# Assessing the Spatial Diversity of Urban Cultural Landscape using Street View Data and Investigating Influential Factors: A Case Study of Beijing

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**Abstract.** As an open space bearing the urban context, urban cultural landscape is an important place to enhance the connotation of urban space and create the vitality of urban space. Cultural landscape is influenced by multiple factors in the process of formation and evolution, and there are distinct differences in individuation and regionalization. In this paper, with the help of Baidu Street View images, the evaluation system and measurement method are constructed from the five dimensions of architectural style, infrastructure, ecological environment, urban sketch and historical context. Taking Beijing as an example, the man-machine combination method is adopted to explore the factors affecting the spatial heterogeneity of urban cultural landscape based on GIS grid, and effective remediation measures are proposed. It has positive significance to enhance the connotation of urban culture, strengthen the comfort level of citizens and promote the deep development of urban cultural space.

**Keywords:** Street view images; landscape evaluation; urban culture; spatial heterogeneity.

## 1. Introduction

With the continuous advancement of urbanization in China, residents' demand for "quantity" and "quality" of urban space is growing simultaneously. As an important carrier of urban cultural spirit, urban cultural space is a specific reflection of the cultural and geographical characteristics of a cultural system[1]. At present, the blind expansion and renewal of urban space constantly compresses the living space of urban culture, making cities fall into a crisis of "homogenization", which seriously threatens urban development. How to reasonably develop potential urban cultural resources and promote urban cultural Renaissance is still an important challenge.

Urban cultural landscape has dual functions. On the one hand, as an important component of urban space, urban cultural space is the space that residents frequently contact in their daily life. A good urban cultural landscape can enrich residents' spiritual and cultural life[2]. On the other hand, with the improvement of people's consumption level and the upgrading of tourism formats, people's demand for tourism has gradually changed from simple tourism to more spiritual and cultural pursuits. As a new tourism symbol, urban cultural landscape can improve tourists' travel satisfaction, and enhance out-of-town tourists' willingness to visit again[3].

Taking Beijing as an example, this paper uses the landscape evaluation method combining subjective and objective to randomly select Baidu Street View map data for comprehensive evaluation of urban cultural perception[4], summarizes the factors affecting the development of urban cultural landscape and comprehensive evaluation results, and puts forward measures for transformation and upgrading. So that it can not only reflect the traditional characteristics of old Beijing, but also further promote the development of cultural tourism in the whole city of Beijing, and provide a theoretical basis for the construction of cultural pattern in other cities.

## 2. Methods and procedures

### 2.1 Analytical framework

In order to better measure citizens' perception of urban culture, this paper takes Beijing as an example and selects five dimensions to measure the spatial differences of urban cultural landscapes

in different regions of Beijing with the help of Baidu Street View images[5]. Construct an evaluation system for urban cultural tourism landscapes to provide a theoretical basis for the rational use of urban cultural space in the future.
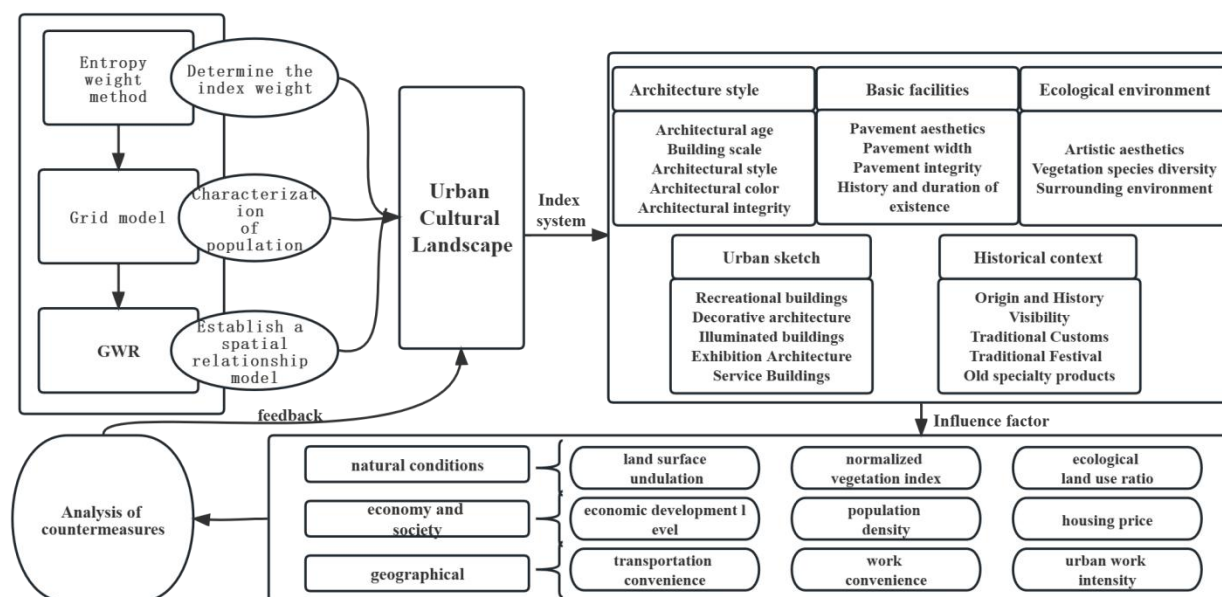


