Research on Behavior Distribution of Small-scale Commercial Public Space Based on Space Syntax – Taking the Taikoo Li Commercial Street in Daci Temple Area, Chengdu as an Example

Xinchen Jiang[1]; Renke Liu[2]; Yuanyuan Li[3]

ABSTRACT

From the perspective of space syntax, it describes the distribution of personnel behavior in actual use more accurately, by constructing the analytical model of urban external space[4] structure (taking Daci Temple as an example). It compares the correlation degree of the actual behavior distribution description under three different models, the line segment model, convex space model and visual topological model, to explore the other important influencing factors to be incorporated in this case, so as to further optimize the analytical model.

The Taikoo Li Commercial Street in Daci Temple is a business card in Chengdu, which locates in the downtown area of Chengdu. There are a variety of spatial types here, with many commercial activities and complex human activities. The public space consists of the first floor space, second floor connecting corridor, and an underground public space. In the human behavior research in the Taikoo Li Commercial Street, it conducted a quantitative research on human passing speed, passing quantity, staying rate, and staying mode, and then drew a behavioral distribution plan. In the construction of the space syntax model, it conducted a behavior distribution on the correlation analysis, a research on the radiation range of commercial blocks, and an analysis of mass transit public transportation, so as to optimize the buffer area and the construction principle of the space syntax model, as well as the way of determining the traffic impact of mass public transit.

In the research, we found that the subway and the connected underground public space have a great impact on distribution of human behavior; the buffer area of the syntactic model of the local commercial space shall cover the commercial radiation area to which it belongs; the segment model has a higher correlation with the passing behavior, but has a relatively small correlation with the staying behavior. Both the convex space model and the spatial visual model are highly correlated with the passing behavior and staying behavior.

KEYWORDS

Space Syntax, Segment Analysis, Convex Space, Visual Graph Analysis, Behavior Distribution

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1. Introduction

1.1. Research Background

Space Syntax was put forward by Bill Hillier and Julienne Hanson, which was described as “in this sense architecture does resemble language. The laws of the field of architecture do not tell designers what to do. By restricting and structuring the field of combinatorial possibility, they prescribe the limits within which architecture is possible. As with language, what is left form this restrictive structuring is rich beyond imagination. Even so ,without those laws buildings would not be human products, any more than meaningless but syntactically correct concatenations of words are human sentences.” It abstract s the space, describes the mutual relations between the spaces through mathematical and topological methods, so as to further reflect the internal relations between the physical space of buildings or cities and activities. Since the establishment of the space syntactic theory in 1970, the academic circle has continuously optimized and improved it on the original theoretical basis and with analytical methods, with adjustments and changes made for different application scenarios, which has greatly improved the application scenario s of space syntax, whose research fields have (which) extended from architectural design, urban design and urban planning to traffic planning, archaeology, information technology, urban human geography and anthropology.

It can be seen from the development process of space syntax over the past 50 years that it presents a gradually complicated and refined trend. In the initial highly abstract Axial Model, the space syntax was gradually added with more spatial information that was previously ignored, such as angle, length, or even a visibility graph. Such changes are beneficial to explain the differences of physical space due to different scales, shapes and other influencing factors under the same topological relationship.

1.2. Gap in the Researches

During the process of the constant optimization and adjustment of spatial syntax, the analytical methods are becoming increasingly perfect, while there are still research gaps in the following aspects:

(1) Three-dimensional networks
There are many research cases of space syntax based on multi-story space of buildings but few research cases of space syntax based on three-dimensional space of urban and regional scale. For some open three-dimensional blocks, pedestrian flows above the ground will have a topological impact on the ground floor, especially in the conjunction point. Therefore, the three-dimensional networks should be taken into account, as it can reflect the characteristics of the space more precisely.

(2) Quantitative Analysis
In traditional spatial syntactic analysis, the conclusions are mostly qualitative descriptions, such as the degree of integration and choice of a certain region. These values can be compared laterally with other regions in the same model, but cannot be compared outside the model, because there are few studies to reveal the measurable relationship between these values and the true space vitality (number of people passing by and number of people staying).

(3) Physical Properties of Space

Bill Hillier mentioned in Space Is the Machine that “architecture is an art because, although in key respects its forms can be analyzed and understood by scientific means, its forms can only be prescribed by scientific means in a very restricted sense.” Whereas, with the rapid development of technology, we can now perceive the space of buildings and cities in a restricted sense, which depends on the improvement of computer processing speed and the increasingly data sources of cities and communities. In this context, it would be a meaningful research direction to try to introduce other quantifiable spatial physical properties of space into spatial syntax.

1.3. Research Methods

This study consists of three parts: spatial syntax analysis, field survey data statistics, statistical analysis and quantitative evaluation system.

Firstly, according to the actual spatial connection relation in the Taikoo Li business streets, the modelling of the Segment model and the Convex model were established respectively, and the data such as the integration degree and choice degree to describe the spatial topological relation were calculated. On this basis, we conducted a comprehensive and in-depth field survey and record of the population vitality of Taikoo Li commercial district based on time (day and evening) and area (covering all external spaces of Taikoo Li) as well as behavior (passing by and staying). Finally, through a correlation analysis, we selected the data in the spatial syntactic model that could better describe the actual spatial vitality, and further quantified the evaluation data of spatial vitality (population vitality) in dimensions of spatial syntactic integration and choice through regression equation.

2. The Spatial Characteristics of Taikooli Commercial Street

2.1. Spatial Structure and Cost of Space

In a spatial topological relationship, Integration is mathematically the reciprocal of the total depth of a space. “Total depth represents the distance, energy, or time consumed of one during the travelling process from the starting point to all end points,” i.e., integration represents the reaching of the destinations in a space. The higher the degree of integration, the lower the reaching cost of destinations in a space. While Choice is defined as, "For spatial points between each pair of starting point and ending point, it calculates the number or Probability of people passing through these spatial points, that is, the number or probability of encountering others by people located at these spatial points who do not need to travel, i.e., choice represents the probability of a space being randomly passed through by people, and the higher the choice, the lower the cost of being passed through for a space.

