

# Research on Space Syntax Theory and Spatial Configuration of Museum Buildings under the Background of Digital Science and Big Data Technology

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**Abstract:** The development of the country and people's life and big data technology becomes increasingly close. By the end of 2021, there are 6,283 museums for the record in China. And the internal configuration design of the museum is complex and of great significance, but there is little analysis of space itself with big data technology. This paper tries to take the Jilin Provincial Museum as a research case based on Big data technology and take space syntax under big data technology as the theoretical basis to study the spatial configuration of the museums, including the axis, convex space, and quantification of view sheds, and to discuss its deep relationship and internal laws by collecting and collating the materials of the museums. Verifying them by combining with the actual research data, this paper will dig deep into the whole process from the museum space's original design to its actual use, and put forward the corresponding reference evaluation and suggestions for the Jilin Provincial Museum. In addition, the author hopes that the paper can provide analytical ideas and research methods for museum design to refer to.

## 1. Introduction

Space syntax theory is a unique and complete theoretical and methodology system expressing the complex relationship between spatial structure and human social behavior, which can show the relation between space and society through a series of measurable quantitative indexes [1]. Space syntax theory is widely applied to the fields of urban planning, road and traffic, exhibition buildings, commercial complex and so on. And in recent years, the space for a series of research and practice using space syntax in the urban construction of Changchun City has achieved good results. Jilin Provincial Museum is a comprehensive museum composed of three exhibition halls, using a courtyard-garden layout. This paper attempts to carry out the quantitative analysis and case study on the spatial configuration of Jilin Provincial Museum by the method of configuration analysis of space syntax.

## 2. Spatial configuration characteristics of Jilin provincial museum

Spatial configuration refers to the interconnection between many spaces, which constitute the spatial layout of the entire building or the whole city, not just the individual spatial attributes, that is to say the correlation existing among various parts and making them into the whole [2].

The Jilin Provincial Museum has a construction area of 32,000 square meters, including five parts: display and exhibition area, collection warehouse area, cultural relics protection technology area, public service area [3] (see Table 1).

Its three exhibition halls are arranged in a triangular shape, connected by a rotunda in the middle, "three exhibition halls constituting one museum" which is the first example in a provincial-level city in China. The Jilin Provincial Museum as a whole is a coordinated layout of the central and

passage styles, and the three exhibition halls all adopt a symmetrical approach, with the central hall as the center, dividing the building into four large areas.

Table 1 Area of Jilin Provincial Museum

Area	m <sup>2</sup>
Display and Exhibition Area	17700
Collection Warehouse Area	6614
Cultural Relics Protection Public Service Area	1510
Public Service Area	2190
Office Area	3986
Total Area	32000

Source: Self-drawn by the author

The spatial configuration is clear and easy to understand, which is conducive to speculating on the status of the entire large space in time through small areas of space in the process of visiting the exhibition, and the unobstructed routes for visiting can also be conducive to deepening the exhibition significance of the exhibits [4].

### 3. Methods of configuration analysis

This section will explore the spatial configuration of the Jilin Provincial Museum by the analysis methods of axis, convex space and viewsheds, and analyze the relation of its spatial configuration through the calculation of specific data. Each research element is given the corresponding color according to the data, with red being the highest and blue being the lowest as the basic principles, so as to obtain the results [5-11].

#### 3.1 Axis analysis on a macroscopic scale

The Jilin Provincial Museum is selected to be far away from downtown areas and industrial areas, and some open spaces are used for landscaping, parking vehicles and disaster and fire prevention. And there are seven residential areas, six schools, Changchun Movie Wonderland and Jingyue Park nearby, which meet the needs of the surrounding people for cultural construction. Figure 1 is an analysis of the integration degree of the roads where the Jilin Provincial.

