SPATIAL PATTERN ANALYSIS OF ATTRACTIONS BASED ON POI DATA FOR EXAMPLE: MACAU, CHINA

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Abstract

As a world city of tourism and leisure, the Macau Special Administrative Region is rich in tourism resources. However, under the influence of the new crown epidemic, the number of tourists in Macau has diminished significantly, and the tourism economy has declined. This study analyzes the spatial pattern of Macau’s scenic spots by using the POI of Macau’s tourist attractions, and analyzes the spatial pattern of scenic spots on the Macau Peninsula and Macau outlying islands (Taipa Island, Cotai Reclamation Area, Coloane Island) using the average nearest neighbor ratio method, the kernel density estimation method and the standard deviation ellipse method, respectively, and then compares them, and analyzes the spatial distribution of different types of tourist attractions in Macau. The spatial syntax method is used to analyze the traffic situation in areas with more dense tourist attractions, and some suggestions are put forward for optimizing the distribution pattern of Macau’s tourism industry and improving the distribution of Macau’s tourism routes and tourism construction.

Keywords: POI data, spatial pattern, Macau

1. INTRODUCTION

With the development of the times, people's pursuit of quality of life and demand for living space are getting higher and higher (Zhou, 2016), and the demand for tourism experience is also getting higher and higher; the spatial distribution of tourist attractions elements has an impact on tourism activities, play an important role (Yan, 2018). In recent years, due to the impact of the new crown pneumonia epidemic, the national tourism industry has been greatly impacted (Wang, 2020), especially cities such as Macau, which rely on the tourism industry as their economic pillars, have been greatly affected. According to data from the Macau Statistics and Census Bureau, Macau’s inbound tourists dropped sharply in 2020, and Macau’s GDP fell by 56.3% in 2020. As a world-class tourist city, Macau’s main source of income depends on the number of tourists (Guo, 2020). The analysis of the distribution of tourist attractions in Macau is conducive to the analysis of tourist activity areas in Macau, and for more reasonable planning and construction of tourist service facilities and transportation in Macau facilities and public infrastructure to enhance Macau's tourism economy and enhance tourism vitality (YE, 2020).

The urban density of Macau is relatively high. As of 2020, the population density of Macau is 20,800 people/km², of which the population density of Macau Peninsula is 58,300 people/km², Taipa Island is 139,000 people/km², and Coloane Island is 42,000 people/km². The population of Australia as of 2020 is 683,100. On the basis of limited land, the state has also laid out the Hengqin Guangdong-Macau Deep
Cooperation Zone to provide Macau with a multi-industry cooperation platform and a good land foundation for the development of Macau's multi-industry (Wu, 2021). Therefore, the spatial pattern of tourism in Macau is analyzed. It is more conducive to coordinating the development of tourism cooperation in Macau and surrounding areas, and increasing the tourism opportunities and tourism economy of Macau (Zhan, 2021).

With the advancement and innovation of technology, the construction of smart cities is also constantly being practiced. My country started smart city construction in November 2012 (Dang, 2018), which is very beneficial for Macau to develop based on the technological background of the Greater Bay Area. Combining the method of smart city construction to analyze the layout of tourism space can increase the scientificity and rationality of the analysis. Based on the background of smart city construction, big data analysis is also more and more widely used in the field of urban planning, and relying on traditional planning methods to analyze the needs of people is no longer suitable for today's scenic spots layout (Qi, 2018). In recent years, Point-Of-Interest (POI) has received extensive attention as a typical spatio-temporal data classification (Xing, 2021), and more and more scholars have studied it based on the geographical location of POI. With the development of urbanization, the density of cities is getting higher and higher. The population, buildings, and municipal facilities in high-density urban areas are highly dense, and the space available for people to carry out public activities is very limited (Xiao, 2017). While carrying the function of serving tourists, the urban attractions space can be used intensively as a public activity space for urban residents. As a public resource, tourist attractions can serve tourists and urban residents and benefit both residents and tourists, so it is necessary to analyze their spatial distribution characteristics. Many of the current tourism resources in Macau are developed and established based on existing resources. By exploring the distribution of Macau's scenic spots, one can understand the historical development of Macau, reasonably evaluate the rationality of the distribution of the existing tourism system, and summarize the high-density urban tourism development system. The experience of construction will add information and provide experience for the future tourism system planning of other cities with unique tourism resources in the country.

