Research on the Spatial Value Assessment of Historical and Cultural Districts

A Case Study of Hengkou Old Street

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Abstract. Historical and cultural districts are vital components of urban cultural heritage, they contribute significantly to urban development. However, these areas face challenges, including the destruction of traditional patterns and spatial values due to modern developments such as haphazard expansion and large-scale construction projects. The study selects the historical and cultural district of Laojie in the Hengkou Demonstration Area of Ankang City, Shaanxi Province, as the research subject. By introducing space syntax theory, it quantitatively analyzes the spatial value characteristics of the historical and cultural district and constructs a corresponding spatial value assessment model to accurately evaluate the spatial value of the district. The results indicate that the functionality, accessibility, and security of the space are closely related to the road network layout of the historical and cultural district. The outcomes of the spatial value assessment hold significant practical implications for optimizing spatial layout and enhancing spatial value.

Keywords: Historical and cultural districts, spatial value, space syntax

1 Introduction

As a vital genetic component nurturing the urban narrative, historical and cultural districts represent significant cultural heritage. The spatial elements such as streets, buildings, and landscapes, along with non-spatial elements like folk art and lifestyles, collectively form the local genetic sequence of the city's narrative [1]. With a growing emphasis on the preservation and transmission of historical cultural heritage, these districts, which embody local cultural identity, not only inject new energy into urban development but also play a crucial role in shaping the public spirit and value recognition of the city [2][3].

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However, during the modernization of these historical cultural districts, chaotic expansion and large-scale development activities have severely damaged the traditional layout and spatial value of these areas [4][5]. There exists a clear contradiction between the spatial needs of the districts and the demands of residents, making it difficult for traditional spaces to adapt to new requirements [6]. Additionally, the public lacks a significant understanding of the importance of preserving these historical cultural districts, resulting in low participation in their protection and renewal [7]. These factors have led to a rapid decline in the spatial value of these areas. Previous research has often analyzed the spatial aspects of these districts from a broad perspective, neglecting the detailed spaces within them [8][9][10]. Therefore, this paper focuses on the architectural and node spaces of Hengkou Old Street, constructing a spatial value assessment model for historical and cultural districts. This approach aims to identify and analyze the spatial components of these districts and clarify the influencing factors of their spatial value, ultimately providing targeted references and technical support for optimizing spatial layouts and enhancing spatial value.

2 Research Object and Method

2.1 Research Area

Hengkou Old Street, one of the fourth batch of historical and cultural districts in Shaanxi Province, as the subject of my research. Located in the western part of the Yuehe river valley in the Hanbin district of Ankang City, Shaanxi Province, Hengkou Old Street is situated at the confluence of the Yuehe and Henghe within the Hanjiang River Basin. In 2021, it was designated as one of the fourth batch of historical and cultural districts in Shaanxi Province. The Old Street was established during the Northern Song Dynasty and flourished during the Qianlong and Jiaqing periods of the Qing Dynasty, serving as a significant testament to the economic development and prosperity of southern Shaanxi during that era. Hengkou Old Street is a well-preserved architectural complex of Ming and Qing dynasty residences in northern China, showcasing distinct cultural characteristics of the Yangtze River basin. The street is encircled by urban roads, forming a "hollow- shaped" layout, while the main thoroughfare within the district is arranged in a "cross" pattern. The overall street structure resembles a "fishbone," featuring a variety of road forms, including straight lines, zigzags, and curves. The spatial nodes of Hengkou Old Street encompass cultural gathering points that showcase and preserve folk customs and religious culture, traffic hubs formed by the intersection of different streets, and leisure gathering spots for residents. These nodes vary in scale and spatial structure, catering to both small-scale interpersonal interactions and larger public gatherings and entertainment needs.