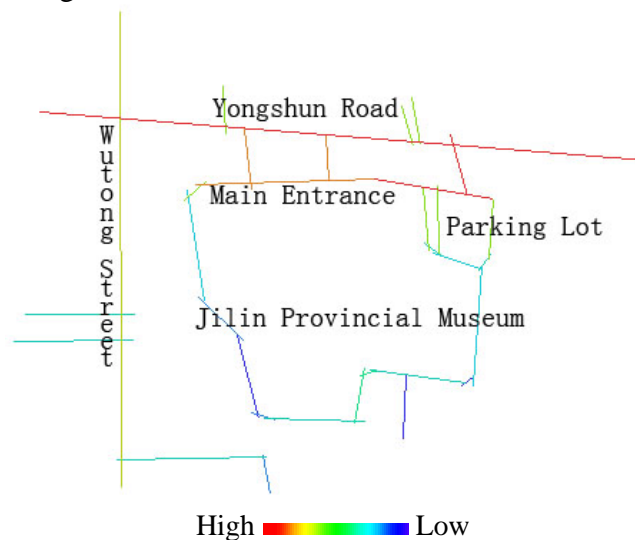


Figure 1 Axial Map of Global Integration of the Museum (Source: Self-drawn by the author)

Museum is located. And it can be seen through the illustration that the Jilin Provincial Museum emphasizes the convenience of external transportation, the requirements for centrality and flow of people are not high, and the location with the highest degree of integration is distributed near the main entrance of the museum, which is consistent with its actual situation.

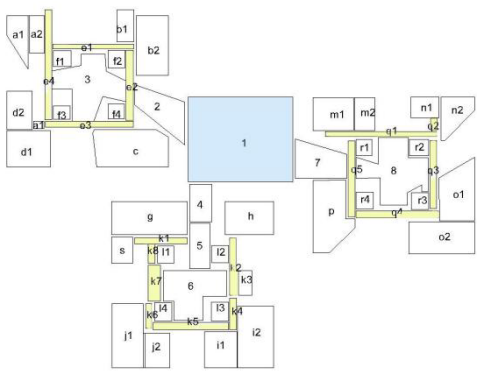
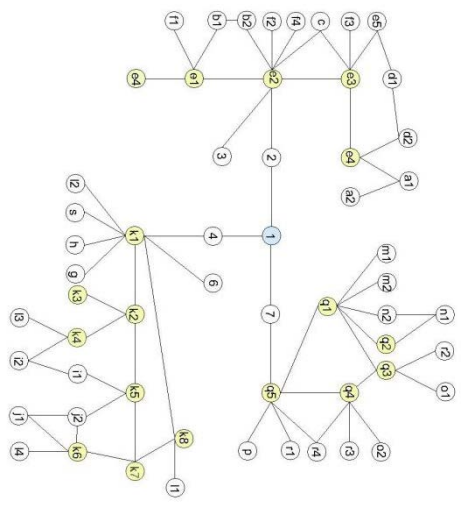

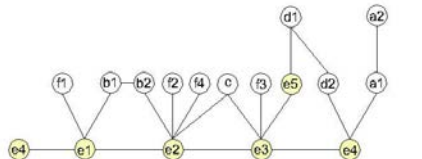
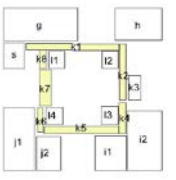
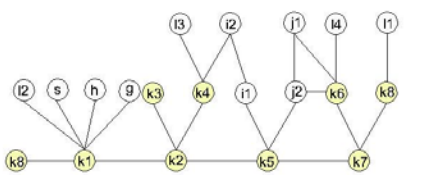
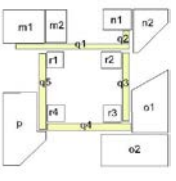
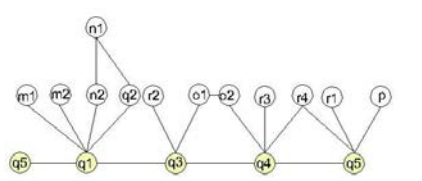
### 3.2 Convex space analysis of configurational relations

#### 3.2.1 Spatial topological relations and integration of convex space

Topological relations refer to the naming of each space from the perspective of space syntax, and the connection between spaces and the relations among spaces. Redistributed them without changing the relations, space relations can be expressed in a simple and visualized way.

The rightmost columns in Table 2 are the topological diagram of the museum. The first floor is centered on the Space of Hall 1, and the other three exhibition halls are re-mapped with the corridor space as the center, and it can be clearly concluded from the diagram that the lowest accessibility of the museum space is all located in the exhibition hall space, and the spaces of the three exhibition halls are independent. No matter which exhibition hall you want to reach, you must pass through the corridor space. The place with highest accessibility is the public transport space of each museum, which has an overall influence and can guide and limit visitors.

