Application of planning evaluation of historical block based on space syntax ——Case study: Third Streets and Two Alleys historical block, Nanning

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Abstract. With the current acceleration of urbanization, the evaluation of spatial planning of historical blocks has become an emphasis in urban research. Reasonable spatial interpretation and planning evaluation deserve consideration. This study takes the historical block of the Three Streets and Two Alleys as an example, which is a key development strategy of Nanning city. With GIS spatial analysis method and improved spatial syntax (sDNA model) to construct the syntax model of the core area of the first phase of the third streets and two alleys. Through the analysis of time scale, integration degree, Choice and understandability, the first-phase planning of the block is evaluated on multiple scales. The result shows three conclusions: (1) As an advanced space syntax method (sDNA model) has significant advantages in large-scale in the evaluation of historical blocks. (2) On the whole, the planning evaluation of third streets and two alleys follows the "formal-traffic-function" principle. The integration degree, Choice and understandability have made a certain progress. (3) The correlation between spatial morphology and spatial function is verified by combining commercial data, it shown the space is a part of developing social and economic life. The research argues that, as an advanced special analysis method, sDNA model has a great application prospect.

1. Introduction
The level of urbanization in contemporary China is constantly improving, urban renewal has become a hot topic. A reasonable evaluation of the spatial characteristics of historical blocks and deepening the spatial cognition of historical blocks are of great significance for protecting the cultural heritage of historical blocks, promoting commercial integration, and rejuvenating the old urban area. In the current planning and reconstruction, historical blocks often become a problem in urban development due to the contradiction between their relatively high historical connotation, cultural value and relatively backward spatial form. In the evaluation of traditional historical district planning, the cultural continuity is often separated from the spatial renewal [1], and there is a lack of a reasonable explanation of the relationship between the spatial form and the spatial function.

As a new spatial feature evaluation model, the spatial syntax model explores the relationship between spatial structure and human economic, cultural and social through the perspective of "human perception"[2], which can avoid the limitations of traditional planning evaluation methods, such as the separation of culture and spatial form. And the lack of spatial statistics and quantitative indicators [3].
By taking the natural movement of people in the historic district as an entry point, the evolution analysis of the "structure-function" of the space and its adaptation relationship provides a new way of thinking for the planning and evaluation of the historic district [4, 5]. The improved space syntax model (sDNA model)—an emerging space analysis model, which continues the traditional space syntax analysis method based on street modelling, reveals the internal logic of space form and space function, by simulating human "natural travel", through the promotion of variable algorithms to make it closer to the actual road network form. Combining the sDNA model with other research methods, such as PSPL survey method, big data analysis, etc., helps to explore the relationship between the spatial structure of historical blocks, commerce and crowds, rationally evaluate the spatial form of blocks [6], reveal and summarize the urban functions of historical blocks, thereby guiding the protection of historic districts.

Three Streets and Two Alleys is located in the Chaoyang Commercial District, the most prosperous commercial area in the centre of Nanning. It is one of the historical districts of Guangxi province. It has the only remaining residential groups from the Qing Dynasty and the Republic of China in Nanning. In recent years, the urbanization level of Nanning City has increased, and the Three Streets and Two Alleys have declined into an old urban area that needs to be renovated but cannot be effectively protected, developed and utilized. This study is based on the sDNA model and combined with commercial POI data to evaluate the development planning of the Three Streets and Two Alleys historical district from the aspects of integration, accessibility, and intellectualization. It can quantitatively analyse the temporal and spatial relationships between people and activities from the perspective of space ontology. Connecting the subjective logic with the objective spatial relationship, quantitatively analyse the internal cultural logic through the spatial ontology structure, provide a reference for the protection, renewal and rejuvenation of the historic districts of Three Streets and Two Alleys, verify the rationality of the model, and accumulate relevant research experience.