Fig.1 Research Technology Roadmap

## 2.2 Evaluation index

Based on expert experience and existing research, this study proposes five observation indicators: architectural appearance, infrastructure, ecological environment, urban sketches and historical context. In order to ensure the objective accuracy of scoring and eliminate the influence of personal preference factors on the results, 3 undergraduate students and 2 graduate students were selected for systematic training, and 3-5 iconic points were extracted from each grid for comprehensive scoring, and cross-verified for cross-verification. A total of 4496 scoring results were formed, which has interactive verification.

In terms of the composition of the indicators, there are 22 specific indicators in the five guideline layers.(1) Architecture is the continuation of urban history, the accumulation of culture, and the key factor affecting the perception of urban culture. It consists of five indicators: building age, building scale, architectural style, architectural color and preservation integrity. (2) Infrastructure can meet the numerous needs of residents and tourists, and carries people's emotional attachment to urban culture[6]. It includes four indicators: facility popularity, planning rationality, road surface integrity, history and time of existence, which comprehensively reflect the service value and management objectives of the infrastructure. (3) Ecological environment is an important part of urban development[7]. A good ecological environment is the basis for the development of tourism, and the ecological environment criterion layer consists of three major indicators: artistic aesthetics, diversity of vegetation types, and surrounding environment. (4) Sketches have ornamental or decorative functions and forms of artistry, and are an indispensable part of the urban cultural landscape, mainly including five indicators: leisure sketches, decorative sketches, lighting sketches, display sketches and service sketches. (5) Historical context has profound cultural value and is an important resource for local transformation and upgrading[8], which consists of five indicators: historical origin and evolution, regional popularity, traditional customs, traditional festivals and time-honored products.

Table. 1 Factor evaluation index of urban cultural tourism landscape characteristics

| Guideline layer | Factor layer | Weights |
|---|---|---|
| Architecture style（A） | Architectural age（A1） | 33.578% |
| | Building scale（A2） | |
| | Architectural style（A3） | |
| | Architectural color（A4） | |
| | Architectural integrity（A5） | |
| Basic facilities（B） | Pavement aesthetics（B1） | 12.625% |
| | Pavement width（B2） | |
| | Pavement width（B3） | |
| | History and duration of existence（B4） | |
| Ecological environment（E） | Artistic aesthetics（E1） | 17.846% |
| | Vegetation species diversity（E2） | |
| | Surrounding environment（E3） | |
| Urban sketch（U） | Recreational buildings（U1） | 9.676% |
| | Decorative architecture（U2） | |
| | Illuminated buildings（U3） | |
| | Exhibition Architecture（U4） | |
| | Service Buildings（U5） | |
| Historical context（H） | Origin and History（H1） | 26.275% |
| | Visibility（H2） | |
| | Traditional Customs （H3） | |
| | Traditional Festival （H4） | |
| | Old specialty products（H5） | |

## 2.3 Entropy weighted integrated evaluation method

In this paper, the evaluation results of Baidu Street View Map are used as the basic data for observing the urban cultural perception. Among them, the primary indicators are subjectively weighted by expert evaluation, and the secondary indicators are objectively weighted by entropy weight method, so that the observation indicators have both expert experience and data information value. The specific calculation steps of entropy weight method are as follows:

Step 1: Calculate the standardized value of each indicator:

$$P_{ij} = X_{ij} / \sum X_{ij}$$

（2-1）

Step 2: Calculate the entropy value ej of index j:

$$e_j = -k \sum P_{ij} \ln P_{ij}, \quad k = -\frac{1}{\ln n}$$

（2-2）

Step 3: Calculate the difference coefficient gi of index j:

$$g_i = 1 - e_j$$

（2-3）

Step 4: Calculate the weight Wj of the jth index:

$$W_j = g_i / \sum g_i$$

（2-4）

Step 5: Calculate the index branch UCLi of the ith cell

$$UCL_i = \sum X_{ij} \times W_j \qquad (2\text{-}5)$$

## 2.4 Urban grid evaluation model

The grid model method is mainly characterized by converting vector data into raster form, which can present traditional vector type point, line and surface data through filling while establishing spatial raster index. The specific calculation method is as follows:

$$GUCL = Median\{UCL_1, UCL_2, \ldots, UCL_k\}$$

In the above formula, U represents the degree of perception of urban landscape on a grid scale; Median is a median function; $\{UCL_1, UCL_2, \cdots, UCL_k\}$ represents the set of urban cultural perception of cities in different communities within the grid range from small to large, and k represents the number of cells in the grid.