2.2 Research Method

The theory of spatial syntax, as an emerging tool for assessing urban morphology, centers on revealing the intrinsic structure of urban spaces and the relationships between their elements through scale division and spatial segmentation [11]. This theory

encompasses various analytical methods, including axial analysis, convex space analysis, visibility analysis, and segment analysis. The axial method allows for the identification of the main roads in Hengkou Old Street and divides the district units into independent entities, providing a foundation for quantitative analysis and morphological interpretation. The convex space method facilitates the quantitative analysis of spatial forms and organizational structures. Visibility analysis simulates the coverage of sightlines from specific viewpoints, identifying different types of areas and quantifying the impact of visual factors in spatial analysis. Segment analysis, based on axial diagrams, transforms these into segment models, taking into account the directional movement of pedestrians and the turning angles at road intersections to analyze the tendencies in subjective path selection. Spatial syntax offers a multidimensional perspective for understanding and evaluating the spatial value of historical and cultural districts, aiding in the in-depth exploration of spatial morphological characteristics and functional connections, thereby providing a scientific basis for optimizing the layout of Hengkou Old Street.

2.3 Research Object

Utilizing the five elements of urban imagery proposed by Kevin Lynch, along with the physical and economic characteristics of space, to dissect the spatial structure of historical and cultural districts [12]. The elements of paths, edges, districts, nodes, and landmarks often lack a cohesive overall structure. However, spatial syntax can facilitate the understanding of various spatial systems through the construction of topological relationships [13]. Utilizing the segmentation methods of spatial syntax, paths and nodes are selected as the spatial types for assessing the spatial value of Hengkou Old Street. This evaluation is interpreted through three dimensions: functionality, convenience, and safety, thereby delineating the street and node spaces of Hengkou Old Street(**Fig. 1**).

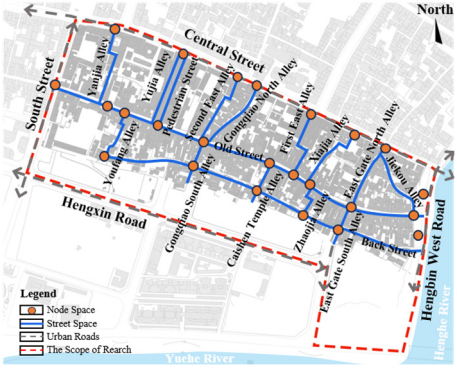

Fig. 1. Spatial Distribution

3 Spatial Value Assessment

3.1 Spatial Value Assessment System

In conjunction with the analysis of the spatial characteristics and types of Hengkou Old Street, while considering the operability of the indicator system, choosing integration, connectivity, and depth as the assessment indicators for the spatial value of Hengkou Old Street, building a Comprehensive Spatial Value Assessment System of "Three Characteristics, Three Values, and Two Spaces"(**Fig. 2**).

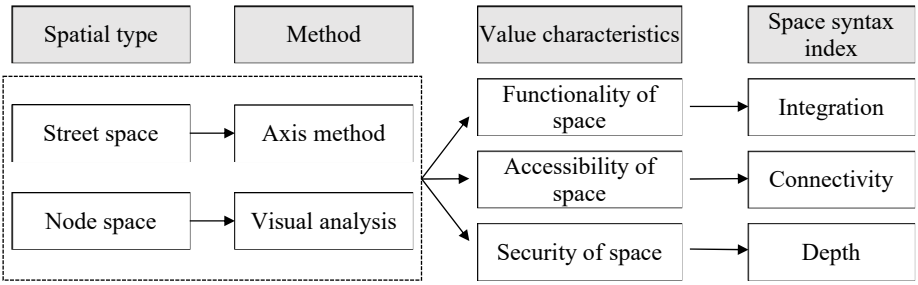

Fig. 2. Spatial Value Assessment System

3.2 Spatial Assessment Model

Street Space Value Assessment Model.

Adhering to the "minimum and maximum" principle in the axial line model of space syntax, an axial map depicting the spatial layout of the old street alleys was created. To ensure the accuracy of the analysis, based on the satellite and topographic map information of Hengkou Old Street, combined with multiple field surveys of the alleyway conditions, include all roads with traffic capacity, and draw the CAD model diagram of the alleyway space network, then, convert the model into DXF format. The spatial syntax analysis software DepthMap was introduced to obtain the street space value assessment model(**Fig. 3**).

Node Space Value Assessment Model.