2. sDNA model building of Three Streets and Two Alleys

2.1. sDNA model

The premise of Space Syntax analysis is a mathematical model to establish a division of space syntax model for space-based. After long-term development, four types of models have been produced, namely, axis, convex, line segment and field of view models. This research adopts the analysis method of the line segment model and regards the urban space as a linear spatial network structure. In different urban spaces, the line segment between each intersection in the grid plays a different role according to its spatial characteristics. Using spatial line segments for modelling, the main difference between its theoretical basis and axis model is that it assumes that travel follows the rule of "minimum deflection angle". Compared with the axis model, the line segment model is more intuitive and has less error.

| Index parameter | Integration |
|-----------------|-------------|
| Calculation formula | NQPDA(X) = Σ_{y∈RS} p(y) d(x,y) |
| Indicator meaning | In the formula, p(y) represents the weight of node y within the search radius R. In continuous space analysis, p(y) is in discrete space analysis, and p(y) takes the value 0 or 1. d(x,y) represents the shortest topological distance from node x to node y, and NQPDA(x) is the degree of integration |
| Calculation formula | OD(y, z, x) = |

Table 1. sDNA model related parameter calculation formula and meaning
Indicator meaning In the formula, OD (y, z, x) represents the shortest topological path between nodes y and z through node x within the search radius R, and TPBt(X) represents the Choice of node x.

Index parameter understandability

Calculation formula

Indicator meaning R2>0.5 positive correlation
R2<0.5 negative correlation

2.2. Model building and analysis
Since the Three Streets and Two Alleys are located in the central area of Nanning City, in order to avoid the boundary effect, the line segment model is calculated and constructed based on the pedestrian travel speed based on satellite images, including the Three Streets and Two Alleys historical district and its surrounding area of 1600m (equivalent to walking about 15 Minutes).

3. Evaluation of Three Streets and Two Alleys Historic District
The evaluation of historical block planning mainly analyses the three aspects of intellectualization, integration and accessibility of historical blocks. Based on the sDNA model analysis of the integration and penetration of the core blocks in the first phase of the Three Streets and Two Alleys planning, this article scientifically evaluates the planning of the Three Streets and Two Alleys historic block at the spatial level to provide a scientific basis for subsequent renovation and planning.

3.1. Intellectualization Analysis of Historic Districts in Three Streets and Two Alleys
Through the establishment of the spatial syntactic line segment model of the Three Streets and Two Alleys historical district and the surrounding road network in 2010 and 2020 (before and after the renovation), Analysis of the local integration degree of the 250m search radius and the global integration degree of the radius n. The results are fitted and analysed to get the comprehensibility of the block, as shown in Figure 1 scatter plots.

![Figure 1. Scatter plot of comprehensibility (a)2010 (R2=0.3066) (b)2020 (R2=0.3610)](image)

After renovation and reconstruction, the comprehensibility of the block has been increased from 0.3066 (the interpretation rate of the local block to the whole block is 30.66%) to 0.3610 (the interpretation rate of the local block to the whole block is 36.10%). The overall comprehensibility of
the Three Streets and Two Alleys block is low, and it cannot well reflect the cognition of the overall space, which is related to the cultural background of the historical block and the difference in the living habits of the original inhabitants. Through the first phase of the plan (completed in 2018) to transform the road network form in Three Streets and Two Alleys, the residential, commercial, and living activity areas make the block planning more reasonable. Although the degree of comprehensibility is still low, it has improved to a certain extent.

3.2. Integration degree Analysis of Historic Districts in Three Streets and Two Alleys

Space syntax theory believes that a certain space feature is inseparable from other spaces within a certain range, and the range is generally determined by the radius R. By constructing the syntactic model of the core area of Three Streets and Two Alleys in the first-phase planning under different radius, it can be clearly seen that the spatial characteristics analysis results under different radii are different. Therefore, it is necessary to check and analyse the syntax model to determine the appropriate search radius. As the spatial syntax follows the analysis paradigm of "form-traffic-function", the spatial form as an explained variable can be checked by variables such as traffic flow and city function. In this study, the optimal radius check method is selected, and the optimal radius selection is carried out based on the POI data reflecting the urban spatial function. By superimposing the POI data core density analysis results with the spatial syntax parameters and the density analysis results, the more relevant radius is selected as the analysis radius.

Figure 2. Integration degree and commercial POI core density map of Three Streets and Two Alleys phase I(a) 250m (b) 500m
This research uses ArcGIS 10.4 nuclear density analysis tool to analyse the nuclear density of POI data commercial nodes, as shown in Figure 2. Then, the analysis result is superimposed and analysed with the syntax model under different radius of the block. The integration degree of 250m in the core area of the first phase of the Three Streets and Two Alleys shows that the central area of the block shows a strong degree of integration, and the street prospect network is concentrated in the "Silver Lion Alley", "Golden Lion Alley" and around the Chenghuang Temple. This area is a commercial and cultural landscape built at the core of the first phase of the planning area of the Three Streets and Two Alleys Historic District. The old Nanning Three Streets and Two Alley tourist souvenir shops are located in the centre of this area. Through the analysis and superimposition of the core density of the commercial nodes of the POI data, it can be seen that the commercial nodes show a trend of agglomeration in this area, which matches the function of the block and presents a high spatial correlation. Therefore, 250m is selected as the analysis radius.

