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To cite this article: Zhehan Zhang, Kai Fang, Xinpeng Wang, Lin Chen, Wenda Zhang & Nobuaki Furuya (2020): Characteristics, correlations of traditional street space elements and tourist density following spontaneous renovation: a case study on Suzhou’s Shantang Street, Journal of Asian Architecture and Building Engineering, DOI: 10.1080/13467581.2020.1781647

To link to this article: https://doi.org/10.1080/13467581.2020.1781647

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Characteristics, correlations of traditional street space elements and tourist density following spontaneous renovation: a case study on Suzhou’s Shantang Street

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ABSTRACT
Shantang Street in Suzhou serves as the object of this study; field investigation, street mapping, data statistics, and other methods are utilized to observe spatial elements, tourist density, and the relationships among them. The spatial elements of Shantang Street are divided into basic elements (store density, facade opening, water proximity, D/H) and activity elements (upper shelter, commercial overflow, life overflow). These characteristics are also analyzed quantitatively. Next, tourists on Shantang Street are counted on-site to analyze their basic density. The SPSS software Canonical Correlation tool is utilized to establish a relationship between basic elements and activity elements; a set of canonical variates with a significant correlation between the two are obtained. The SPSS Multiple Regression tool is then used to observe the correlation between tourist density and street space elements. Store density, D/H, water proximity, commercial overflow, life overflow, and tourist density are found to be significantly correlated.

ARTICLE HISTORY
Received 11 November 2019
Accepted 29 May 2020

KEYWORDS
Traditional streets; spatial elements; tourist density; canonical correlation; multiple regression

1. Introduction
1.1. Research background and purpose
Today’s China is in the process of rapid development accompanied by an abundance of large-scale urban construction projects. Traditional street structures are also shifting. Due to their unique historical and humanistic characteristics, traditional streets typically attract tourists (and thus grow economically profitable) by means of commercial development. Outside of the government-dominated, top-down planned development model, commercial redevelopment of the traditional streets is individual, bottom-up, and characterized by small scale, spontaneity, and diversity.

The research object of this study is a section of Shantang Street that is not yet fully commercialized. A great deal of spontaneous transformation has had an enormous impact on the street space. This study centers on space that has undergone individual spontaneous transformation rather than the historical architectural elements of the surrounding space. The spatial characteristics of the object were divided into basic elements and activity elements; their respective characteristics were observed to determine the correlation among them, and between them and tourist density. The results presented below can be applied to other space and behavior studies. The work presented here is a reference for the redevelopment of similar historical streets in the future as well.

1.2. Previous research
There have been numerous previous studies on street space. Ashihara (1979) proposed primary contour and secondary contour concepts for street space analysis. The primary contour refers to the inherent form of the building, and the secondary contour refers to the space form formed by the protrusions and temporary additions of the outer wall. Naoki Saito, Tatsumi, and Almazán (2019) divided the alley space elements into ground elements, boundary elements, and activity elements to analyze the spatial characteristics. These researchers analyzed the external space characteristics by dividing the street space into several types of spatial elements. The basic elements and activity elements selected in this study were inspired by them.

Previous researchers have also explored traditional spaces in Suzhou. Wang and Hiroshi (1996), for example, summarized the characteristics of waterways and street space and their relationship in the process of urban development. Mitsuru et al. (1990) explored residential land development in Suzhou as per the characteristics of street space, the composition and detailed architectural characteristics of typical residential buildings, and historical building data for the Shantang Street area. Yan, Seiji, and Yuji (2000) extracted the constitutive elements of the waterside space in Suzhou to explore the spatial distribution and composition pattern of the space. These studies primarily focus on traditional spatial

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forms; the scholars did not evaluate spatial characteristics quantitatively.

There have also been valuable contributions to the literature on the spontaneous renovation of traditional spaces. Lee and Furuya (2012) studied a quadrangle courtyard-oriented development and commercialization in Nanluogu Alley, Beijing, quantitatively; they also explored the relationship between traditional streets and quadrangle courtyard renovations. Wang et al. (2019) studied the spontaneous renovation of traditional dwellings in Fuzhou City, Fujian Province, China, and probed the relationship between types of architectural spaces and resident consciousness of shared space via statistics and function-fitting analysis. These studies revealed the relationship between elements quantitatively, but were confined to discussions between only two elements. There are typically multiple factors that influence the dependent factor, however, and ultimately affect this relationship.

