering the actual traffic operation in Dalian City, the driving speed on national and provincial roads is set at 60 km/h, while it is set at 50 km/h on country roads, 40 km/h on township roads, and 30 km/h for ferries.

3.2.2. Establishment of the Tourism Node Model. The development of the tourism industry depends on traffic conditions, and the number of tourism nodes can follow the traffic principle ($K=4$) of the central place theory [50]. "Tourism node" is an expression of the tourism center. The centrality of tourism nodes indicates the scale of their external service functions. Generally, the greater the centrality, the greater the service scope. The hierarchy of tourism nodes matches their individual functional systems. The supply service systems of high-level tourism nodes are relatively sound, and they also cover the functions of tourism nodes at lower levels.

For tourism nodes, the research scale and content are different, as are the meaning, scale, and level. On a larger scale, tourism nodes can be defined as regional central cities, which serve to gather and diffuse tourists [10]. At the county scale, the first-level tourism nodes can be defined as county cities, and the second-level tourism nodes can be defined as transit places from county cities to tourist attractions, which mainly manifest in some towns [13]. From the city-scale perspective, tourism nodes can be defined as townships and subdistricts. Dalian has 162 townships and subdistricts, that is, 162 tourist nodes. High-level tourism nodes within the city are economically developed, with dense traffic networks and high-level tourist attractions as well as planned key towns. According to the coherent distribution of tourism enterprises in the city, the high-level tourism nodes can be divided into two levels (Figure 2). The first-level tourism nodes gather tourists and transport them to second-level tourism nodes and the second-level tourism nodes serve the surrounding tourism enterprises. The first- and second-level tourism nodes play the role of gathering, diffusing, and transferring tourists. Among them, the first-level tourism nodes are the central nodes, the second-level tourism nodes are the secondary central nodes, and the remaining tourism nodes are noncentral nodes.

3.2.3. Tourism Node Centrality Index. Referring to the research of Huang et al., Deng et al., and Du [10, 15, 18], a total of 22 types of tourism resources, such as nature reserves,

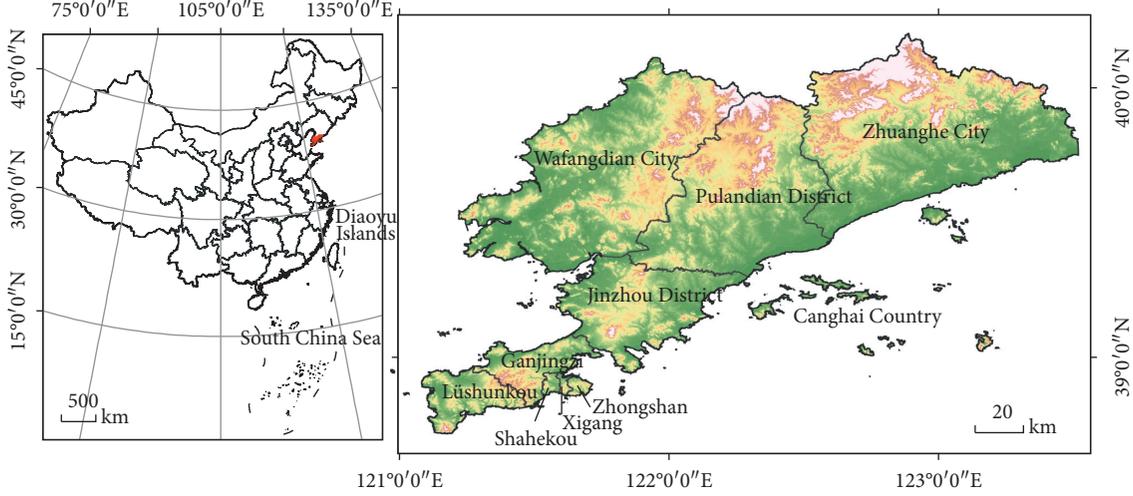
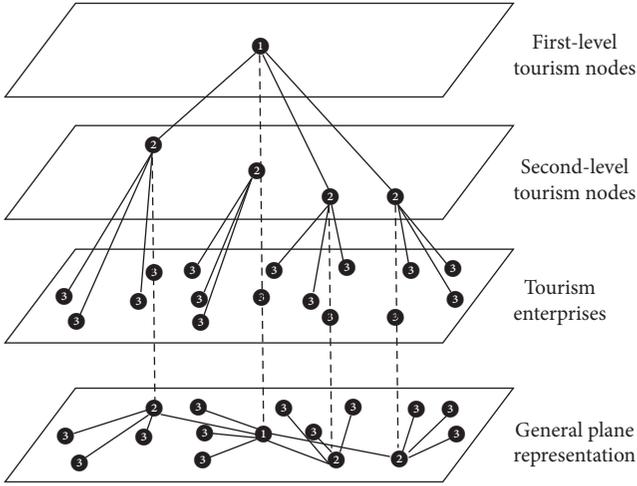


FIGURE 1: Study area.