## 2.5 Geographically weighted regression model

Using regional heterogeneity as the basic hypothesis, this paper investigates the factors affecting the urban cultural landscape using GWR. The GWR model is solved by the local weighted regression analysis model about the location to quantitatively reflect the heterogeneity or non-stationary characteristics in the spatial data relationship with the parameter estimation results varying with different spatial locations. Assuming that the observation value of the independent variable is $\{x_{ij}\}$ (i=1,2,..., m; j=1,2,..., n}, and the corresponding observation value of the dependent variable is $\{y_i\}$, then the GWR model is as follows:

$$y_i = \beta_0(u_i, v_i) + \sum_{j=1}^{k} \beta_k(u_i, v_i)x_{ij} + \varepsilon_i \qquad (2\text{-}7)$$

In the above formula, $(u_i, v_i)$ represents the spatial coordinate i of the position; $\beta_k(u_i, v_i)$ denotes the value of the continuous function $\beta_k(u_i, v_i)$ at point i. The closer the observed value is to position i, the greater the effect that leads to the estimation of $\beta_k(u_i, v_i)$. Methods to determine bandwidth include CV, AICs, BIC/MDL, etc. In this paper, a more objective AICs is used.

# 3. Results and discussion

## 3.1 Evaluation result of Beijing city culture perception degree

In terms of the composition of the urban cultural landscape, It can be seen from Figure A that: .(1) the overall architectural score of Beijing is at a medium level. The areas with high architectural scores are mainly distributed in the area around the Forbidden City, as well as the Summer Palace and Old Summer Palace areas; The areas with low building ratings are mainly distributed in the west and southeast areas between the fourth and fifth ring roads. (2) It can be seen from Figure B that the score of traffic roads in Beijing is distributed in the middle with high in the middle and low at both ends, and the characteristics of traffic roads are not prominent. The areas with high traffic road scores are mainly distributed in the area around the Forbidden City, as well as the Summer Palace and Summer Palace; The areas with low traffic road scores are mainly distributed in the western area between the fourth and fifth ring roads. (3) It can be seen from Figure C that the ecological environment score of Beijing is at a moderately high level, showing an "inverted U-shaped" distribution. The areas with high architectural scores are mainly distributed in the area around the Forbidden City, as well as the Summer Palace and Old Summer Palace areas; The areas with low ecological environment scores are mainly distributed in the southwest and