Therefore, it can be considered that integration and choice jointly elaborate the concept of the cost of space, which is a necessary condition for urban economic activities, and the level of which often directly determines whether urban economic activities can take place or not. We can find in the actual business choice situation that, if a business is located in an unfavorable space position (whose space cost is too low), then it is faced with the risk of investing more costs in propaganda, marketing, service, management and production in order to achieve certain economic benefits.

As a result, the level of space cost directly determines the status of a space in the economic life of a city.

In the analysis of the commercial public space of Daci Temple, we used the degree of integration and choice to evaluate the space cost, and explored the possibility of using the segment model and the convex model to analyze the commercial space.

2.2. Characteristics of Taikoo Li Commercial Street

We took the Taikoo Li commercial district as a sample, which is located in the central district of Chengdu, adjacent to the traditional commercial street ChunXi Road. It is an open, low-intensity and three-dimensional commercial shopping district built in combination with temples, covering an area of about 70,800 square meters, with a building area of more than 251,000 square meters. Since it was built and put into operation in 2014, Taikoo Li commercial district has brought together various types of brands and attracted a large number of consumer groups. One of the reasons for the great success of Taikoo Li commercial district is the strong investment ability of its operators. Another reason lies in the unique shopping space experience created for its consumers: the open style street layout, the air corridor on the second floor and the public square surrounded by historical buildings are all the shopping space patterns rarely seen in Chengdu in the past.

2.3. Optimization Plan of the Analysis Scope

At the very beginning, we conducted a spatial syntactic analysis with the entire Taikoo Li commercial district as the full scope of study. However, in the preliminary analysis results, we found that the Integration Core and Selection Core were greatly different from the distribution of pedestrian in field observation. In the current situation, the pedestrian flow from the west entrance and KuaiLi Rd were much larger than that from the Dacisi South Square, but in the syntactic analysis, the integration core Int 564m (SLW) and the choice core Choi 564m (SLW) were located in the Dacisi South Square and the Abbaye Bar. Through our comparative analysis of two models with different analysis scopes, it is attributed to two reasons. First, in the topology, the topological elements at the edge often reflected inaccurate outcomes, which brought adverse effects to the calculation results of the whole analysis. Second, the subway station on the west side and the IFS shopping mall generated a large number of people, which had a great impact on the flow in the Taikoo Li commercial district. Therefore, in response to these two problems, we adopted the following strategies. Strategy 1: Expanded the research and analysis scope of the Taikoo Li commercial district by 1-2 topological depths, thereby reducing the impact of edge effects on the calculation and analysis results within the core scope. Strategy 2: Expanded the west side to include the subway station and surrounding public space. After analyzing the expanded model, we found that the analysis results were highly correlated with the actually observed flow, the integration core was distributed in KuaiLi Rd, and the Choice value of the KuaiLi Rd was significantly improved. As the weight of line segment length was used in the line segment analysis model, the subway station and the large-scale square where it was located brought enough impacts. Therefore, we finally expanded the scope of analysis.

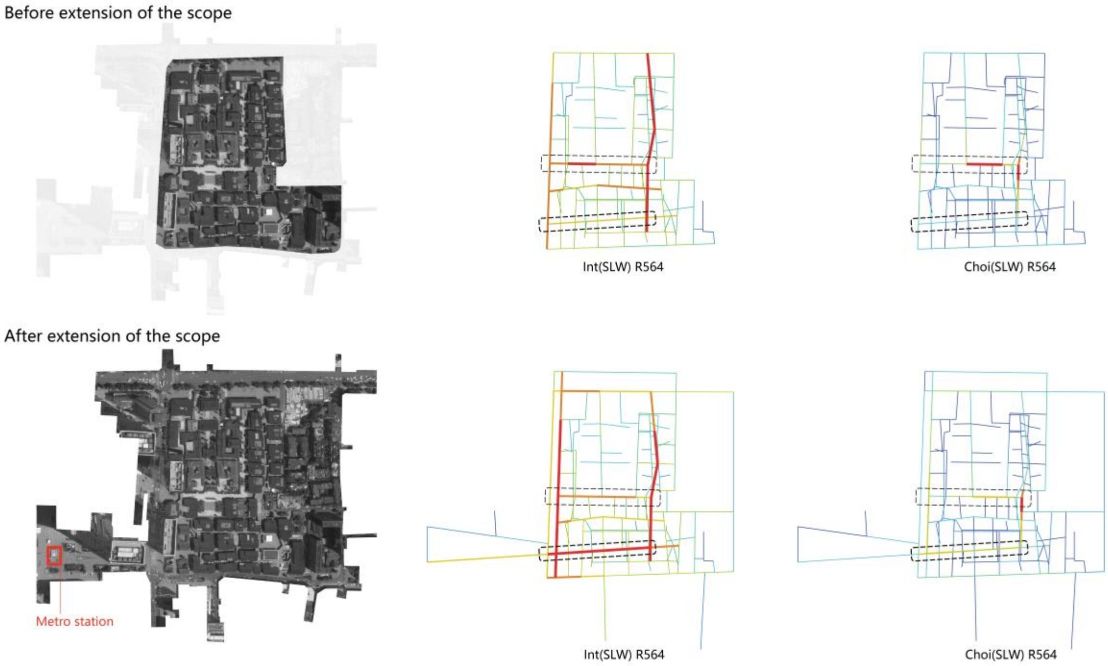

Fig 1. The comparative analysis of the scope

2.4. Segment Analysis

The segment model well preserves the spatial characteristics by abstracting the space into segments, which are topological elements with spatial information contained, such as spatial length and spatial angle, etc.