FIGURE 2: Tourism nodes grade and quantity relationship ($K=4$).

forest parks, geological parks, museums, scenic spots, and religious buildings, as well as 3138 tourism enterprises, including hotels, travel agencies, special restaurants, special shopping, and performing arts, are selected. Transportation accessibility is expressed by weighted average travel time, and a tourism node centrality index model is constructed. The formulas are

$$L_i = \sum_{i=1}^n W_{zi} * A_i + \sum_{i=1}^n W_{ji} * B_i + \sum_{i=1}^n W_{ygi} * C_i, \quad (6)$$

$$D_i = \frac{\sum_{j=1}^{n-1} (T_{ij} * S_j)}{\sum_{j=1}^{n-1} S_j}, \quad (7)$$

$$Q_i = \frac{L_i}{D_i}. \quad (8)$$

In formulas (6) to (8), i is the candidate tourism node, L_i is the degree of attraction of the node, A_i , B_i , and C_i , respectively, represent the number of tourism resources,

reception facilities, and performing arts and shopping enterprises, and W_{zi} , W_{ji} , and W_{ygi} , respectively, represent the weights of factors affecting the attraction of tourism resources, reception facilities, and entertainment and shopping facilities; D_i is the weighted average travel time of node i , which indicates the traffic accessibility of node i . The smaller the value of D_i , the higher the accessibility. T_{ij} represents the shortest travel time between two nodes; S_j represents the weight of node j ; and the higher the value, the stronger the attraction to the surrounding area and the greater the radiation scope. In view of the agglomerating and driving effects of high-level scenic areas (spots) on regional tourism, S_j is calculated by multiplying the number of scenic areas (spots) at all levels in the subdistrict where the node is located. The weights of 5A, 4A, 3A, 2A, and A scenic areas (spots) are set at 5, 4, 3, 2, and 1.5, respectively, and the weights of all undetermined scenic areas (spots) are set at 1. Q_i is the tourism node centrality index. The higher its value, the stronger the node's ability to service the surrounding tourism enterprises and the greater its service scope.

According to formula (6), L_i is calculated by the entropy weight method. According to formula (7), based on the traffic network dataset, GIS network analysis function is used to generate the time-distance matrix between the two nodes (Table 1), and the weighted average travel time D_i of each node is further obtained, thus calculating the tourism node centrality index Q_i (Table 2).

4. Results

First, the low-level tourism nodes are optimized. The high-level tourism nodes are then optimized according to the locations and number of low-level tourism nodes, that is, the "bottom-up" idea. The two-step optimization methods of "minimizing facility points" and "maximizing coverage" are used to determine second-level tourism nodes, which serve neighboring tourism enterprises. A number of nodes with large service scale and leading roles for surrounding tourism enterprises are then selected from the second-level tourism

TABLE 1: Tourism nodes time-distance matrix (partial) (unit: km).

	Anbo Town	Anzixiang Subdistrict	Bayilu Subdistrict	Baishanlu Subdistrict	Baiyun Subdistrict	Beihai Subdistrict
Anbo Town	0	126.1	171.6	165.4	167.7	189.8
Anzixiang Town	126.1	0	220.8	214.6	216.8	239
Bayilu Subdistrict	171.6	220.8	0	9.451	8.719	55.75
Baishanlu Subdistrict	165.4	214.6	9.451	0	6.189	48.3
Baiyun Subdistrict	167.7	216.8	8.719	6.189	0	51.8
Beihai Subdistrict	189.8	239	55.75	48.3	51.8	0

TABLE 2: Tourism nodes centrality index (partial).

Node name	Li	Di	Qi
Anbo Town	0.491	127.235	0.004
Anzixiang Town	0.070	169.876	0.000
Bayilu Subdistrict	0.142	94.535	0.001
Baishanlu Subdistrict	0.164	88.960	0.002
Baiyun Subdistrict	0.240	91.512	0.003
Beihai Subdistrict	0.138	111.439	0.001
Beijing Subdistrict	0.213	87.360	0.002
Paoya Town	0.036	108.762	0.000
Paotai Town	0.403	89.670	0.004
Pikou Town	0.172	90.196	0.002
Qidingshan Subdistrict	0.257	86.443	0.003
Qingdui Town	0.104	160.482	0.001
Qingniwaqiao Subdistrict	0.469	89.675	0.005
Quanshui Subdistrict	0.304	83.561	0.004

nodes as first-level tourism nodes to achieve the optimization purpose of maximum number of enterprises served by minimum number of facilities.

4.1. Optimization of Second-Level Tourism Nodes

4.1.1. Selection of Required Tourism Nodes. The required tourism nodes must be selected during the optimization of the tourism nodes system, while the candidate tourism nodes may be selected during the system optimization. The required tourism nodes and candidate tourism nodes should be determined first; then, the first- and second-level nodes can be optimized. The second-level required tourism nodes come from two parts. First, the centrality index of tourism nodes is clustered into three levels by the natural fracture method; Laohutan and Daweijia Subdistricts, which are the first type of tourism nodes, are listed as second-level required tourism nodes. Second, key towns that have begun to take shape and whose plans and documents have been published can be included as a part of the first- and second-level required tourism nodes; Wangjia Town, Anbo Town, Xietun Town, Jinshitan Subdistrict, Guanglu Township, and Shuishiyang Subdistrict are defined as second-level required tourism nodes; the other towns, townships, and subdistricts are the candidate nodes for the second-level tourism nodes.

According to central place theory, high-level central places function as low-level central places, and the first-level required tourism nodes must be the second-level required tourism nodes. As a classification system of tourist

attractions with Chinese characteristics, A-level scenic spots are one of the most important bases to classify the importance levels of tourist destinations. High-level tourism scenic spots play a positive role in promoting the development of regional tourism industry, directly affect the spatial behavior of tourists, and have a profound impact on the speed and scale of development as well as the utilization efficiency of regional tourism resources. Jinshitan Subdistrict (with 5A-level tourist scenic area, Jinshitan National Tourist Resort) and Laohutan Subdistrict (with 5A-level tourist scenic area, Tiger Beach Ocean Park Tourist Area) are set as first-level required tourism nodes, and the remaining second-level required tourism nodes and newly added second-level tourism nodes are set as first-level candidate tourism nodes.