Table 2 Syntax Analysis and Relations of Convex Space in Jilin Provincial Museum

Floors	Division of Convex Space	Topology diagram
First-floor plan of the Museum		
Floor plan of the Museum		
Floor plan of the Science and Technology Museum		
Floor plan of the Optical Museum		

Source: Self-drawn by the author

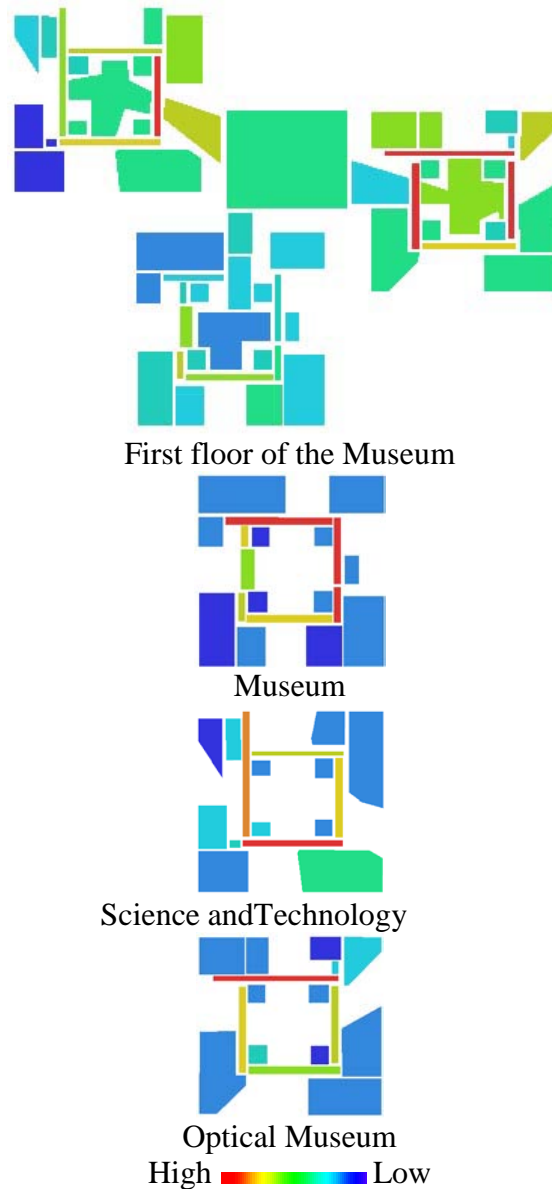


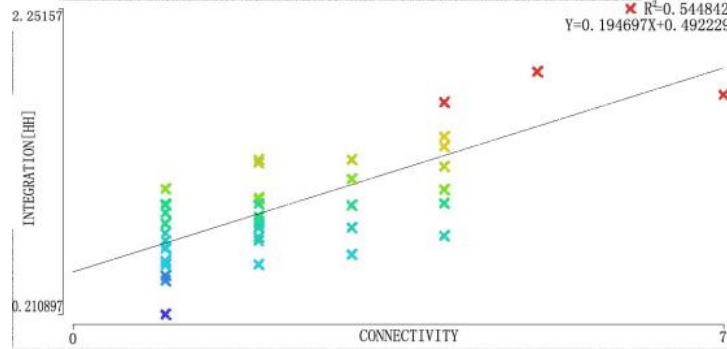
Figure 2 Convex Spatial Integration Degree of Jilin Provincial Museum (Source: Self-drawn by the author)

It can be seen from Figure 2 that in the spatial configuration of the convex space of the first floor plan, its overall integration is higher than that of other floors. The colors of space e, q, and k are the reddest, indicating that they have the best control over the overall space. The spaces e, q, k are the areas for public transportation in the museum connected the various exhibition halls of the three exhibition halls, and if you need to reach other spaces, they are the best choice. Space 2 is the place where the museum space and its atrium are connected, which is the first one you see when entering the museum, and its convex space integration is also higher. The integration of the space a, b, c, d, g, h, i, j, s, m, n, o, and p is generally low. As exhibition halls, they are relatively independent for the overall space. Looking at the entire space of the museum as a whole, it shows a central spatial Configuration relation.