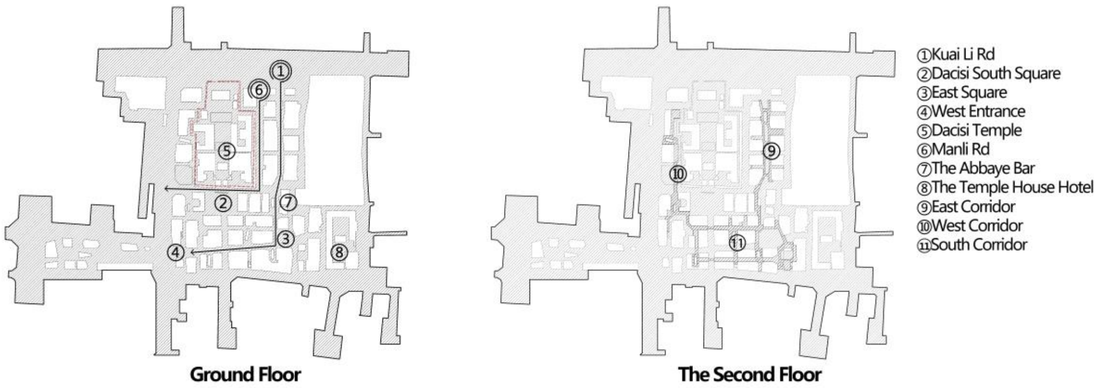

Fig 2. The Existing Public Space of Taikoo Li Commercial Street.

The public space of Daci Temple is mainly composed of the commercial space on the ground and the commercial connecting corridor on the second floor(Fig 1). In the modeling process of the public space, we also took the public space on the second floor into consideration as we found an interesting phenomenon in the field research: the connecting node (public escalator) between the first and second floors attracted many people, though the flow of people on the second-floor corridor was much smaller than that on the public space on the ground. Therefore, we conducted segment modeling for the commercial space on the first floor and the commercial connecting corridor on the second floor respectively, and then set junction point at the traffic junction of the first floor and second floor, with the 'Junction' order in the Depthmap software, to form a complete topology model. We expanded the Taikoo Li commercial district with a topological depth of a segment and minimized the adverse effect of topological boundary on topological relations within the site.

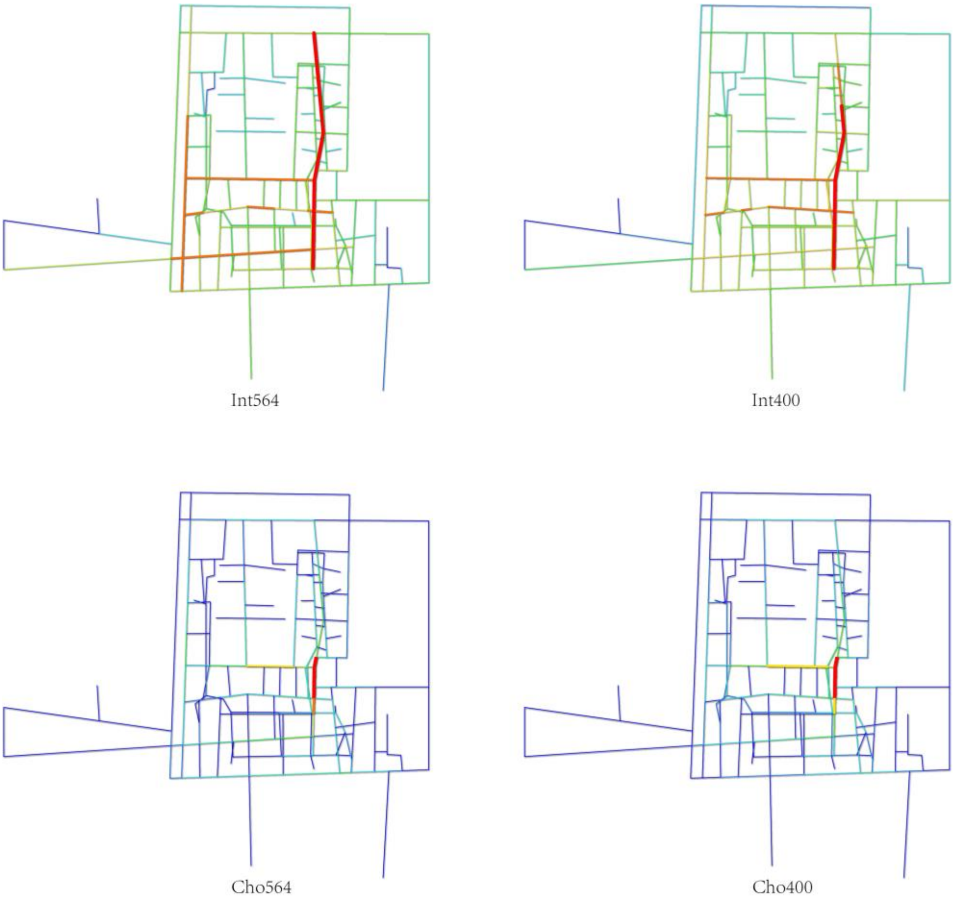

Fig 3. Segment Analysis

Based on the results of the spatial syntactic analysis of the segment model(Fig 2), the integration core is located on the Kuai Li Rd of Taikoo Li, and the integration degree of the surrounding areas of the South Square and East Square of Daci Temple is relatively high. Though the core of integration is far away from the subway station and the old commercial center of Chunxi Road in space, this road, as the main road, connects many secondary spaces around it, and has two main vertical traffic connections with the connecting corridor space on the second floor, making it more advantageous in connecting with the surrounding spaces and easier to be reached. The core of choice is located in a position near the bar and the South Square of Dazi Temple, where the public space connects the South Square of Dazi Temple, the Kuaili Street on the north side, the East Square on the south side and connects the commercial connecting corridor on the second floor directly, resulting in the easiness of the position to be chosen on the 400m-800m scale, in terms of space. In general, the core of integration and the core of choice are highly like the sense of spatial vitality in reality.

2.5. Convex Analysis

Compared with the segment model, the convex model can retain some physical properties of the space, such as shape, area, perimeter, etc. Therefore, on the basis of exploring the topological relationship of the convex, we can further analyze the relationship between the physical properties of the space and the spatial vitality. Compared with the segment model, the convex model is more simplified, thus its advantage lies in that it can more succinctly describe the mutual topological relationship between each node-type space.