4.1.2. Number and Locations of Second-Level Tourism Nodes.

The number and locations of second-level tourism nodes are determined by the minimizing facility points model. A total of 3138 tourism demand enterprises, 8 second-level required tourism nodes, and 154 second-level candidate tourism nodes are loaded. Tourism nodes are “facility points,” and tourism enterprises are “request points.” According to the traffic principle of the central place theory, the number of tourism enterprises, and the urban-rural differences in the distribution of tourism enterprises, it is estimated that there are about 5 first-level tourism nodes and 18 second-level tourism nodes; of these, 3 are urban second-level tourism nodes and 15 are suburban second-level tourism nodes. The theoretical service radiuses of urban and suburban tourism nodes are calculated, and the maximum impedance interruption distances to receive services are set for urban and suburban tourism enterprises. After repeated experiments, the second-level tourism nodes cover all tourism enterprises, and 17 second-level tourism nodes are optimized; these include 8 second-level required tourism nodes and 9 newly added second-level tourism nodes.

4.1.3. Scales and Service Scopes of Second-Level Tourism Nodes.

Using the maximum coverage model, under the condition of no limitation on service radius, each tourism enterprise can obtain services from second-level tourism nodes nearby (Figure 3), and the service scale of each tourism node is determined according to the number of tourism enterprises served by the tourism node (Table 3).

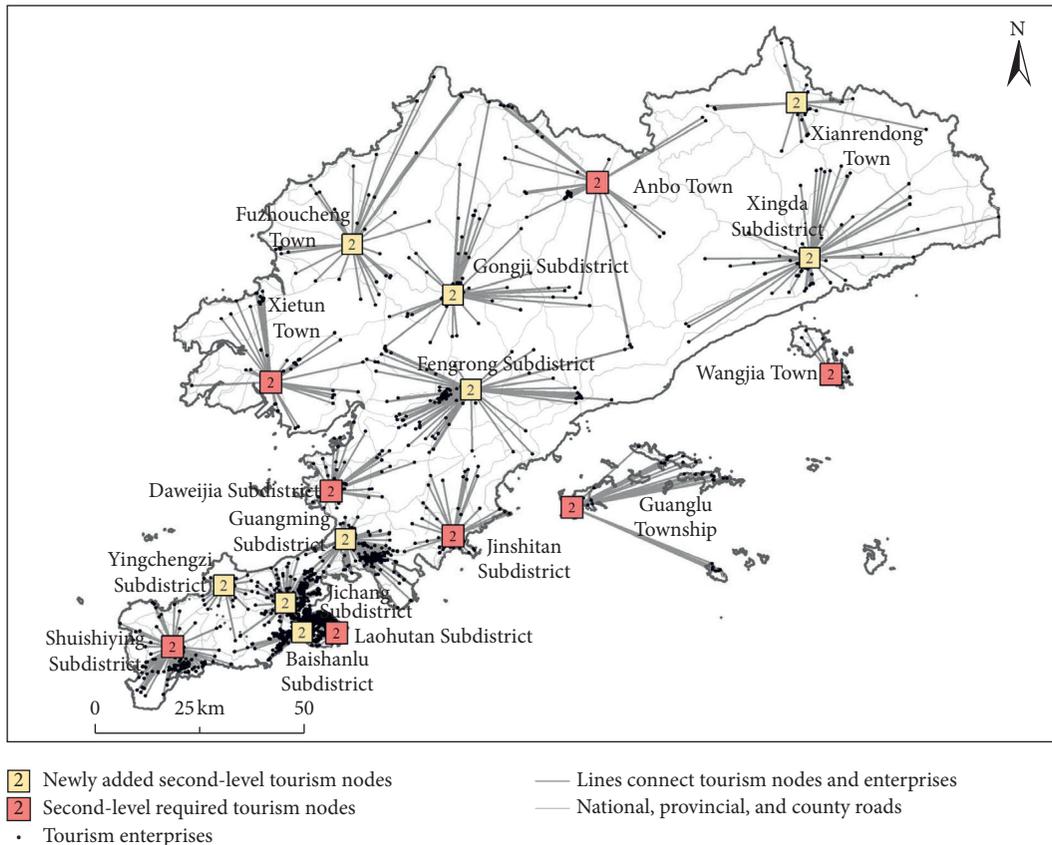


FIGURE 3: Distribution of second-level tourism nodes and enterprises.

According to Table 3, in terms of the service scale of tourism nodes, under the “maximum coverage” model, 3138 tourism enterprises are all served by tourism nodes. Guanglu Township, Anbo Town, and Xianrendong Town are located at the edge of the city. Due to their locations, their average service distances to the surrounding tourism enterprises are much farther than those of other subdistricts. The average service scale of second-level tourism nodes in urban areas is 469, while that of second-level tourism nodes in suburban areas is 92. Urban tourism enterprises are densely distributed, and a smaller service radius can cover more tourism enterprises.