The application of POI big data is also increasing in urban planning, transportation, epidemic prevention and control and other fields (Li, 2018). Foreign POI data is used in vehicle navigation and traffic flow analysis, as well as social geographic location and point of interest mobile data and in the analysis of geo-social privacy point protection, etc. (Yha, D, 2021, Wu, R, 2021). Domestic POI data analysis has been applied in the fields of comprehensive urban disaster prevention and traffic benefit analysis. Some experts and scholars have also studied POI data of different urban attractions. However, due to the large differences between the fields studied by other scholars and the urban scale of Macau, there are insufficient In order to illustrate the distribution characteristics of Macau's tourist attractions and how the public infrastructure that needs to be improved should be laid out, this study takes Macau as an example to analyze the spatial distribution pattern of its tourist attractions.

2. RESEARCH PURPOSES AND OBJECT

2.1. Research Purposes

Mainly study the distribution of tourist attractions in Macau and understand the tourist activity areas in Macau, with the purpose of analyzing the spatial distribution pattern of tourist attractions in Macau, providing better services for future tourism development in urban planning and construction, and understanding the relationship between historical development and modern tourism development in Macau, reasonably evaluate the rationality of the distribution of the existing tourism system, and summarize the experience in the construction of high-density urban tourism development system.

2.2. Research Object

This study takes the whole area of the Macau Special Administrative Region as the research scope. The Macau Special Administrative Region is located in southern China, on the west side of the Pearl River Delta in southern China, and on the west bank of the Pearl River Estuary. It is a world center of tourism and leisure. Macau has a subtropical monsoon climate, including the Macau Peninsula, the outlying islands of Macau (Taipa Island, Cotai Island and Coloane Island), with a total area of 32.9 square kilometers and a population of 683,200 by the end of 2020. There are seven parishes under its jurisdiction (Kao Hall) District, Wangde Parish, Fengshun Parish, Lobby Area, Fatima Parish, Carmo Parish (Taipa), St. Francis Parish (Coloane)), with rich tourism resources.

3. DATA SOURCE AND PROCESSING

3.1. Data Sources

The urban park POI data used in this study was collected from the geographic location information of the

AutoNavi Map website (https://www.amap.com/) in December 2021, mainly including the names of scenic spots, spatial location coordinates and other information. After obtaining the data, combine with other map websites such as Baidu Maps website (https://map.baidu.com/) and Google Earth website (https://google-earth.gosur.com/cn/) to supplement and improve the information to obtain Macau Name data, coordinate data, and geolocation data for all attractions.

3.2 Data Processing

The study is to study the spatial distribution pattern of Macau’s scenic spots composed of specific tourist attractions in Macau, and analyze the spatial pattern of scenic spots. Convert the coordinates of the original data obtained by web crawling from the GCJ-02 coordinate system or BD-09 coordinate system to the WGS_84 coordinate system using the QGIS 3.16.1 platform as shown in Figure 3.2.1 and Figure 3.2.2, and then based on ArcGIS10.4 The platform realizes data space visualization, and finally cleans and filters the data (Yang, 2021).

Figure 3.2.1 POI without coordinate transformation

Figure 3.2.2 POI after coordinate transformation

Eliminate the repeated point data and coordinate data, then observe and eliminate the non-scenic spot data in the acquired data, and then classify and analyze the scenic spot space. For the specific classification method, refer to Huang Qin’s classification method (Huang, 2021).

4. RESEARCH METHOD

The obtained POI data is analyzed by the following three methods through ArcGIS, and the spatial distribution status of the POI elements of the scenic spot is judged through the analysis results.