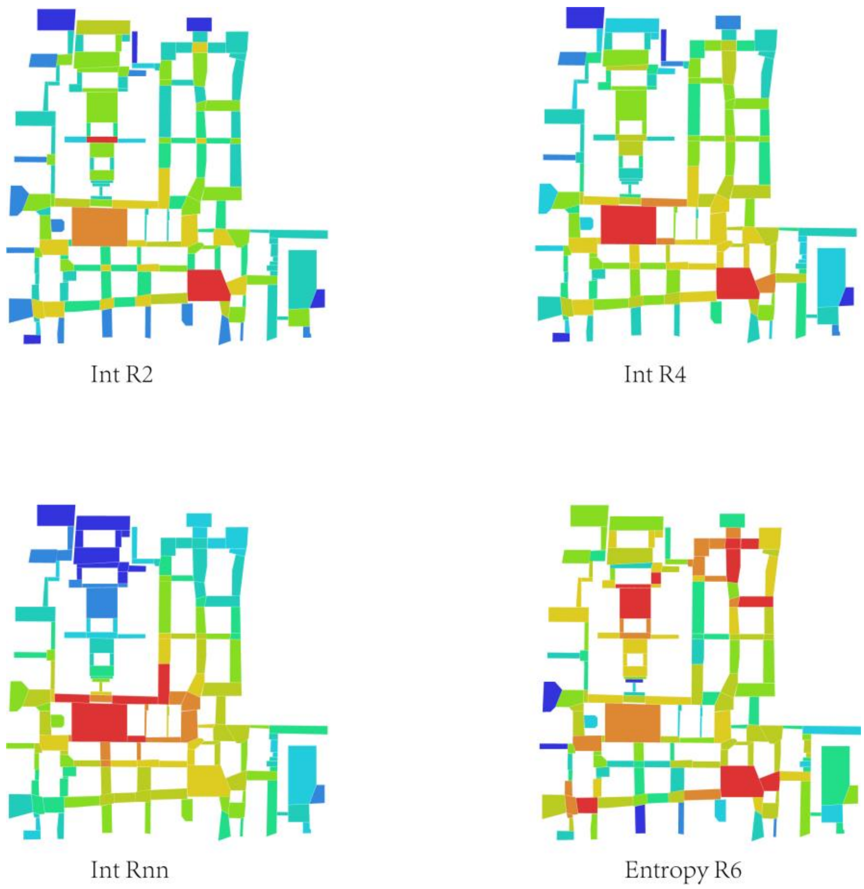

Fig 4. Convex Analysis

We carried out a convex model analysis on the commercial public space of Daci Temple (Fig 3), and calculated the results of the integration (R2, R4, R6), choice (R2, R4, R6), entropy, global depth of the convex space. Seen from the results, the core of convex space integration is mainly concentrated in the surrounding areas of the South Square and East Square of Daci Temple, which is similar to the stop-over population of the two squares in reality. There are at least four passageways between the two squares and their surrounding main public spaces for direct connection, making them more accessible in spatial structure. Similarly, the core of choice is also distributed around the South Square and the East Square, and is high near the bar as well. In the convex space model, the integration core and choice core tend to be similar, indicating that the South Square and East Square are similar on attainability and passing through rate under the circumstance when there is no physical spatial location information.

3. The Distribution of People in Taikoo Li Commercial Street.

Through field investigation and systematic observation of users' behaviors in public spaces of Daci Temple, the actual use status of all public spaces in commercial blocks was obtained. Through a correlation analysis, an evaluation system for such public spaces was formed.

3.1. Segment Map of Flow

3.1.1 Research and Data Acquisition Method

According to the spatial model, the topological structure of activity spaces was extracted to form a network structure, which was taken as the basis of investigation and analysis(Fig 4). The survey data of 115 axes were obtained in accordance with the "cross-section sampling of the people flow ", and whether the staying time reached 3 minutes or not was used to distinguish the pass-by flow and stop-over flow, which was recorded by photography and manual counting.

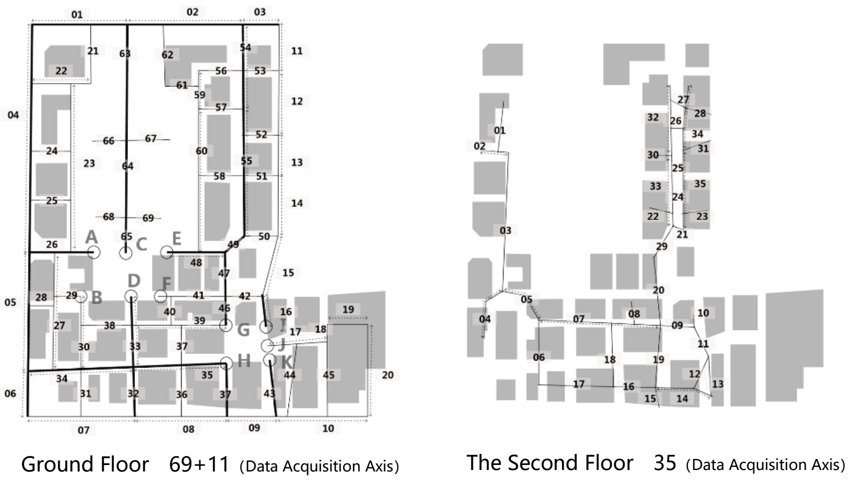

Fig 5. The Serial Numbers of Investigation Nodes

The survey was divided into three time periods: 10:00-12:00, 15:00-16:00, and 17:30-18:30. The data of people flow in each time period includes three categories: the quantity of pass-by flow, percentage of stop-over flow, and duration of the stop-over flow. The average pass-by flow and the average stop-over flow in the morning, afternoon and evening were calculated respectively, and the record time of each individual data is 5min. The average people flow on the streets throughout the day was calculated using the individual data obtained in the three time periods, thus obtaining four lines maps of the people flow distribution. Besides, software was used to assign values to the model.