The levels, quantities, and spatial combinations of tourist attractions affect the development speed, scale, and time-space arrangement of the tourism industry. At the same time, tourist attractions are also an important basis for the construction of tourism nodes. Among the 17 second-level tourism nodes, 10 nodes belong to regions with high-level and newly built government-planned tourist attractions and leisure resorts. Tourist attractions play a significant role in leading and driving tourism nodes. Such nodes rely on the advantages of high-level tourism resources to develop and prosper, expand their scales, and increase investment in construction.

4.2. Optimization of First-Level Tourism Nodes. The number, locations, scales, and service scopes of the first-level tourism nodes are determined by adopting the minimizing facility

points model. Jinshitan Subdistrict and Laohutan Subdistrict, with 2 first-level required tourism nodes and 17 second-level tourism nodes, are loaded. According to the traffic principle of the central place theory, it is initially estimated that the optimization result of the first-level tourism nodes is about four. According to the theoretical service radius of the first-level tourism nodes, the impedance interruption distance value of the tourism enterprise request points is set. After repeated tests, when the maximum impedance radius of the tourism enterprises’ request to receive service is set at 80 km, a relatively ideal layout scheme can be obtained, that is, two first-level required tourism nodes and three newly added first-level tourism nodes, which add up to a total of five first-level tourism nodes (Figure 4). Considering the traffic locations and the relevance of tourism enterprises, the administrative division limit of tourism development has been broken, and 5 first-level tourism nodes and 12 second-level tourism nodes have been formed.

4.3. Extraction of Tourism Channels. According to the principle of shortest path, the nearest facility point model [51] is used to extract tourism channels. The first-level tourism nodes are set as “facility points” and the second-level tourism nodes are set as “event points.” The number of searched facility points for event points is set to 1, and the simulation is run. This uncovers the interconnection among all the first-level tourism nodes and eliminates duplicate

TABLE 3: The parameters table of second-level tourism nodes.

Second-level tourism nodes	Location attribute	Nodes attribute	Number of services under impedance (a)	Number of services under maximum coverage (a)	Average distance under impedance (km)	Average distance under maximum coverage (km)
Shuishiyang Subdistrict	Suburbs	Required	147	147	9.420	9.420
Jinshitan Subdistrict	Suburbs	Required	75	75	7.806	7.806
Daweiijia Subdistrict	Suburbs	Required	41	41	12.210	12.210
Guanglu Township	Suburbs	Required	26	54	18.221	33.747
Xietun Town	Suburbs	Required	56	56	17.137	17.137
Anbo Town	Suburbs	Required	43	59	15.043	24.051
Wangjia Town	Suburbs	Required	13	13	6.432	6.432
Laohutan Subdistrict	Urban	Required	621	621	5.663	5.663
Guangming Subdistrict	Suburbs	Newly	338	338	7.847	7.847
Gongji Subdistrict	Suburbs	Newly	135	141	6.936	8.528
Fuzhoucheng Town	Suburbs	Newly	43	48	15.206	18.572
Fengrong Subdistrict	Suburbs	Newly	121	124	16.276	17.023
Xingda Subdistrict	Suburbs	Newly	134	140	8.840	10.266
Xianrendong Town	Suburbs	Newly	19	25	16.114	24.144
Baishanlu Subdistrict	Suburbs	Newly	855	855	4.574	4.574
Airport Subdistrict	Urban	Newly	371	371	6.716	6.716
Yingchengzi Subdistrict	Urban	Newly	30	30	5.948	5.948

Note: the average distance is the average distance between second-level tourism nodes and enterprise.

routes, thus obtaining a total of 10 first-level tourism channels and 12 second-level tourism channels (Figure 5). The first-level tourism channels are mainly distributed in the central and southern areas of Dalian. These channels establish connections between nodes primarily through national and provincial roads and have high tourist distribution capacity. The second-level tourism channels are mainly distributed in the central and northern areas of Dalian City, where tourism enterprises are relatively sparse; it is therefore not reasonable to build first-level tourism channels in the near future. In addition to relying on national and provincial roads, the second-level tourism channels also include county-level roads and ferries.

4.4. Optimization of the Organization Mode

4.4.1. Evolution of the Organization Mode. An analysis of the formation and evolution of Dalian's tourism industry spatial organization mode can provide an understanding of relevant patterns for the construction of a more reasonable tourism industry spatial organization mode. Dalian's tourism industry began to grow between 1978 and 1989. Tourists were mainly sporadic inbound tourists as well as a small number of tourists from surrounding regions. Along the coastline,

which had better utilization of tourism resources and convenient transportation conditions, Binhai Road, Baiyun Mountain Scenic Area, and Xiuyue Peak Scenic Area were the main attractions. These areas formed a singular agglomeration mode of a tourism center-hinterland system.

The period from 1990 to 1999 saw significant growth in Dalian's tourism industry. High-quality tourism resources were further developed. Tourists took the downtown area as their base camp and spread to the surrounding areas, showing a one-way radiation pattern from the downtown area to the periphery. The downtown area is the organization center for Dalian's tourism industry development. Other areas rely on high-quality tourism resources to form second-level tourism nodes, thus improving traffic accessibility and strengthening the links among tourism nodes.