There have been previous studies on multi-element correlations in this context. Fang et al. (2019) analyzed the spatial characteristics of Tianzifang, Shanghai using such theories as spatial syntax; they assigned values to spatial characteristics including store density, the overflow rate of storefront spaces, building entrance-exit density, the degree of integration, building height, and distance from block entrances to explore the relationship between spatial characteristics and pedestrian density via multiple regression analysis. Zhang, Chen, and Shen (2015) quantitatively analyzed the correlation between the spatial elements of traditional mountain settlements as per the figure-ground relation, street interface type, vertical site characteristics, street scale, and other factors.

The paper references the literature but does not discuss the historical elements of such spaces nor simply their spatial form. By contrast, the target street space here is divided following spontaneous renovation into basic elements and activity elements. The spatial characteristics are assessed quantitatively, and a canonical correlation analysis is conducted on the basic and activity elements to explore the correlation between them. A multiple regression analysis of seven spatial elements and tourist density is also conducted to probe the correlation among spatial elements and tourist characteristics.

2. Research overview

2.1. Overview of survey site

Suzhou is located in Jiangsu Province, China, a well-known historical and cultural hub. Shantang Street is located in the northwest part of the city’s ancient center; it has a total length of 3,600 meters and branches into side streets along the river. This area is typical in regards to the spatial characteristics of traditional riverside towns in Suzhou. Its geographical location and the traffic conditions of rive-side streets made this place an important trading center in the Ming and Qing Dynasties of China. Like most cities in China, Suzhou began large-scale development and expansion in the late stages of the last century. Shantang Street has fallen into decline, however, as it currently does not meet the needs for modern residential life.

The research object in this study is a section of Shantang Street 360 meters west of Guanjgi Road. Due to the lack of unified commercial development there, a large number of spontaneous renovations have occurred leading to abundance of diverse spatial elements; in this place, new and old things uniquely coexist.

2.2. Investigation overview

Supporting data were obtained from a street investigation conducted in May of 2018. The investigation focused on the streets and buildings within the range 360 meters west of Guanjgi Road of Shantang Street, mainly including the following:

1. Surveying and mapping of the basic plans of the street and the buildings alongside it;
2. Investigating the remaining basic spatial elements of the street including the height of buildings alongside it, the waterside space, the openness of building facades, and the functions of these buildings;
3. Investigating street activity elements including commercial overflow, life overflow, and upper shelter;
4. Counting tourists in multiple periods by means of segmented photography; and
5. Recording the street with 8 mm fish-eye photos at a 5-m interval (Figure 1).

2.3. Research methods

The width of Shantang Street is different in different locations on the street, which gives the target area unit-based characteristics. By reference to the plane division theory of the spatial syntactic convex space (Hillier and Hanson 1989) and in combination with its current situation, the survey site was divided into 32 units. The main street was divided into 19 units and the branch streets into 13 units for subsequent analysis (Figure 2).

The street space was divided into basic elements including store density, facade opening, water proximity, and D/H as well as activity elements including upper shelter, commercial
overflow and life overflow (Figure 3). The spatial characteristics of various street units were evaluated by data quantification. Tourist characteristics were analyzed statistically in multiple periods on multiple dates. Finally, the basic elements and activity elements were subjected to SPSS canonical correlation analysis to explore the correlation between spatial elements. The spatial elements and tourist density were subjected to SPSS multiple regression analysis to explore the correlation between them (Figure 4).

3. Basic elements
3.1. Store density

The original plans of the buildings on both sides of Shantang Street are dominated by townhouses. This house type was maintained even as they later became increasingly used as retail spaces rather than family homes. In the context of modern, spontaneous, commercialized renovation, differences in rent and space demands during the subleasing process (among other factors) have produced various
Figure 4. Research route.

Figure 5. Store plan types.