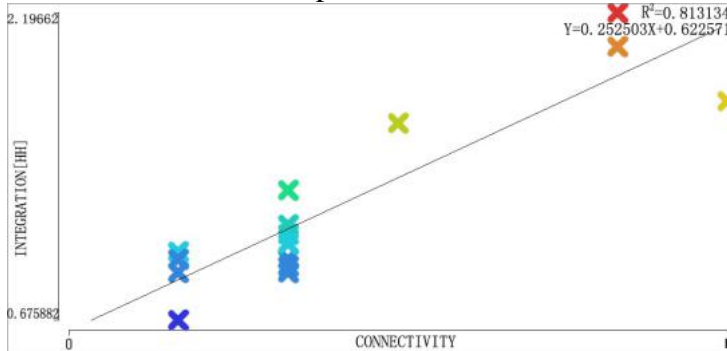
### 3.2.2 Connection value and integration level

The spatial scatterplot reflects the intelligibility relationship of convex space. The values of the R square of Jilin Provincial Museum and its first floor respectively are 0.81 and 0.55; the values of the Optical Museum and Science and Technology Museum respectively are 0.86 and 0.78. The connectivity between the first floor and each entrance of the three exhibition halls is better, and the intelligibility of the space in line with people's behavior and habits is also high. The overall R-squared value of the museum is above 0.5, which makes visitors quickly have a very good

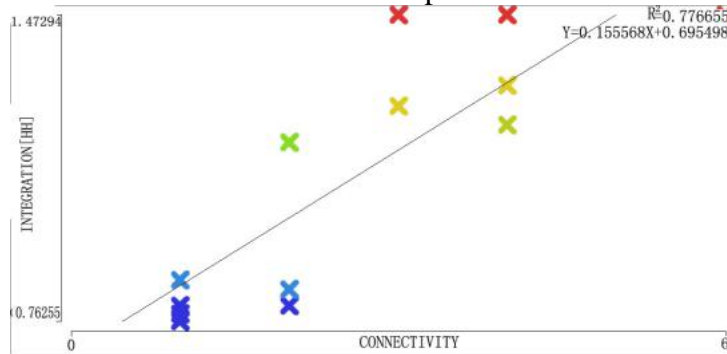
understanding of the spatial structure from the part to the whole (see Figure 3).



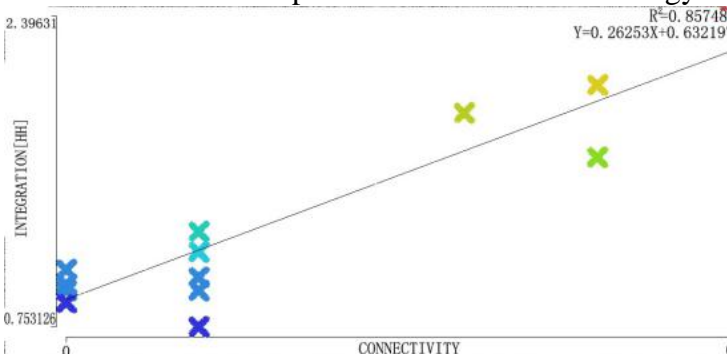
Scatter Plot of the Convex Space on the first floor of the Museum



Scatter Plot of the Convex Space of the Museum



Scatter Plot of the Convex Space of Science and technology Museum



Scatter Plot of the Convex Space of the Optical Museum

Figure 3 Scatter Plot of Convex Space of Jilin Provincial Museum (Source: Self-drawn by the author)

### 3.3 Viewshed analysis of spatial visibility

#### 3.3.1 Clustering coefficient and integration level

Viewshed analysis is a method of analyzing space based on the angle of people's visual range in space. Clustering coefficient is how many other points are seen at a certain point. If the Clustering coefficient of people's visual range in space is high, more people will gather. The position with high

viewshed integration is more likely to see the role that the whole situation plays in gathering and scattering crowd.

As can be seen in Table 3, most of the parts with better viewshed integration are located at the transport nodes in the space. The clustering coefficient and the integration level basically show a corresponding relationship with each other. And the part with the better clustering coefficient usually has a higher level of spatial integration. It can be clearly seen that the clustering coefficient of the first floor of the Museum is higher, which is shown as the red area and mainly distributed at the intersection of the entrance hall and the three exhibition halls. The highest position is on the left side of the Museum. The area with high spatial integration is also located on the left side of the first floor hall and the position where the first-floor hall intersects with the three exhibition halls.