Since 2000, Dalian's tourism industry has matured. The downtown area has a strong tourist distribution function, leading and guiding the development scale and direction of the city's tourism industry. The tourism has further expanded to the periphery. Second-level tourism areas of different natures have established contact with upper-level tourism centers through tourism channels, dispersing the pressure of tourist flows in Dalian's downtown area, expanding the scope of tourist activities, enhancing the

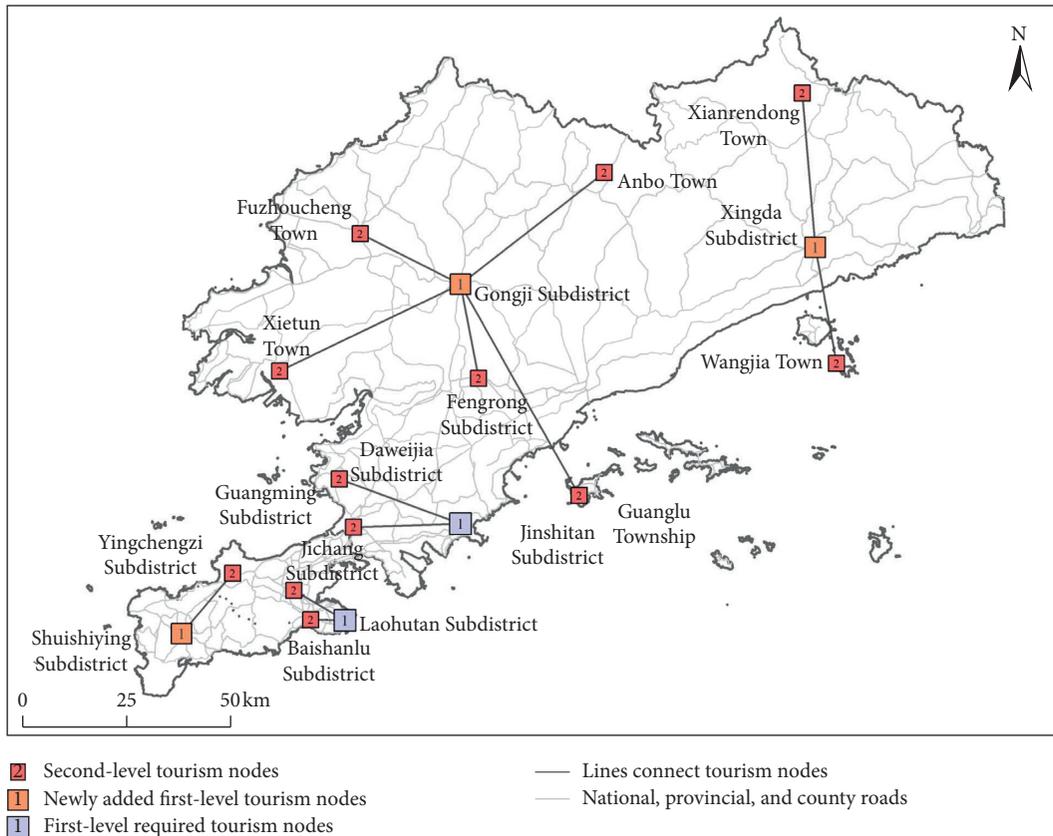


FIGURE 4: The optimization results of tourism nodes.

attraction of regional tourism, and forming an expansion model from central tourism areas of tourist destinations to second-level central tourism areas as well as to tourism hinterland channels.

The coexistence of multiple second-level tourism areas has made the competition among tourist destinations in Dalian increasingly intense, and the likelihood of regional tourism economy disorder has increased. The connection level among second-level tourism areas is not high, and the tourism industry's development is uneven. Analyzing the comparative advantages and development trends of tourist destinations at all levels is necessary as it will strengthen regional tourism cooperation, optimize the spatial organization mode of the tourism industry, and reconstruct the scientific spatial structure of regional tourism.

4.4.2. Reconstruction of the Organization Mode. The hub-spoke service network is a type of efficient network that is conducive to reducing the cost of element flow, improving the efficiency of element utilization, and exerting the scale effect [52]. The hub-spoke network tourism spatial mode refers to the integrated organizational form and process of tourism flow presented by interactions among special nodes, between nodes and connection paths, and between nodes and influence domains in the network [24] (Figure 6). With reference to the hub-spoke network tourism space theory proposed by Liang et al., according to the optimization

results of tourism nodes and tourism channels (Figures 4 and 5), and on the basis of the spatial interactions among tourism nodes and tourism channels at all levels, the hub-spoke network tourism industry spatial organization mode for Dalian (Figure 7) is constructed. Different roles are assigned according to the functions of tourism nodes at different levels (Table 4) so as to improve the operational efficiency of tourism channels in organizing tourism flow and the utilization efficiency of tourism industry elements, thus reducing the total cost of road network services.

Figure 7 and Table 4 show that the spatial organization mode of Dalian's tourism industry presents a hub-spoke network tourism industry spatial organization mode with 5 central nodes and 12 secondary central nodes, adding up to a total of 17 hubs, combined with 10 main paths and 12 secondary paths, adding up to a total of 22 spokes, to form 5 first-level tourism domains and 17 second-level tourism domains, adding up to a total of 22 tourism domains. This mode integrates the advantages of agglomeration mode, radiation mode, and expansion mode. The central nodes are endowed with superior tourism resources and frequent tourist activities. They enjoy traffic locations with fast main roads and thus can easily gather tourists, forming a regional tourist source gathering place and center. They are the first-level growth poles of Dalian's tourism industry and are responsible for driving tourism growth while serving as a transportation hub, a reception and information service, industry management, and diffusion and radiation. At the