4.1 Average Nearest Neighbour Ratio

The average nearest neighbor ratio can quantitatively describe the distance between each point feature in space and the location of its nearest neighbor point feature, and then calculate the average of all these nearest neighbor distances (Tu, 2020). If the average distance is less than the average distance in a hypothetical random distribution, the distribution of features under analysis is considered to be clustered. If the average distance is greater than the average distance in a hypothetical random distribution, the feature is considered to be scattered. The average nearest neighbor ratio is calculated by dividing the observed average distance by the expected average distance (using the expected average distance based on an assumed random distribution that uses the same number of features to cover the same total area).

The Average Nearest Neighbor ratio is calculated as:

$$\text{ANN} = \frac{\bar{D}_O}{\bar{D}_E}$$

Where $\bar{D}_O$ is the observed mean distance between each feature and its nearest neighbor:

$$\bar{D}_O = \frac{\sum_{i=1}^{n} d_i}{n}$$

Where $\bar{D}_E$ is the expected average distance between the specified features in random mode

$$\bar{D}_E = \frac{0.5 \sqrt{\frac{A}{n}}}{A}$$

In the above equation, $d_i$ is equal to the distance between feature $i$ and its nearest neighbor. $n$ corresponds to the total number of features, and $A$ is the area of the smallest enclosing rectangle that can include all, or a user-specified "area" value.
If the index (average nearest neighbor ratio) $ANN$ is less than 1, the pattern of feature performance is clustered, and the smaller the value of $ANN$, the more clustered it is. If the exponent $ANN$ is greater than 1, the pattern of element performance is discrete, and the larger the value of $ANN$, the more likely it is to be diffused. If the exponent $ANN$ is equal to 1, the pattern of the feature's behavior is random.

The average nearest neighbor $z$-score for the statistic is calculated as:

$$z = \frac{\bar{D}_n - \bar{D}_e}{SE}$$

$\ln$:

$$SE = \frac{0.26136}{\sqrt{n^2/A}}$$

The $z$-score represents a multiple of the standard deviation. The $p$-value represents the probability. Very high or very low (negative) $z$-scores at both ends of the normal distribution that are associated with very small $p$-values.

### 4.2 Kernel Density Estimation

The kernel density estimation method reflects the relative concentration of elements in the spatial distribution, takes each grid to be calculated as the center, and performs a circular area search to calculate the density value of each grid (Kang, 2018). Each kernel uses the kernel function to calculate the magnitude per unit area from point or polyline features to fit each point or polyline to a smooth, tapered surface. The size of the bandwidth has a significant impact on the fineness of the analysis results. By comprehensively considering the dispersion degree of the spatial distribution of the POIs of tourist attractions and their average influence range, the selection of this analysis is based on the scale of Macau itself, and a search radius (bandwidth) of 300m is selected for the analysis. Analysis, which can reflect the overall landscape distribution characteristics.

### 4.3 Standard Deviation Ellipse

The standard deviation ellipse analysis method uses the standard deviation of the major and minor axes, the center of the ellipse and the azimuth as the basic parameters to quantitatively describe the concentration, dispersion and direction trend of geographic elements. Objective expression (Xiong, 2021) At present, it is mainly used in related researches such as the location of scenic spots, the development pattern of tourism, and the network attention of tourism elements. The calculation based on Euclidean distance or Manhattan distance needs to project the data to accurately measure the distance. The standard deviation ellipse calculation method is as follows:

$$C = \begin{pmatrix}
\text{var}(x) & \text{cov}(x,y) \\
\text{cov}(y,x) & \text{var}(y)
\end{pmatrix} = \frac{1}{n} \begin{pmatrix}
\sum_{i=1}^{n} x_i^2 & \sum_{i=1}^{n} x_i y_i \\
\sum_{i=1}^{n} x_i y_i & \sum_{i=1}^{n} y_i^2
\end{pmatrix}$$

where

$$\text{var}(x) = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n} \sum_{i=1}^{n} \bar{x}_i^2$$

$$\text{cov}(x,y) = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x}) (y_i - \bar{y}) = \frac{1}{n} \sum_{i=1}^{n} \bar{x}_i \bar{y}_i$$

$$\text{var}(y) = \frac{1}{n} \sum_{i=1}^{n} (y_i - \bar{y})^2 = \frac{1}{n} \sum_{i=1}^{n} \bar{y}_i^2$$