In the three exhibition halls, the viewshed integration is relatively high inside the space while low in the corridor area. And the sites with high clustering coefficient are located at the points of junction among the spaces, where people can see the most places around. In the three exhibition halls, the viewshed integration of the corridor area is low. Their clustering coefficients still maintain in a good range.

Table 3 Viewshed Analysis of Jilin Provincial Museum

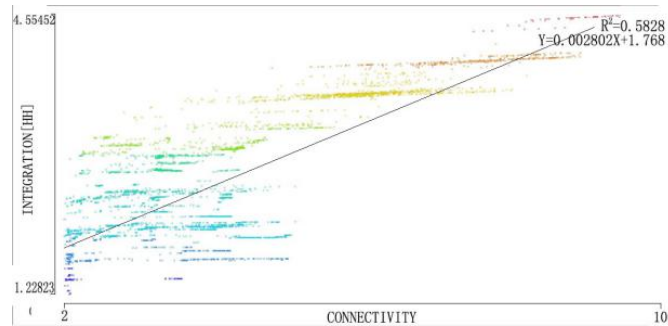
Floors	First floor of the museum	The Museum	Science and Technology Museum	Optical Museum
Floor Plan				
Viewshed Clustering Coefficient				
Viewshed Integration Level				

High Low Source: Self-drawn by the author

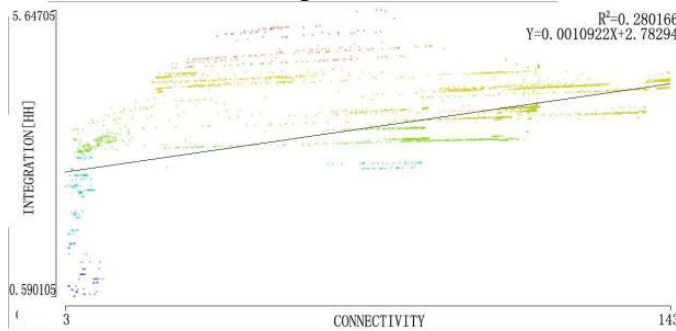
### 3.3.2 Connection value and integration level

When the value of the R square on the first floor of the Jilin Provincial Museum is 0.58, which is above 0.5, its horizontal axis is related to the vertical axis. And the intelligibility of the space is high. For the R square value of the scatterplot of the viewshed space in three halls is all lower than 0.5, the visitor's cognitive abilities to see from the local area to the whole hall are weaker. For each of the three exhibition halls of the Jilin Provincial Museum is connected by the straight corridors, which are quite similar, the visitors in the corridor area will be so confused by the similar environment that they can't know the entire space well, which makes the visitor's viewshed

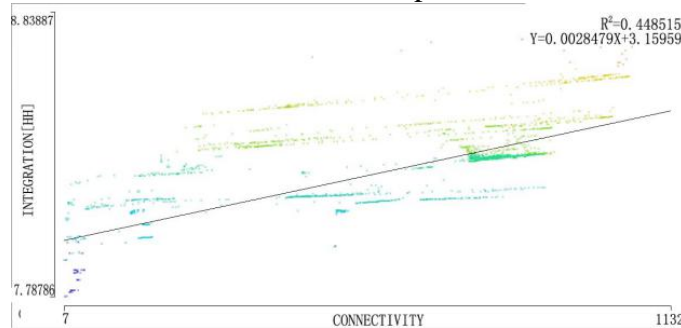
intelligibility of the Museum space become low. In general, the sections with the higher viewshed integration in a museum are concentrated in the public space. As a moving traffic space, the coefficient of clustering visitors in the corridor space should be relatively high, but it is low in the Jilin Provincial Museum. This is related to the intelligibility of spaces. The space design of the museum is monotonous, and it is difficult to understand the museum space by seeing from a local space (see Figure 4).



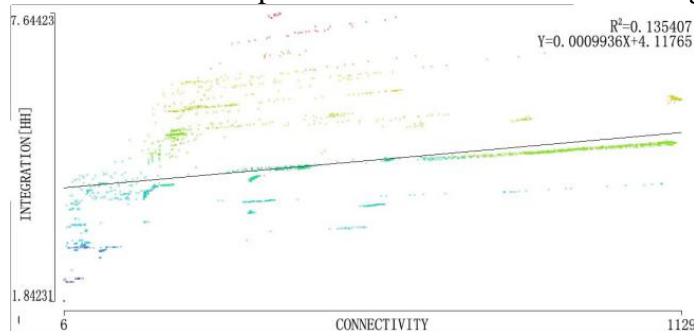
Scatter Plot of the Viewshed Space on the first floor of the Museum