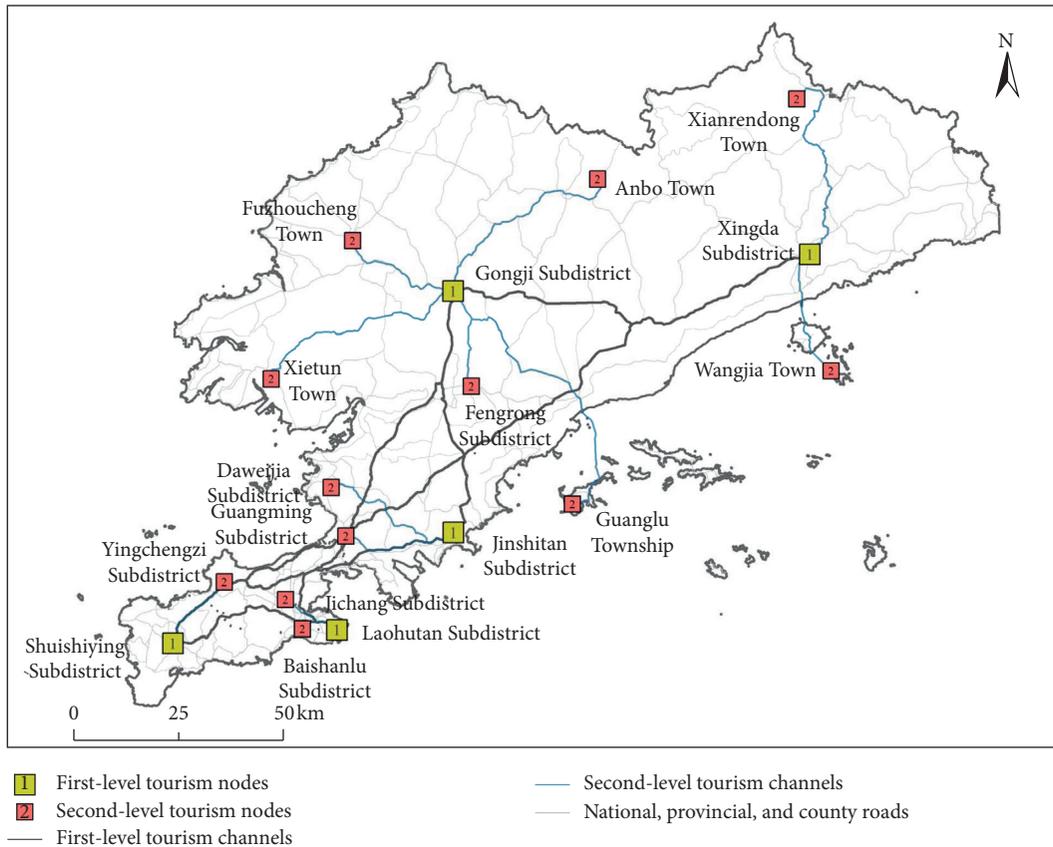


FIGURE 5: The extraction results of tourism channels.

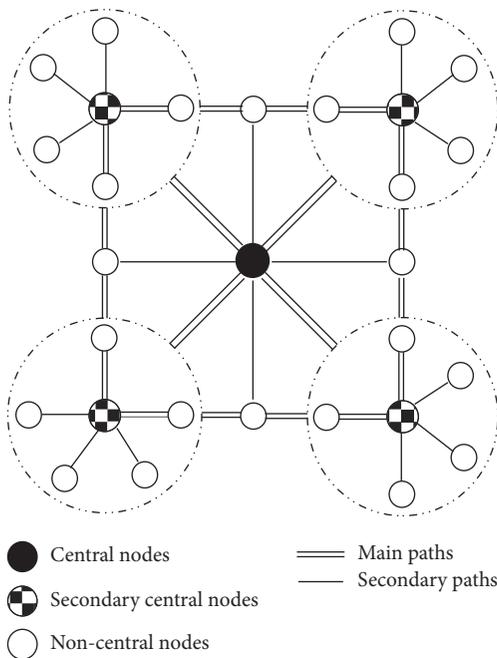


FIGURE 6: The hub-spoke network tourism spatial structure [24].

same time, the central nodes have the most complete tourism service functions, gathering tourists, increasing the traffic density on their corresponding spokes, and generating

scale, agglomeration, and spatial benefits. In this mode, the hub-spoke network can be used to develop hub-spoke route tourism products. The central nodes gather tourists and create a “feeding” effect for secondary central nodes (or tourist attractions) through spokes. Tourists choose to stay in the tourist accommodation facilities in the central nodes and visit the scenic spots through the adjacent “spokes” of these hubs. The mode realizes the spatial tourism flow and balanced development of regional tourism by means of spatial connection between the hubs and spokes in the region.