Where $x$ and $y$ are the coordinates of the $i$ feature, $\{\bar{x}, \bar{y}\}$ represents the average center of the feature, and $n$ is the total number of features (Yang, 2019).

The sample covariance matrix is decomposed into standard form so that the matrix can be represented by eigenvalues and eigenvectors. So, the standard deviation of the $x$ and $y$ axes is:
\[
\sigma_{1,2} = \left( \frac{\sum_{i=1}^{n} x_i^2 + \sum_{i=1}^{n} y_i^2}{2n} \pm \sqrt{\left( \sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} y_i^2 \right)^2 + 4\left( \sum_{i=1}^{n} x_i y_i \right)^2} \right)^{1/2}
\]

5. RESULTS AND ANALYSIS

5.1 Overall Spatial Pattern

In order to analyze the spatial distribution and morphological characteristics of the POIs of Macau tourist attractions as a whole, the POI data of Macau’s tourist attractions were analyzed, and the average nearest neighbor ratio, kernel density estimation results and standard deviation elliptical distribution of all attractions were obtained. Through ArcGIS10.4 software analysis, it is obtained that the nearest neighbor ratio ANN of Macau Tourist View Dina is 0.516, which is less than 1; the average observation distance is 83.500m, and the expected average distance is 161.835m; the P value is 0, and the Z value is -22.492 (less than -2.58), passed the significance test with 0.01 confidence level, so there is a 99% probability of rejecting the null hypothesis. From this, it can be preliminarily judged that the overall distribution type of scenic spots on both sides of Macau is agglomeration type. By superimposing the core density analysis layer and the Macau road network map layer, it can be seen that the historic center of Macau has become the area with the highest density value, and Guan Ye Street and its surrounding areas in Taipa have become the core of sub-density. The overall pattern is a spatial pattern in which the scenic spots in the historical city of Macau are aggregated as a whole, and are scattered on Taipa Island and Coloane Island. The core of the highest value is generally with Macau Straight Street as the main axis, and the main attractions are distributed in the historic center of Macau. The distribution of scenic spots on the Macau Peninsula is also mainly concentrated around the historical city of Macau, which covers the largest area, mainly including famous hot spots such as St. Paul's Arch, Dom Ding Theater, St. The main attractions of the island are distributed in Guanye Street and its surrounding areas; the main attractions of the Cotai area are located in the main shopping malls and casinos on both sides of the Continental Highway; the attractions of Coloane Island are mainly concentrated in the Coloane Pier and its surroundings In the area, there are mainly attractions such as Coloane Children's Park and Coloane St. Francis Church.
From the standard deviation ellipse, it can be seen that the development of the urban tourism pattern of Macau can consider the coordinated development of the tourism resources of the island of Macau and the tourism resources of the outlying islands in the future, especially the relatively complete commercial service facilities of the outlying islands of Macau. Play a more complete supporting role.