southeast corners between the fourth and fifth ring roads. (4) As can be seen from Figure D, the score of urban sketches in Beijing is concentrated at a low level. The areas with high urban sketch scores are mainly distributed in the area around the Forbidden City, as well as the Summer Palace and Summer Palace; The areas with lower scores are mainly distributed in the southern area between the fourth and fifth ring roads. (5) As can be seen from Figure E, the score of geographical names in Beijing is mainly concentrated at the low and medium levels. The areas with high geographical name scores are mainly distributed in the area around the Forbidden City, as well as the Summer Palace and the Old Summer Palace; The areas with low geographical name scores are mainly distributed in the western, southern and southeastern areas between the fourth and fifth ring roads. (6) It can be seen from Figure F that the comprehensive score of landscape characteristics in Beijing is mainly concentrated at a low level, among which the comprehensive score of landscape characteristics in the northwest corner within the second ring road and between the fourth and fifth ring roads is higher, and the comprehensive score of other areas is low.
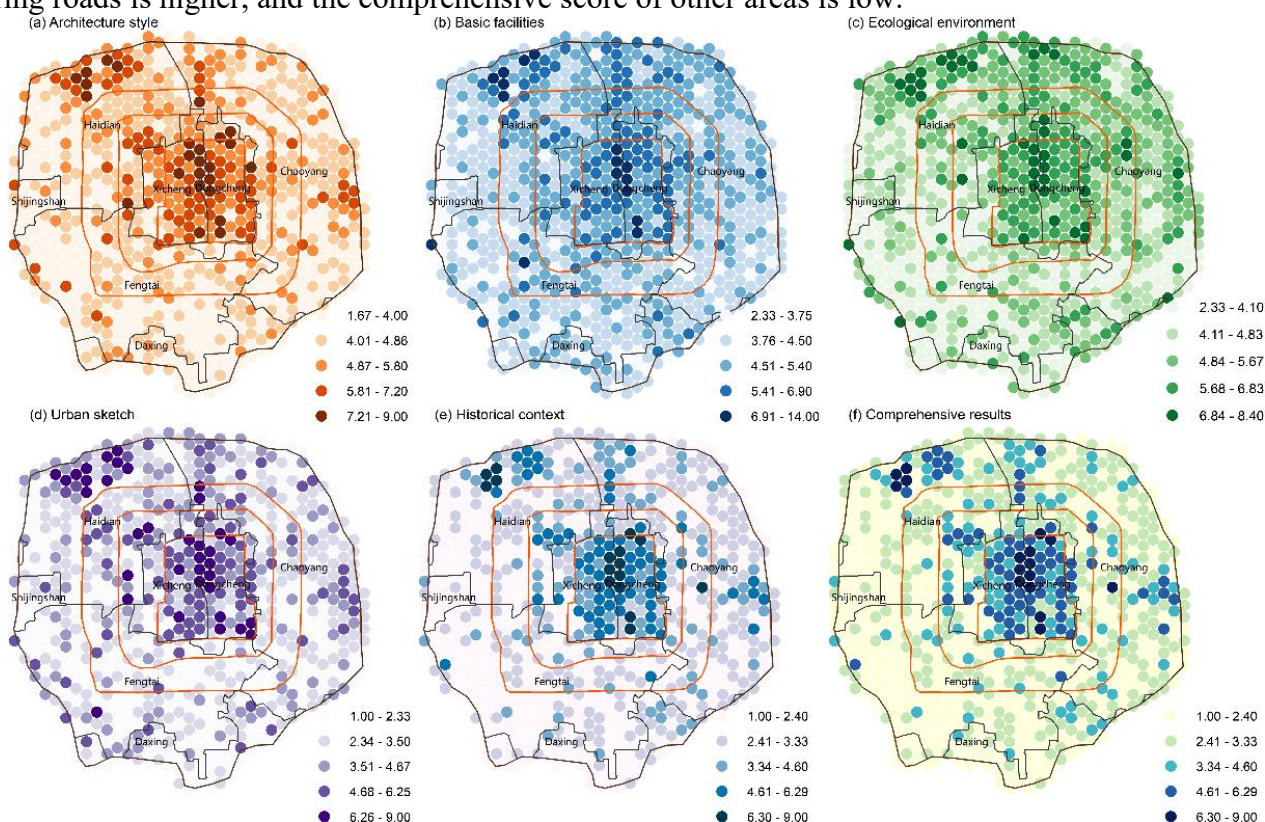


Fig.2 Distribution map of cultural landscape perception in Beijing

## 3.2 Analysis of factors affecting urban cultural perception

This paper selects the factors that affect the perception of urban cultural landscape from the following three aspects: First, in the dimension of natural conditions, the factors in this aspect directly act on people's visual senses of cultural landscapes and are important factors affecting landscape perception. In this study, three factors were further selected for quantitative analysis: land surface undulation, normalized vegetation index and ecological land use ratio. Second, in terms of economy and society, the level of economic and social development in the region plays a decisive role in the construction and maintenance of cultural landscapes, which in turn has a greater impact on the perception of urban cultural attributes. The study further selected three factors of economic development level, population density and housing price in the area for quantitative analysis. Third, in terms of geographical conditions, the construction of regional cultural landscapes with better conditions is often more perfect and high-quality, which is also an important factor affecting people's perception. Three factors, transportation convenience, work convenience and urban work intensity, were further selected for quantitative analysis. In summary, a total of 9 factors were

screened out from three aspects, including natural conditions, economic foundation and geographical location, and the influencing factors of urban cultural landscape perception were analyzed by GWR spatial regression method.

Table. 2 The result of the GWR model

| Influence factor | Coefficient |
|---|---|
| land surface undulation | -0.0053 |
| normalized vegetation index | -0.0954 |
| ecological land use ratio | 1.9995 |
| economic development level | 0.1277639 |
| population density | 0.0000033 |
| housing price | 0.0000066 |
| transportation   convenience | -0.00018 |
| work convenience | -0.00027 |
| urban work intensity | 0.04895 |

The processing results of GWR model show that the optimal bandwidth is 423.56, the fit degree is 0.49, and the chi-square statistic of the fit inferior is 1163.13. It was intuitively revealed that the influence of various indicators on the perception of urban cultural landscape was quite different, and the land surface undulation, vegetation index, transportation convenience and work convenience had a negative impact, and the regression coefficients of other factors had a positive impact. From the regression results of the GWR model, the urban cultural landscape of Beijing shows significant spatial heterogeneity. Ecological land, regional economic level, population density, regional housing prices, and urban construction intensity have a positive role in promoting the perception of Beijing's cultural landscape, while the surface undulation, normalized vegetation index, transportation and living convenience have a negative impact. In terms of impact intensity, regional economic level has the greatest impact on the perception of cultural landscape, and the impact intensity of population density and regional housing price is relatively small.