5. Discussion

5.1. Construction of Centrality Index Model of Tourist Nodes.

The construction of the tourism nodes centrality index model is based on the six elements of the tourism industry: food, housing, transportation, tourism, purchase, and entertainment. These factors have enriched the theoretical basis of tourism node optimization research, but the model needs to be improved. Due to availability, only the data of tourist attractions, hotels, travel agencies, traffic conditions, and so on that are closely related to the development of the regional tourism industry within the jurisdiction of townships and subdistricts are considered. The influencing factors of the tourism nodes centrality index, such as the number of tourists, regional economic development level, natural and human environment, residents’ cultural literacy, and

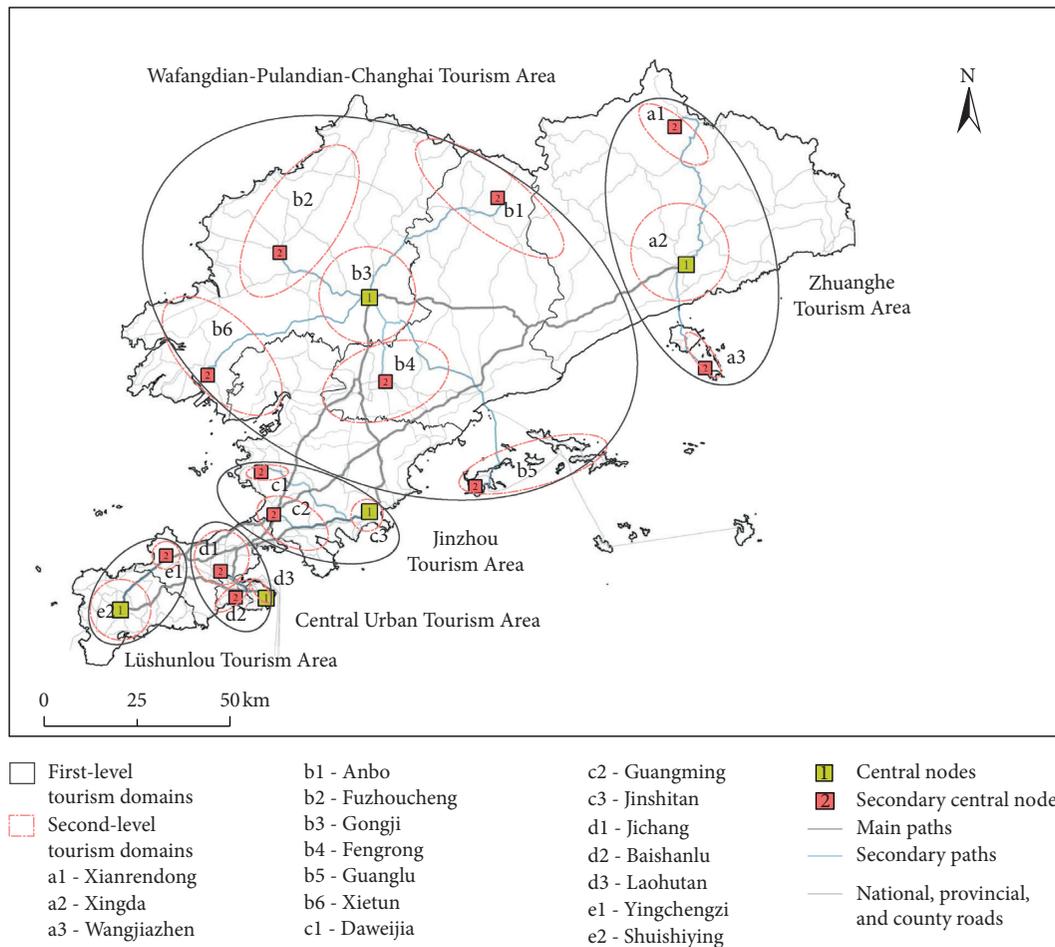


FIGURE 7: The hub-spoke network spatial organization mode of Dalian's tourism industry.

hospitality, are not considered. At the same time, the continuous emergence of new tourism formats will cause changes in the type of tourism resources available. In the future, it will be necessary to update data regularly and adjust the selection of central index items for tourism nodes, thereby reinforcing the scientificity and reasonability of the research conclusions. In addition, the research perspective can try to expand from considering only the tourism industry and regional economic development to also considering the spiritual and psychological fields of residents' life and culture. This will allow the layout of tourism nodes to be more fully understood.

5.2. Selection of Network Analysis Methods. GIS network analysis technology is introduced into tourism-themed research to optimize tourism nodes and channels. Based on this, the spatial organization mode of the tourism industry is constructed; this differs from most current research, which has typically used qualitative research methods to determine tourist distribution centers and organization modes [25, 27]. Based on the traffic network dataset and the simulation of the distribution of tourism enterprises, the layout scheme is obtained; this provides more scientific research results and is superior to the empirical layout

method [3, 13, 20] in predicting the service effect, quantity, and service scale of tourism nodes. The research results based on the traffic network dataset perfect the research ideas proposed by Deng and Zheng [15, 21]. Using the network analysis method, all tourism enterprises are covered by tourism nodes, and the shortest traffic path between the two is realized, thus improving the efficiency of tourism industry elements utilization. This breaks through the disadvantages of the buffer analysis method [53] and proximity analysis method [54] in solving such problems. In the future, setting simulated traffic impedance should be more refined, so that the optimization scheme is more conducive to improving the scientific validity of tourism decision-making.

5.3. Restrictive Factors. Since tourism reception facilities, such as catering, shopping, and entertainment, serve both tourists and nontourists, there is no-good method to separate the data, so only some representative enterprises are selected to construct an index system. The number and types of index items affect the centrality index of tourism nodes, thus affecting the determination of the number and locations of tourism nodes at all levels, which, to some extent, limits a more scientific understanding of tourism nodes.

TABLE 4: The hub-spoke network spatial organization mode of Dalian's tourism industry.