3.1.2 Characteristics of Flow in Segment Map

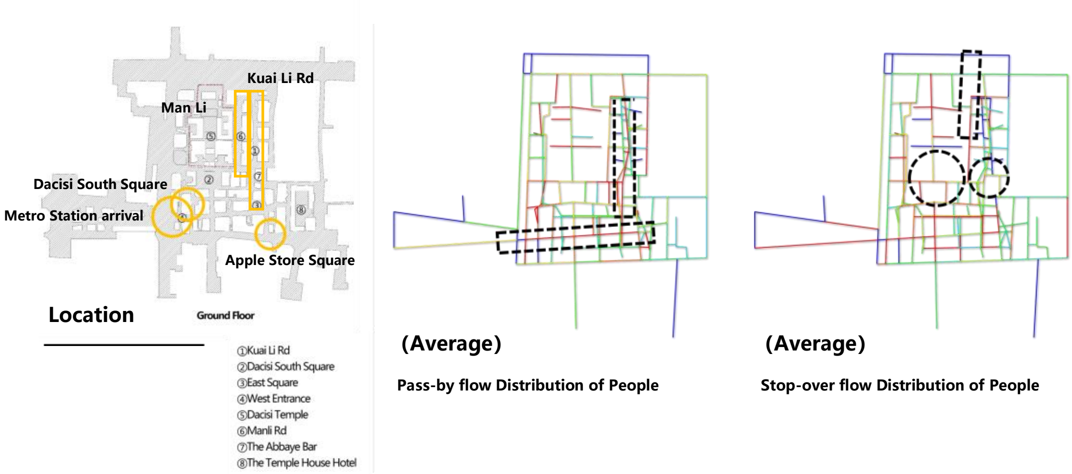

Fig 6. The Distribution of Flow

(1) The Analysis of Pass-by Flow:

According to the line maps of pass-by flow distribution(Fig 5), the most traffic happened in the path of Metro Station arrival and Apple Store Square shown in the figure. Secondly, as shown in the picture, the north side of Apple Store Square and Kuai Li Rd also had a large flow of people. On the whole, the people flow distribution of the micro-block on the south side of the Daci Temple was large, while the flow on the west side, north side of Daci Temple and that of Boshe Hotel was relatively small. The temple itself had relatively independent space, with a relatively small flow of people, and the flow of people move about purposefully.

(2) The Analysis of Stop-over Flow:

Through the line maps of stop-over flow distribution, it can be seen that the major stopover appeared in the two large-scale node spaces shown in the pictures of Guangdong Guild Hall and Apple Store Square. There was also a large amount of flow staying at Man Li Rd and Daci Temple South Square in the picture. In addition, some branches also showed high values of stop-over flow relative to the pass-by flow.

(3) Comparative Analysis:

Through comparative analysis, it can be seen that in the line model, the distribution characteristics of the pass-by flow and the stop-over flow are significantly different, with the stop-over flow concentrating in the larger node space and the internal channel with better privacy, while the pass-by flow mainly concentrated on the channel with better connection with the surroundings.

3.2. Convex Map of Flow

3.2.1 Research and Data Acquisition Method

On the basis of the line maps of people flow, the numerical information of the line maps was assigned to the convex space maps by GIS software, and the distribution of people flow was obtained in the convex space model, thus providing model support for the further comparative analysis of spacesyntax analysis results and the results of people flow distribution.

3.2.2 Characteristics of Flow in Convex Map

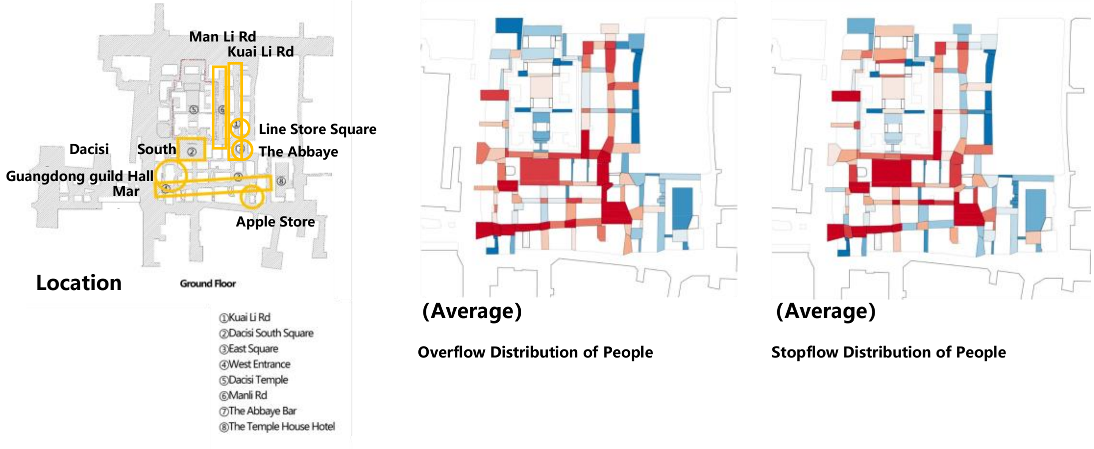

Fig 7. The Distribution of Convex map of flow

(1) The Analysis of Pass-by Flow

It can be seen from the convex space maps of people flow that the pass-by flow is mainly concentrated in the Kuai Li Rd streamline and the surrounding lanes of Daci Temple South Square shown in the figure 6. And the figure shows that more people concentrated near Daci Temple South Square and The Abbaye Bar.

In terms of timeline, The figure shows that the people flow of Daci Temple South Square and The Abbaye Bar maintained a high value from morning to night while more and more people passed by the streamline of Kuai Li Rd over time. Besides, the distribution of people flow in Daci Temple South Square peaked in the afternoon and decreased in the evening.

(2) The Analysis of Stop-over Flow

It can be seen from the convex space map of people flow distribution that the stop-over flow mainly concentrated in the Apple Store Square, Daci Temple South Square, Guangdong Guild Hall Square, and Line Store Square, as well as some deep branches.

In terms of timeline, the figure shows that the people flow on Daci Temple South Square and Apple Store Square remained high from morning to night while more people appeared in the Marni Rd streamline during afternoon and evening. As for the Daci Temple, the stop-over flow peaked in the morning and decreased in the afternoon. The figure also shows that the stop-over flow of the Man Li Rd stream line also reached its peak in the morning, decreased in the afternoon and rose to a certain extent in the evening.