Compared to the linear axial analysis model of street and alley spaces, the study of node spaces adopts a more localized perspective, grounded in field research and analysis. The Hengkou Old Street area is relatively flat, with no significant elevation differences internally. The model is established based on visual layers, while the surrounding districts are designed with a closed contour line. Within the district, solid elements are used as separators to construct the internal structure, disregarding visually non-critical elements such as streetlights, bus stops, and low vegetation. Therefore, in conjunction with the current state of Hengkou Old Street and the modeling requirements of spatial syntax visual analysis, a model for assessing the value of node spaces is constructed(**Fig. 4**).

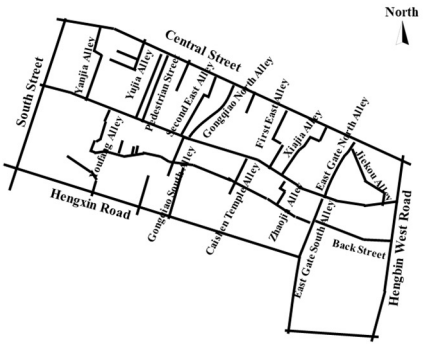

Fig. 3. Street Spatial Value Assessment Model

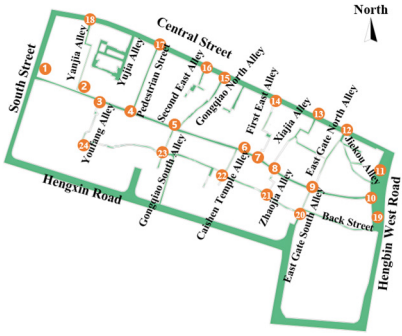

Fig. 4. Node Spatial Value Assessment Model

3.3 Assessment Result

Functional Analysis.

In spatial syntax, integration reflects the degree of clustering or dispersion of a particular element within a spatial system in relation to other elements. It measures a space's ability to attract traffic as a destination and indicates the centrality of its elements within the overall system. The calculation of integration is based on topological depth, which represents the "depth" of an element within the entire network of the study area. The formula for calculating integration is as follows:

$$I = \frac{1}{N-1} \sum_{i=1}^{N-1} \frac{1}{D_i} \tag{1}$$

I represents the integration degree, N is the total number of nodes in the system, and D_i is the sum of the shortest path lengths from node i to all other nodes in the system. The higher the integration degree, the stronger the attraction of the space as a destination, the higher its accessibility, the stronger its centrality, and the easier it is to concentrate human traffic.

Table 1. Integration Data

Integration Value	Maximum	Minimum	Average
Street Space	1.84609	0.48721	1.07915
Node Space	8.43604	1.37424	5.66200

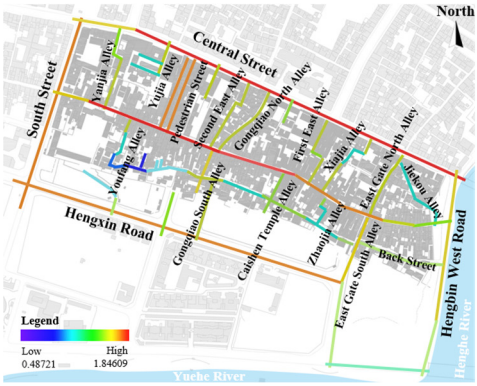

Fig. 5. Integration of Street Space

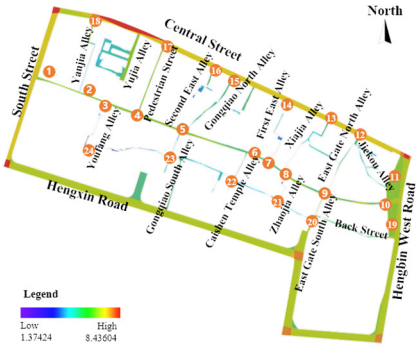

Fig. 6. Integration of Node Space

The results of the spatial integration analysis of Hengkou Old Street indicate that both the Old Street and the Central Street exhibit a high degree of global integration within the district. Similarly, nodes ① and ③, located at the intersections of the old street with South Street and the Pedestrian Street with the Old Street, respectively, also demonstrate high visual integration. However, the overall global integration of the internal streets is generally low, suggesting that most spaces have weak accessibility and poor functional diversity. The cultural gathering nodes ②, ④, and ⑤, which are closely surrounded by buildings, show low visual integration. Overall, the average visual integration within the district is moderate, with minimal variation (**Table 1**, **Fig. 5**, **Fig. 6**).