Element	Item	Level	Details
Axes	Central nodes	First-level tourism nodes	Laohutan Subdistrict, Shuishiying Subdistrict, Jinshitan Subdistrict, Gongji Subdistrict, and Xingda Subdistrict
	Secondary central nodes	Second-level tourism nodes	Baishanlu Subdistrict, Airport Subdistrict, Yingchengzi Subdistrict, Guangming Subdistrict, Daweijia Subdistrict, Fuzhoucheng Town, Xietun Town, Fengrong Subdistrict, Guanglu Township, Anbo Town, Xianrendong Town, and Wangjia Town
Spokes	Main paths	First-level tourism channels	Laohutan Subdistrict-Shuishiying Subdistrict, Laohutan Subdistrict-Jinshitan Subdistrict, Laohutan Subdistrict-Gongji Subdistrict, Laohutan Subdistrict-Xingda Subdistrict, Shuishiying Subdistrict-Jinshitan Subdistrict, Shuishiying Subdistrict-Gongji Subdistrict, Shuishiying Subdistrict-Xingda Subdistrict, Jinshitan Subdistrict-Gongji Subdistrict, Jinshitan Subdistrict-Xingda Subdistrict, and Gongji Subdistrict-Xingda Subdistrict
	Secondary paths	Second-level tourism channels	Yingchengzi Subdistrict-Shuishiying Subdistrict, Airport Subdistrict-Laohutan Subdistrict, Baishanlu Subdistrict-Laohutan Subdistrict, Guangming Subdistrict-Jinshitan Subdistrict, Daweijia Subdistrict-Jinshitan Subdistrict, Guanglu Township-Gongji Subdistrict, Fengrong Subdistrict-Gongji Subdistrict, Xietun Town-Gongji Subdistrict, Fuzhoucheng Town-Gongji Subdistrict, Anbo Town-Gongji Subdistrict, Xianrendong Town-Xingda Subdistrict, and Wangjia Town-Xingda Subdistrict
Domains	First-level tourism domains	First-level tourism areas	Central urban tourism area, Lüshunkou tourism area, Jinzhou tourism area, Wafangdian-Pulandian-Changhai tourism area, and Zhuanghe tourism area
	Second-level tourism domains	Second-level tourism areas	Laohutan tourism area, Shuishiying tourism area, Jinshitan tourism area, Gongji tourism area, Xingda tourism area, Baishanlu tourism area, Airport tourism area, Yingchengzi tourism area, Guangming tourism area, Daweijia tourism area, Fuzhou tourism area, Xietun tourism area, Fengrong tourism area, Guanglu tourism area, Anbo tourism area, Xianrendong tourism area, and Wangjia tourism area

Calculations for the time distance between tourist nodes are currently completed according to the transportation speed laws in the relevant areas. The accuracy of this method of determining the tourism nodes centrality needs to be improved. Navigation data can be used to improve the calculation method of time distance in the future so that the tourism node centrality index can be more realistic.

Since the research scale is townships and subdistricts, the conclusions are based on the road network optimization without considering the railways. With the change of transportation mode, the road network system is gradually improved, the accessibility between nodes is improved, and the regional tourism network is further expanded. Dynamic regulation and long-term tracking should be strengthened in the future, and follow-up research should be carried out through multisource and multiscale data fusion. With multiple modes of transportation, grids and communities are used as research units to construct tourism nodes and tourism channels above level three and to improve the tourism industry spatial organization model. This study offers a reference point for the solution of similar problems. The analysis results are based on certain assumptions and simulation premises and need to be repeatedly verified in practice.

6. Conclusion

- (1) In terms of the number of tourism nodes, 17 second-level tourism nodes and 5 first-level tourism nodes are optimized using the model of “minimizing

facility points” on the basis of considering the traffic locations and the relevance of tourism enterprises. Tourism resources are the basic conditions for the development of the tourism industry. The level and quantity of tourist attractions play a significant role in leading and driving tourism nodes. Tourism nodes rely on tourist attractions to develop and grow.

- (2) In terms of the service scale of tourism nodes, under the “maximum coverage” model, 3138 tourism enterprises are served by tourism nodes. The average service size of second-level tourism nodes in urban areas is 469, while that of second-level tourism nodes in suburban areas is 92. Compared with suburban areas, tourism enterprises in urban areas are densely distributed, and a smaller service radius can cover more tourism enterprises.
- (3) A total of 10 first-level tourism channels and 12 second-level tourism channels are optimized using the nearest facility model. The first-level tourism channels are mainly distributed in the central and southern areas of Dalian. These channels establish connections between tourism nodes mainly through national and provincial roads and have high tourist distribution capacity. The second-level tourism channels are mainly distributed in the central and northern areas of Dalian City, where tourism enterprises are relatively sparse, and it is thus not reasonable to build first-level tourism channels in the near future.

- (4) The optimization scheme enables all tourism enterprises to connect with tourism nodes and tourism channels, thus making full use of tourism industry elements. Tourism enterprises can obtain services from the nearest tourism nodes, allowing them to realize the shortest traffic path between tourism enterprises and tourism nodes, thus minimizing the total cost of network services.
- (5) Dalian's tourism industry spatial organization mode has gone through three stages of development, namely, condensation, radiation, and expansion. Based on the optimization results of tourism nodes and tourism channels, Dalian's hub-spoke network tourism industry spatial organization mode is constructed, which presents 5 central nodes and 12 secondary central nodes, adding up to 17 hubs. These hubs combine with 10 main paths and 12 secondary paths, adding up to 22 spokes, to form 5 first-level tourism domains and 17 second-level tourism domains for a total of 22 domains. This model integrates the advantages of the condensation, radiation, and expansion modes.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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