## 4.  Policy implications

Combining the evaluation results and impact factors, this paper believes that improving the quality of urban cultural landscape should be started from the following three aspects:

(1)  At present, the development of urban cultural landscape within the Third Ring Road with the Forbidden City as the center is relatively clear, but the development of urban cultural space outside the third Ring Road is still in the initial stage. Based on the spatial heterogeneity of urban cultural landscape, the Beijing municipal government should formulate cultural policy objectives by jurisdiction and at different levels, make full use of local cultural resources, define a unique urban cultural image, and avoid falling into the trap of "homogenization".

(2) It is the basic right of every citizen to enjoy urban cultural services, which requires that relevant public organizations to attach great importance to the construction of urban cultural services and try their best to meet the reasonable needs of citizens in terms of urban cultural services. Public organizations should focus on the shortcomings of Beijing in terms of ecological environment and infrastructure, speed up the renovation and upgrading of old residential areas and backward villages in the suburbs of Beijing, and ensure that residents' living environment is clean and tidy. At the same time, it is also necessary to solve the problems of "low distribution" and "fragmentation" in the current suburban infrastructure construction, accelerate the extension of urban infrastructure to the suburbs, improve the level of refined community management.

(3) The construction of the city's image is inseparable from the extensive support and strong participation of citizens, and citizens and the city are each other's contributors and beneficiaries. On

the one hand, we will actively explore music and sports competitions with wide participation of citizens, create a vibrant urban atmosphere, and activate the cultural vitality of public space. On the other hand, citizens are called upon to consciously develop good habits, improve the civility of citizens, and promote the sustainable development of urban cultural space.

## 5. Conclusion

From the perspective of landscape perception, this paper adopts the urban cultural landscape evaluation method combining subjectivity and objectivity, takes the 1000-meter spatial grid as the research unit, uses the human-computer interaction system to comprehensively analyze the urban cultural landscape. In the construction of future urban cultural space, Beijing needs to dig deep cultural deposits in terms of architecture and build high-quality cultural tourist areas. In terms of infrastructure, it is also necessary to increase investment in infrastructure, promote transportation integration in urban agglomerations, and create high-quality living Spaces. In terms of ecological environment, it is still necessary to increase the proportion of green area, create green ecological tourism belt in the suburbs, and build a strong green ecological barrier. In the aspect of urban sketch, it is necessary to formulate reasonable urban planning and development schemes, increase the greening and leisure area of the community and villages, and improve the happiness of people's life. In terms of historical context, it is necessary to dig deep into local historical celebrities and events to create holiday tourism hotspots and further improve the comfort level of citizens.

## References

[1] Taylor K. Heritage challenges in Asian urban cultural landscape settings[J]. Routledge handbook of heritage in Asia, 2012: 266-279.

[2] Taylor K. The Historic Urban Landscape paradigm and cities as cultural landscapes. Challenging orthodoxy in urban conservation[J]. Landscape Research, 2016, 41(4): 471-480.

[3] Tien N H, Dung N T H, Trang T T T, et al. Factor affecting tourists'return intention. A case of binh quoi village in ho chi minh city[J]. PalArch's Journal of Archaeology of Egypt/Egyptology, 2021, 18(09): 493-507.

[4] Apte J S, Messier K P, Gani S, et al. High-resolution air pollution mapping with Google street view cars: exploiting big data[J]. Environmental science & technology, 2017, 51(12): 6999-7008.

[5] Ito K, Biljecki F. Assessing bikeability with street view imagery and computer vision[J]. Transportation research part C: emerging technologies, 2021, 132: 103371.

[6] Gallan B. Night lives: Heterotopia, youth transitions and cultural infrastructure in the urban night[J]. Urban studies, 2015, 52(3): 555-570.

[7] Song Y. Ecological city and urban sustainable development[J]. Procedia Engineering, 2011, 21: 142-146.

[8] Lillevold K, Haarstad H. The deep city: Cultural heritage as a resource for sustainable local transformation[J]. Local Environment, 2019, 24(4): 329-341.