3.3. Accessibility Analysis of Historic Districts in Three Streets and Two Alleys
Accessibility is used to evaluate the crossing and passing capacity of the movement flow in the road network, and is a very important indicator in urban planning and design. It reflects the probability of a certain space node being passed. The higher the Choice, the greater the probability of the space being traversed, which often reflects the high dredging ability of the road.

The Choice can be divided into local Choice and global Choice according to the analysis radius. Since the Three Streets and Two Alleys historical block is a pedestrian street, the local Choice representing the radius of the walking topological distance is selected as the evaluation index. Based on the analysis of the 250m penetration in the core area of the first phase of the Three Streets and Two Alleys planning, it can be seen that the primary choice for pedestrian "crossing traffic" within the area is the geometric core location of the block. The walking plan of Yousan Street and Two Alleys (Figure 3) shows that "Golden Lion Alley", "Silver Lion Alley" and the surrounding blocks are the areas where pedestrians pass the most. Similarly, the block with historical sites such as Chenghuang Temple, Lingyin Temple, Deng Yingchao Memorial Hall, and "Golden Lion Alley" residents group presents a relatively obvious core, which is the core area of the block.

![Figure 3. 250m Choice of Three Streets and Two Alleys in phase I](image)

4. Conclusions
Based on the sDNA model at the forefront of space syntax, this research analyzes the spatial morphology of historic blocks in Three Streets and Two Alleys in 2010 and 2020 (before and after the first phase of planning). Combined with commercial POI data and nuclear density analysis, the relationship between the spatial form and the spatial function of the historical block is explored. Based on the traditional space syntax model, the sDNA model comprehensively considers topological cost,
economic cost and other factors to improve the variable algorithm, so that its result is closer to the real space road shape than the traditional space syntax model. The sDNA model is integrated into the ArcGIS software toolbox, and it can be applied to large areas and big data research relying on the stable data processing platform of ArcGIS. Combined with the spatial analysis capabilities provided by ArcGIS, it has a wider application prospect in urban analysis and spatial morphology analysis.

After evaluating the planning of the historic district of Three Streets and Two Alleys, the results are as follows: After the first-phase planning of the Three Streets and Two Alleys Historic District, the core of integration continued to expand outward, and the number of roads increased significantly and the scale increased. The blocks of Three Streets and Two Alleys and the surrounding area present a block structure of "cross axis" and "central radiation". The low comprehensibility of the block is related to its historical and cultural background and the function of the community of residents. After the first phase of renovation, it has been upgraded from 0.3066 in 2010 to 0.3610 in 2020, and the space rationality has been improved. Surrounding the "Silver Lion Alley", "Gold Lion Alley" and the Chenghuang Temple is a network of street prospects. It is a commercial cultural landscape built at the core of the Phase I planning area of the Three Streets and Two Alleys Historic District, with a high degree of integration and travel. The blocks where historical sites and attractions such as Chenghuang Temple, Lingyin Temple, Deng Yingchao Memorial Hall, and "Golden Lion Alley" are located, present a clear core of Choice, which provides convenience for tourists. On the whole, the planning of the first phase of Three Streets and Two Alleys is reasonable, following the "form-transport-function" planning principle. Based on the superposition analysis of commercial POI data and spatial syntax analysis results, it is concluded that spatial form and spatial function have a strong correlation, which proves that the improved spatial syntax model is reliable.

Historical block planning is an important topic in the reconstruction and urban renewal. The comprehensive evaluation and analysis of the three-street and two-lane historical block planning with the parameters of Choice, integration and understandability is an important supplement to the research in this field. Using the sDNA model to analyse the spatial morphology is to inherit and develop the traditional spatial syntax model. The sDNA model can be improved to further enhance the application value of the model. It can be applied to the micro and mesoscale historical block planning evaluation research to make up for the lack of targeted research on the internal courtyards and special road sections of the block.

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