(3)Comparative Analysis:

Through a comparative analysis, it is found that in the convex space model, the distribution features of the stop-over flow and pass-by flow are also significantly different. The stop-over flow mostly concentrated in the node square and the internal channel with better privacy, while the pass-by flow mainly concentrated in the traffic aisles and square with good spatial connectivity.

4. Evaluation System of Spatial Vitality

4.1. Correlation and Regression Analysis

4.1.1. Correlation and Regression Analysis Based on Segment Analysis

A correlation analysis was conducted between the results of space syntax analysis and the number of passers-by and stop-overs of the people in the Taikoo Li commercial space. The analysis results are composed of the Integration (R400m, 564m, 800m), Choice (R400m, 564m, 800m) and Total Depth of then segment model. Moreover, we standardized the variables in the analysis to reduce the impact brought by different units. The correlation analysis was performed using the Pearson correlation coefficient, where correlation coefficient R<0.4 indicated weak correlation; R≥0.4, R<0.6 indicated moderate correlation; R≥0.6, R<0.8 indicated high-positive correlation and R ≥ 0.8 indicated strong correlation.

Correlation-Segment Model			
		ped average ALL	Stay vol ALL
ped average ALL	Correlation coefficient	1	.542**
Stay vol ALL	Correlation coefficient	.542**	1
Zscore(CH)	Correlation coefficient	.618**	.197**
Zscore(CHr100.00m)	Correlation coefficient	.244**	.048
Zscore(CHr1000m)	Correlation coefficient	.612**	.194**
Zscore(CHr200m)	Correlation coefficient	.475**	.158*
Zscore(CHr400m)	Correlation coefficient	.588**	.207**
Zscore(CHr564m)	Correlation coefficient	.650**	.218**
Zscore(CHr800m)	Correlation coefficient	.634**	.209**
Zscore: CH[segLEN]	Correlation coefficient	.509**	.182**
Zscore: CH[segLE_1	Correlation coefficient	.456**	.296**
Zscore: CH[segLE_2	Correlation coefficient	.486**	.170**
Zscore: CH[segLE_3	Correlation coefficient	.594**	.307**
Zscore: CH[segLE_4	Correlation coefficient	.629**	.283**
Zscore: CH[segLE_5	Correlation coefficient	.648**	.250**
Zscore: CH[segLE_6	Correlation coefficient	.542**	.203**
Zscore(INT)	Correlation coefficient	.591**	.301**
Zscore(INTr100.00)	Correlation coefficient	.432**	.172**
Zscore(INTr1000m)	Correlation coefficient	.592**	.301**
Zscore(INTr200m)	Correlation coefficient	.509**	.220**
Zscore(INTr400m)	Correlation coefficient	.574**	.300**
Zscore(INTr564m)	Correlation coefficient	.623**	.337**
Zscore(INTr800m)	Correlation coefficient	.594**	.304**
Zscore: INT[segLEN	Correlation coefficient	.541**	.302**
Zscore: INT[segL_1	Correlation coefficient	.498**	.282**
Zscore: INT[segL_2	Correlation coefficient	.542**	.303**
Zscore: INT[segL_3	Correlation coefficient	.599**	.325**
Zscore: INT[segL_4	Correlation coefficient	.640**	.371**
Zscore: INT[segL_5	Correlation coefficient	.622**	.368**
Zscore: INT[segL_6	Correlation coefficient	.550**	.309**

**. 在 0.01 级别（双尾），相关性显著。

*. 在 0.05 级别（双尾），相关性显著。

Table 1. Correlation Analysis of Segment & Pedestrian Flow

It can be seen from the results of the above table(Table 1) that the number of passers-by is highly correlated with the standardized indicators of CH, CHr1000.0m, CHr564m, CHr800m, CHr [segLE_4], CHr [segLE_5], INtr564m, INT [segL_4] in the segment model. In particular, the degree of association between integration and choice at the radius of 564m is of the highest, indicating that the behavior of arrival and random passing through at the radius of 564m brings more vitality to the Taikoo Li commercial space. However, the correlation coefficient between dimensions such as integration and choice of the segment model and the stopping over amount of the crowd is between 0.1 and 0.4, showing a weak correlation, indicating that the line segment model is weak in describing the stopping over activity of the crowd in the space.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.685[a]	.469	.463	24.17415	.938

a. Predictors: (Constant), F3score, F1score, F12score

b. Dependent Variable: ped average ALL

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	30.698	1.502		20.437	.000
	F1score	3.083	.345	.408	8.942	.000
	F2score	6.987	.754	.423	9.268	.000
	F3score	7.183	.929	.353	7.730	.000

a. Dependent Variable: ped average ALL

Regression output of pedestrian passing & segment

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.350[a]	.123	.112	4.30242	1.422

a. Predictors: (Constant), F3score, F12score, F1score

b. Dependent Variable: Stay vol ALL

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.859	.267		14.463	.000
	F1score	.320	.061	.305	5.218	.000
	F2score	.171	.134	.075	1.276	.203
	F3score	.434	.165	.154	2.626	.009

a. Dependent Variable: Stay vol ALL

Regression output of people staying & segment

Table 2. Principal Component Regression (PCR) of Segment Output and Flow

On the basis of correlation analysis, we made a regression analysis of the spatial syntactic analysis results and spatial vitality units(Table 7). Because of the high collinearity between the spatial syntactic independent variables, we used principal component regression (PCR) to perform dimensional reduction on the highly collinear dimensions and establish regression equations with population data. After the principal component regression analysis was completed, as shown in the figure, it was found that VIF ≤ 10, and the factors of the principal components were low in collinearity, which could effectively describe the dependent variables. The significance of each factor was ≤ 0.05, and the regression model could significantly explain the dependent variables. The fitting degree R^2 =0.463 of the regression model of spatial syntax and the crowd's passing through amount could well explain the crowd's passing through amount. However, the fitting degree of the regression model between the spatial syntax and the crowd's stopping over amount was only $R^2 = 0.112$, which could hardly explain the crowd's stopping over amount. Therefore, in the calculation of regression equation, we mainly focused on the regression model of spatial syntactic dimension and the crowd's passing through amount.