The research reveals that the old street connects numerous surrounding alleys, extending the district's east-west orientation. The Central Street exhibits the highest functional diversity, contributing to the district's vibrancy, while the streets that intersect with the main street, such as the Pedestrian Street and Yanjia Alley, show a high degree of integration. However, the internal areas of the district primarily serve residential functions, lacking spaces for entertainment, leisure, and fitness, which hampers the ability to meet residents' daily needs and diminishes the spatial value and functionality.

Accessibility Analysis.

The calculation of connectivity values is based on graph theory concepts within spatial syntax, transforming spatial systems into a relational graph composed of nodes and their interconnections. Each node represents a component of the spatial system, while the connections between nodes indicate direct relationships among spatial elements. The connectivity value refers to the number of direct connections a spatial element has with other spatial elements, the higher the connectivity value of a spatial element, the greater its influence on the surrounding space and the better its spatial permeability.

Table 2. Connectivity Data

Connectivity Value	Maximum	Minimum	Average
Street Space	12	1	2.45
Node Space	14270	6	5180

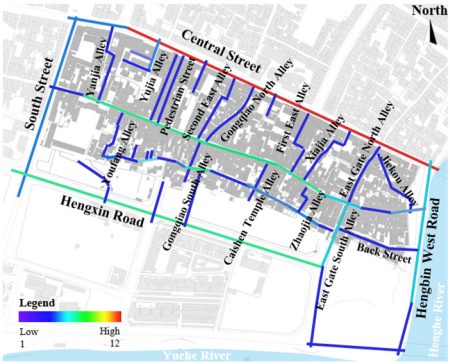

Fig. 7. Connectivity of Street Space

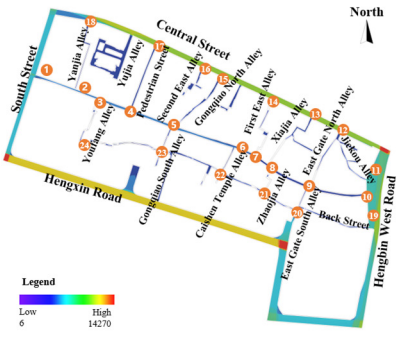

Fig. 8. Connectivity of Node Space

The results of the connectivity values and visual connectivity values for Hengkou Old Street indicate that, aside from the Central Street and the Old Street, the connectivity values of other alleys are generally low, with most alleys having a connectivity value of 2. Similarly, the analysis of visual connectivity values reveals that the overall visibility of the district is poor, characterized by a cooler tone, with higher visual connectivity values primarily concentrated at the nodes located at the intersections of the outer roads of the district(**Table 2**, **Fig. 7**, **Fig. 8**).

The research findings indicate that the Central Street and the Old Street, as the core axes of the district, play a crucial role in connecting the area. In contrast, other alleys predominantly serve residential functions, exhibiting good spatial enclosure but poor permeability and convenience. The connectivity routes of these alleys are mainly utilized by residents, lacking a comprehensive network of interconnected roads, which results in reduced spatial exposure, insufficient spatial vitality, and an inability to fully realize their value.

Security Analysis.

In spatial syntax, the shortest topological distance between any two nodes, represented by the number of spatial transformations, is referred to as the depth value between the two nodes. This depth value indicates the reachability of nodes in a topological sense rather than actual distance, reflecting the ease of transitioning from one space to another. The formula for calculating mean depth is as follows:

$$MD = \frac{\sum_{i=1}^{N-1} D_i \times n}{N-1} \tag{2}$$

MD represents the mean depth, *N* is the total number of nodes in the system, and D_i is the sum of the shortest path lengths from node *i* to all other nodes in the system. *n* represents the number of all nodes located at that particular depth. A smaller depth value indicates that the node is more centrally located within the network, with higher accessibility.