Scatter Plot of the Viewshed Space of the Museum



Scatter Plot of the Viewshed Space of the Science and Technology Museum



Scatter Plot of the Viewshed Space of the Optical Museum

Figure 4 Scatter Plot of Viewshed Space of Jilin Provincial Museum (Source: Self-drawn by the author)

### 3.4 Comparison between analysis results and actual research results

The atrium space on the first floor of the Jilin Provincial Museum is relatively open, and the three exhibition halls have their own atrium, so people will not gather in the same area, and they will be directly dispersed after entering the hall. The crest of the first floor of the museum is at the

location where the Museum and the Science and Technology Museum meet the hall, which is located on the edge of the central hall. And snacks and leisure areas are arranged next to it. This reflects the border effect, where visitors prefer to stay at the edge to experience large-scale spaces and appreciate the details that make visitors stop and discuss (see Table 4).

Table 4 Comparison of Different Spaces in Jilin Provincial Museum

Floors	First floor of the Museum	The Museum	Science and Technology Museum	Optical Museum
Floor plan				
Integration Level of Convex Space				
Viewshed Clustering Coefficient				

High Low Source: Self-drawn by the author

The survey found that it is easy for visitors to have a clear concept of the overall structure of the museum, but it is prone to be confused with whether they have come. This coincides with the convex space analysis and the viewshed analysis. The museum's intelligibility is very high, but the square value of the viewshed intelligibility  $R$  is less than 0.5 except for the first floor. The relationship between the spatial streamline and the integration level of convex space in the Museum is consistent. And visitors' separation and gathering in spaces are basically consistent with the conclusions of the viewshed analysis.

#### 4. Results of Configuration Analysis

The viewing position of the corridor space inside the three exhibition halls is around the internal atrium platform, and there is no solid wall to block, which is better to see than other enclosed exhibition halls, so the crowds are also denser. In such a space, the visitor's entire route should not need too much guidance. But although the spatial configuration of the Jilin Provincial Museum is clear, the internal structure of the exhibition hall is very similar and basically same. Visitors will easily have a familiar perception of the scene, which makes them tend to produce a psychology of fatigue. The corridor spaces of the three exhibition halls are very similar. There is just a row of simple rest seats next to or opposite the exhibition halls, whose interaction with the exhibition hall



is basically zero. The corridor spaces should attract people, but few visitors are willing to stay.

According to the convex space analysis based on space syntax, visitors should be more inclined to visit the Museum first, followed by the Science and Technology Museum, and finally the Optical Museum, but in the actual survey, the number of visitors to the Science and Technology Museum is much higher than that of the other two museums. This is because the Science and Technology Museum, as the main hall of the Jilin Provincial Museum, is more advanced in design and more distinct for the crowd, and each hall has a better interaction with the visitors, which can attract visitors more. Most exhibition halls of The Museum and the Optical Hall use traditional visiting methods, which directly leads to a decrease in the number of visitors.

The spatial configuration of the Jilin Provincial Museum as a whole is mainly based on the function of the exhibition hall, supplemented by public space. The connection between the spaces and the interior of the overall space and the local space need to be further optimized:

(1) Optimize the three exhibition halls based on their own types, increase the participation and interest of the interactive space, and design a variety of combinations to emphasize the variability of the space to meet different using needs.

(2) The interactive space of the front hall of the exhibition hall space is usually indispensable, the small-scale space can promote the occurrence of behavior, and the grasp and control of the spatial scale should be focused.

(3) In the optimization of public space, the rest space should be naturally integrated into the entire exhibition flow, and the connection area between the large open hall space and the exhibition hall should be made full use to provide interactive guidance for the visitor's viewing route.

## 5. Conclusion

This paper uses the method of space syntax to make a detailed spatial interpretation of the spatial configuration of the Jilin Provincial Museum. Through the configuration analysis of axis, convex spaces, viewsheds and other ways, it is concluded that the key to the spatial optimization of Jilin Provincial Museum lies in the interrelationship between local space and overall space. The museum should focus on the optimization of exhibition space and public space, and better connect the area between the spaces. This is to enhance the attractiveness and use of the space and establish an intimate relationship between visitors and the museum space.

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