Rotated Component Matrix				People Passing			Coefficient	Weight
	Component			Unstandardized Coefficient				
	1	2	3	3.083	6.987	7.183		
Zscore(CH)	-.072	.148	.007				0.86417666	0.060579319
Zscore(CHr100.00m)	-.090	-.010	.177				0.927828312	0.065041339
Zscore(CHr1000m)	-.071	.149	.005				0.854736399	0.059917551
Zscore(CHr200m)	-.098	.044	.154				1.108214693	0.077686536
Zscore(CHr400m)	-.100	.119	.076				1.069150786	0.074948132
Zscore(CHr564m)	-.082	.128	.047				0.975882332	0.068409956
Zscore(CHr800m)	-.071	.142	.014				0.877379558	0.06150485
Zscore: CH[segLEN]	-.018	.152	-.083				0.40562836	0.028434799
Zscore: CH[segLE_1	-.005	-.069	.159				0.640114567	0.044872428
Zscore: CH[segLE_2	-.017	.152	-.088				0.382576981	0.026818883
Zscore: CH[segLE_3	-.038	.027	.110				0.862488684	0.060460991
Zscore: CH[segLE_4	-.056	.123	.017				0.81114375	0.056861679
Zscore: CH[segLE_5	-.034	.134	-.027				0.639054542	0.044798119
Zscore: CH[segLE_6	-.015	.148	-.080				0.409008179	0.028671727
Zscore(INT)	.131	-.047	-.016				-0.03632245	0.002546226
Zscore(INTr100.00)	-.011	-.063	.165				0.712408851	0.049940302
Zscore(INTr1000m)	.131	-.047	-.016				-0.03549636	0.002488317
Zscore(INTr200m)	.009	-.058	.144				0.658494039	0.04616084
Zscore(INTr400m)	.081	-.079	.085				0.31286647	0.021932133
Zscore(INTr564m)	.124	-.071	.025				0.065893273	0.004619159
Zscore(INTr800m)	.132	-.049	-.014				-0.03286833	0.00230409
Zscore: INT[segLEN	.144	-.020	-.076				-0.24353804	0.017072168
Zscore: INT[segL_1	.063	-.059	.071				0.292292654	0.020489896
Zscore: INT[segL_2	.145	-.021	-.076				-0.24301841	0.017035741
Zscore: INT[segL_3	.068	-.049	.068				0.354499488	0.024850634
Zscore: INT[segL_4	.116	-.067	.030				0.106970259	0.007498681
Zscore: INT[segL_5	.143	-.054	-.023				-0.10690522	0.007494122
Zscore: INT[segL_6	.146	-.024	-.072				-0.23625156	0.016561381

Table 3. Weights of Dimensions of Segment Analysis

According to the calculation results of principal component regression (PCR), the regression equation of the original independent variables was restored(Table 8). Based on the regression coefficients of the original independent variables in the Coefficient column of the table, it can be seen that the choice of CHr200m and CHr400m have relatively higher weights when determining the passing through vitality in the space. It is in an order of weight as: CHr200m, CHr400m, CHr100m, CHr800m, CH[segLe_1], CHr1000m, INtr100m, which indicates that the choice of segment plays a role in deciding the spatial passing through vitality, with the decision effect especially obvious in the walking range of 200m to 400m. In the Taikoo Li commercial district, people's passing through behavior is more concentrated in the 200m-400m range while the degree of integration is of secondary importance in evaluation.

4.1.2. Correlation and Regression Analysis of Convex Analysis.

In the regression analysis of the convex space model analysis results and the population vitality distribution results(Table 9), we introduced the physical property dimension of the convex space, and as we needed to exclude the irrelevant dimensions, we applied stepwise regression analysis. It can be seen from the above analysis that the independent variable VIF ≤ 10, the principal component factors do not have collinearity, and the factors can effectively describe the dependent variables. And as the significance value of each factor ≤ 0.05, the regression model can explain the dependent variables significantly.

Regression output of people passing & convex

Coefficient[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics		Weight
		B	Std. Error	Beta			Tolerance	VIF	
4	(Constant)	**224.055**	60.517		3.702	.000			
	Choice R4	**2.161**	.220	.714	9.806	.000	.615	1.625	0.007
	Enclosure	**-102.479**	33.129	-.181	-3.093	.002	.954	1.048	0.323
	Choice [Norm]	**-181.744**	59.265	-.230	-3.067	.003	.579	1.728	0.574
	Relativised Entropy	**-30.514**	13.023	-.148	-2.343	.020	.815	1.228	0.096

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Waston
1	.661[a]	.437	.433	92.50405246	
2	.683[b]	.466	.459	90.36057889	
3	.697[c]	.486	.476	88.94589351	
4	.710[d]	.504	.491	87.66889710	1.737

Regression output of people staying & convex

Coefficient[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	Weight
		B	Std. Error	Beta			VIF	
2	(Constant)	**14.608**	4.112		3.552	.001		
	Choice R4	**.411**	.056	1.117	7.319	.000	7.495	0.092
	Harmonic Mean Depth R2	**-4.073**	1.399	-.444	-2.911	.004	7.495	0.908

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Waston
1	.704[a]	.495	.492	10.63979860	
2	.722[b]	.521	.515	10.39221797	1.690

Table 4. Stepwise Regression of Convex Output and Flow

The weight of Choice Norm reached 57.4%, which indicated that it played the most important role to explain the passing through amount of the crowd. It is also interesting to find that the weight of physical enclosure of the convex space also reaches 32.3%, suggesting that apart from the influence of spatial structure on the spatial vitality, the physical properties of space, especially the spatial enclosure, also have a great impact on the spatial vitality. Secondly, the entropy weight reaches 9.6%, suggesting that the spatial entropy value should be one of the important criteria to be considered in the future space vitality determination. In the model explaining the amount of stopping over flow, the weight of Harmonic Mean Depth R2 is as high as 90.8%, which has a decisive influence on the stopping over activity in the space. Besides, Harmonic Mean Depth R2 decides the stopping over behavior of the crowd, the higher the mean depth, the more likely the crowd is to stop over, suggesting that people are more likely to stop over every another convex space when encountering node-type spaces. In actual situations, it is also easy to find that the probability of people’s stopping over behavior in a node convex space will be greatly reduced if they have stopped over for a while once in travelling a commercial space. However, when coming to the third or fourth convex space, people are most likely to stop over again, which is because when people go shopping or sightseeing, their attention is increased intermittently and rhythmically. In addition, Choice R4 also has a 9.2% weight, indicating that the commercial public space of Dazi Temple is more likely to be selected across four convex spaces. But when compared with the average depth, it is less decisive to the stopping over amount of the crowd.