Table 3. Depth Data

Depth Value	Maximum	Minimum	Average
Street Space	9.8101	3.8101	5.4351
Node Space	10.5065	2.5486	3.4478

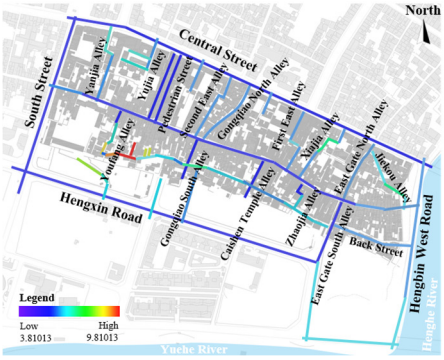

Fig. 9. Depth of Street Space

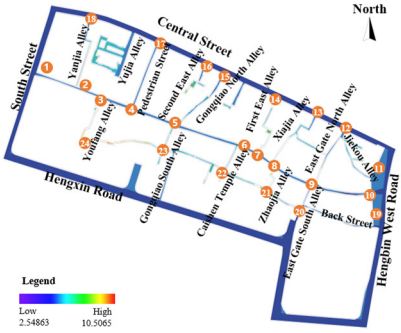

Fig. 10. Depth of Node Space

The results of the depth value analysis for the alleys and streets of Hengkou Old Street indicate a generally high level of safety within the district. The depth values for Back Street, Youfang Alley, Zhaojia Alley, and Jiekou Alley are all above the average depth value. The axes of Central Street, South Street, Hengxin Road, Pedestrian Street, and Yujia Alley are represented in blue, aligning with areas of high functionality and convenience, thus reflecting a higher safety level in these streets. The line of sight depth values for the main streets are lower than those of the secondary alleys, suggesting that the public accessibility of the secondary alleys is less than that of the main thoroughfares. Areas with higher line of sight depth values are concentrated on the south side of Youfang Alley and the west side of the Old Street, particularly at the intersection of Youfang Alley and Back Street, where the colors are represented in orange and red(**Table 3**, **Fig. 9**, **Fig. 10**).

The research indicates that spaces with good enclosure and complex street textures exhibit poorer spatial permeability, requiring more frequent changes in line of sight, which can lead to safety hazards. Consequently, the overall safety of these spaces is compromised, while spaces with higher public accessibility tend to demonstrate greater safety.

4 Conclusions

(1) The assessment results for street spaces indicate notable differences in functionality, accessibility, and security across various street spaces. Main thoroughfares, such as the Central Street and the Old Street, serve as the primary axes of the district, exhibiting strong functionality and convenience. In contrast, many internal alleys demonstrate deficiencies in functionality and convenience due to narrow spatial scales and high building densities. Except for a few alley spaces with strong enclosure leading to relatively lower safety, the remaining alleys generally exhibit high safety levels. Therefore, when optimizing the street and alley spaces of historical and cultural districts, it is essential to respect the original scale of these areas. This can be achieved by addressing blocked "dead ends" and cul-de-sacs to enhance spatial connectivity, thereby promoting interaction and integration among the various street and alley spaces within the district. Additionally, in accordance with relevant safety regulations for historical and cultural districts, it is important to establish emergency function spaces to improve overall safety.

(2) The evaluation results of node space indicate that areas characterized by open layouts and good visual connectivity tend to exhibit higher functionality and accessibility. In contrast, node spaces surrounded by high building density and convoluted street patterns demonstrate deficiencies in functionality and accessibility. Aside from certain node spaces where high enclosure by surrounding buildings leads to lower security, the majority of node spaces maintain a relatively high level of security. Due to the rigorous conservation requirements and plot restrictions of historic and cultural districts, the principle of minimum intervention is adopted, with a strategy of utilizing every available space to increase public areas. Unnecessary walls and illegal constructions are demolished to release space, creating leisure plazas and green spaces. Cultural and distinctive landscape elements are introduced, and supporting facilities are improved. While fulfilling the needs of residents and tourists, this approach highlights the unique historic features of the historic and cultural districts.

(3) The spatial value assessment model constructed based on spatial syntax can provide a scientific and rational new method for the evaluation of the spatial value of historical and cultural districts. In future research, further consideration should be given to multiple factors such as the historical context, socio-economic background, and resident needs of the district. Additionally, attention should be paid to the dynamism and real-time nature of spatial value assessment, integrating modern information technology to provide more scientific and rational decision support for the protection, renewal, and revitalization of historical and cultural districts.

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