5.2 Classification Spatial Pattern

The data of the attractions are classified according to the function and culture of the attractions in Macau, and the points of interest of the 492 tourist attractions are divided into nine categories, namely ruins and sculptures, temples and ancestral halls, waterfront space buildings, culture and exhibition halls, squares There are nine categories of land, museums, playgrounds and botanical gardens, parks and churches, as shown in Table 5.2-1 below:

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Attraction Type</th>
<th>POI example</th>
<th>Amount</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ruins and Sculptures</td>
<td>Fortress, Cui Nuozhi Mansion, Gao Family Mansion, Xian Xinghai Memorial Bronze Statue, Zheng Family Mansion……</td>
<td>122</td>
<td>24.80%</td>
</tr>
<tr>
<td>2</td>
<td>Temples and Shrines</td>
<td>Guanyin Temple, Tianhou Temple, Pakdi Temple, Nuwa Temple, Fude Temple, Bamboo Forest Temple, Sansheng Temple……</td>
<td>54</td>
<td>10.98%</td>
</tr>
<tr>
<td>3</td>
<td>Waterfront Space Architecture</td>
<td>Fisherman's Wharf, Hac Sa Beach, Bamboo Bay Beach, Jiu'ao Lighthouse, Macau Sai Wan Bridge……</td>
<td>13</td>
<td>2.64%</td>
</tr>
<tr>
<td>4</td>
<td>Culture and Exhibition Hall</td>
<td>Cultural Center, Tap Seac Art Museum, Macau Tea Culture Center, Macau Science Museum……</td>
<td>31</td>
<td>6.30%</td>
</tr>
<tr>
<td>5</td>
<td>Plaza and forecourt</td>
<td>Senado Square, Golden Lotus Square, Tap Seac Square, Gangding Front……</td>
<td>26</td>
<td>5.28%</td>
</tr>
<tr>
<td>6</td>
<td>Museum</td>
<td>Maritime Museum, Museum of Religious Art, Macau Museum of Art, Macau Museum……</td>
<td>37</td>
<td>7.52%</td>
</tr>
<tr>
<td>7</td>
<td>Playground and Botanical Garden</td>
<td>Children's Amusement Park, Xinxing Aquarium, Panda Pavilion, Golden Statue Farm, Water Sports Center……</td>
<td>10</td>
<td>2.03%</td>
</tr>
<tr>
<td>8</td>
<td>Park green space</td>
<td>Shek Pai Wan Country Park, Mong Ha Shan Municipal Park, Coloane Peak Park, Hac Sha Wan Park……</td>
<td>81</td>
<td>16.46%</td>
</tr>
<tr>
<td>9</td>
<td>Church</td>
<td>Church of Our Lady of the Rosary, Church of Our Lady of Carmel, Church of St. Francis in Coloane……</td>
<td>118</td>
<td>23.98%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Attractions</td>
<td>St. Paul's Archway, A-Ma Temple, Lianxi Temple, St. Lawrence Church, Gangding Theatre……</td>
<td>492</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Using the above research methods to analyze the classified scenic spots, the specific analysis results are shown in the figure:

Figure 5.2.1 Standard deviation ellipse of POIs of different types of attractions in Macau

Figure 5.2.2 playgrounds and botanical gardens Kernel density analysis
Figure 5.2.3 Museum Kernel Density Analysis
Figure 5.2.4 Analysis of Church Kernel Density
From the classified scenic spot kernel density analysis chart and standard deviation ellipse, it can be seen that cultural scenic spots are mostly concentrated in the Macau Peninsula area, and natural and ecological cultural scenic spots are mostly distributed in Taipa Island and Coloane Island, so in the later landscape development, you can consider optimizing the existing tourist routes and building more reasonable tourist routes.

6 CONCLUSION AND DISCUSSION

According to the above analysis, conclusions and discussions related to the spatial distribution of attractions in Macau can be drawn as follows:

(1) The main tourist attractions in Macau are still concentrated in the Macau Peninsula area, mainly in the type of agglomeration with a single core concentration. Among them, the tourism industry in Macau Peninsula is mainly based on cultural relics. In the future planning and construction of Macau, the cultural conservation of this part of the scenic spots will still be the main work, and the development and layout will be combined with the tourism industry.

(2) The commercial tourism resources and park green space resources of Taipa Island, Cotai City and Coloane Island are very rich, but the infrastructure construction of tourism services needs to be improved, and more services for local residents can be considered in future planning and construction. Ecotourism service route.

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