In conclusion, it can be seen from the above line segment model, convex space model and the regression model of spatial vitality distribution that choice often plays a decisive role in determining the spatial vitality. It must also be pointed out that attributes such as the enclosure of the convex space can also greatly influence the passing through amount in a space. As for the distribution of stopping over vitality in a space, the average depth and integration of small-scale crossing can well determine the capacity of a space in carrying people to stay and play in it.

4.2. Weightiness and Evaluation System

Based on the line segment model analysis, the convex space model analysis and the correlation and regression analysis of the crowd spatial vitality distribution, the influence of the evaluation dimension of each independent variable on spatial vitality is quantified.

The Evaluation System of Spatial Vitality of Taikoo Li Small-Scale Commercial Streets				
			Pass-by Crowd	Stop-over Crowd
Segment Analysis Model	Syntactic Dimensions	CHr200m	7.80%	\
		CHr400m	7.50%	\
		CHr100m	6.50%	\
		CHr800m	6.20%	\
		CH	6.10%	\
		CH[segLe_3]	6.00%	\
		CHr 1000m	6.00%	\
		CH[segLe_4]	5.70%	\
		INTr100m	5.00%	\
		CH[segLe_1]	4.50%	\
		CH[segLe_5]	4.50%	\
		Others	34.20%	\
Convex Analysis Model	Syntactic Dimensions	Choice R4	0.70%	\
		Choice [Norm]	57.40%	\
		Relativised Entropy	9.60%	\
		Choice R4	\	9.20%
		Harmonic Mean Depth R	\	90.80%
	Physical Dimension	Enclosure	32.30%	\

Table 5. The Evaluation System of Spatial Vitality of Taikoo Li Small-Scale Commercial Streets

(1) Evaluation System of Segment Analysis Model

From the table(Table 10) of the results of the small-scale commercial space vitality evaluation system for the Taikooli streets, it can be seen that the dimension of the degree of choice of CHr200m, CHr400m and CHr100m in the line segment model analysis tops in the evaluation system. The degree of choice can explain 60%-70% of the passing-by crowd. This also shows that the degree of choice of the segment model is of the highest reference value for the evaluation of the degree of vitality, but the segment model does not have an advantage in explaining the stop-over crowd.

(2) Evaluation System of Convex Analysis Model

In the analysis results of the convex space model, the degree of standardized choice accounts for 57.4%, while the weight of physical attribute enclosure reaches 32.3%. It shows that, in addition to the degree of choice, the spatial closure can also play a good role in the use of convex space analysis to explain the crowd passing phenomenon. At the same time, the Harmonic Mean Depth of space has a decisive role, averaging 90.8%, in explaining the crowd stay phenomenon.

(3) Significance of Evaluation System

The analysis result index is quantified and the bridge between the analysis result data and the actual passenger flow data is established. It is of great significance to directly apply the results of spatial syntactic analysis to the evaluation and prediction of spatial vitality.

5. Conclusions

The following can be found by studying the space syntax of Taikoo Li commercial space:
(1) The Role of Segment Analysis Model
The spatial syntactic segment model can well evaluate the passing through data of the crowd, but shows a weak ability in describing the stopping over amount of the crowd. And the relevancy between the choice at the radius around 564m of the segment and the current status of the crowd is the highest, while the integration has a weak ability in judging the behavior of the crowd in small-scale commercial spaces like Taikoo Li on the whole.

(2) The Role of Convex Analysis Model
Although the convex model has been less applied to the actual spatial analysis recently, due to its lack of positional information and blur modeling standard, the characteristics of convex model can be used to analyze the courtyard space as one node, as the Taikoo Li commercial block space has obvious nodal space features like a courtyard. On this basis, we introduced the physical properties of space such as enclosure, permeability, and perimeter into the convex space model, which, to some extent, complements the lack of insufficient material space information in convex space and helps to find a high correlation between the passing through amount of the crowd and the enclosed degree of convex space.

(3) Data Collection and Statistics
We obtained a large number of accurate population distribution data through an on-spot investigation of the site, and based on this, we carried out a quantitative regression statistical analysis on the population distribution data as well as on the result of space syntactic operation, and obtained accurate regression equation and weight distribution of spatial syntactic factors on spatial vitality. The construction of this preliminary regression prediction model will provide strong support for similar project space prediction in the future, and also provide experience for the exploration of statistical methods in the analysis process which combines spatial syntax with big data in the future.

(4) Limitations
In the process of analysis, we encountered many difficulties and limitations. Firstly, the crowd data is not real-timed, and the data volume is obviously smaller than the big data of people in a long term. There are also great difficulties in data acquisition. The accuracy of crowd distribution data of big data is low, which cannot meet the needs of spatial syntactic analysis at medium and small scales. In the modeling, we encountered errors caused by the uncertainty of convex space division and buffer range. In the future, we will further explore the influence of different modeling methods on the results of spatial syntactic analysis.

Judging from the analysis of the impact of public transportation on the pedestrian flow, it is difficult to draw an answer from the analysis results of the case space itself, while getting answers from a city-wide perspective poses a greater challenge to modeling and data collection. At present, what can be done is to expand the analysis scope and structure as far as possible, thereby reducing the calculation error.

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