Figure 6. Results of the store density.
renovations and diversified house types in the area. (Figure 5)

Various renovation methods have led to various densities of stores distributed along Shantang Street. The number of stores within a unit divided by the area of the street unit served in this study as an evaluation index for store density (Figure 6). The branch store density is greater than the main street store density; B-6, B-1, B-7, and B-3 are the densities of stores on branch streets. The standard deviation of branch store density is also greater than that of the main street, indicating that the stores on the main street are relatively evenly distributed while those along branch streets fluctuate considerably.

\[ X_{\text{store}} = \frac{N_{\text{store}}}{S_{\text{unit}}} \]

\( N_{\text{store}} \): Number of stores within a unit
\( S_{\text{unit}} \): Area of the street unit

**3.2. Facade opening degree**

The facade opening degree is defined by the open doors and windows of structures on both sides of the street. This variable represents indoor and outdoor connectivity and influences the extent to which merchants are attractive to potential customers traversing the street. Based on the degree of openness, the forms of building facades on either side of Shantang Street were divided into various types as shown in Figure 7.

The facade opening degree was quantified by the sum of the area of door and window openings of buildings on both sides of the unit street divided by the unit street area. Stores on Shantang Street are concentrated on the ground floor, so the facade opening of upper floors was not be considered here. The results are shown in Figure 8. The average facade opening value of the main street is 2.5-fold greater than that of the branch streets. All branches have small values except for B-6. The buildings on Shantang Street are mainly opened towards the main street while branches have low indoor and outdoor connectivity. The variation amplitude of the opening degree of branch facades is slightly larger than that of the main street.

\[ X_{\text{opening}} = \frac{S_{\text{opening}}}{S_{\text{unit}}} \]

\( S_{\text{opening}} \): Sum of the area of facade door and window openings (ground level)

![Figure 7. Facade opening types.](image)

![Figure 8. Results of the facade opening degree.](image)
3.3. Water proximity

Suzhou is a typical waterside city. The waterway space has an important impact on the urban structures, landscapes, and resident lifestyles of the city. Shantang Street extends along the river and its waterside public space is composed of various combinations of features. Below, the basic elements of the public space at the waterside of Shantang Street are discussed including rivers, streets, buildings, quays, bridges, clearing, green lands, and corridors. Based on the number and combination of elements, the waterside public space of the Shantang Street area was divided into several types as shown in Figure 9.

The visibility of waterside space is used here as an indicator to evaluate the water proximity of the street. The ratio of the sum of the areas of the openings open to the river in the water public space at the water’s edge (e.g., stores adjacent to the river) to the area of the street serves as an indicator of water proximity (Figures 10 and 11). Branch streets have altogether significantly higher water proximity than the main street. Riverside stores comprise the main water proximity space of the main street, while the branches have more open public spaces along the water and better connectivity with the river.

\[
X_{\text{water}} = \frac{S_{\text{water}}}{S_{\text{unit}}}
\]

\( S_{\text{water}} \): The sum of the areas of the openings open to the river in the water public space at the water’s edge.

3.4. D/H (Ashihara 1981)

The Shantang Street area shows a considerable difference in D/H values across its different street units due to its various street widths. The D/H value influences the emotional reactions of tourists on the street, which makes it an interesting indicator of a target area’s spatial characteristics. Here, the average height of the buildings in the street unit comprises the H value and the average street width is the D value (Figure 12).

<table>
<thead>
<tr>
<th>Element Number</th>
<th>Element Type</th>
<th>Waterside Public Space Type</th>
<th>Element Type</th>
<th>Waterside Public Space Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 3 Elements</td>
<td>I street building river</td>
<td></td>
<td>II-1 street building river clearing quay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II-2 street building river bridge quay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E-1 street building river clearing</td>
<td></td>
<td>II-3 street building river clearing bridge quay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-2 street building river bridge</td>
<td></td>
<td>II-4 street building river corridor</td>
<td></td>
</tr>
<tr>
<td>II 6 Elements</td>
<td>II-1 street building river clearing green quay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-2 street building river clearing green bridge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-3 street building river clearing bridge corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-4 street building river corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V 7 Elements</td>
<td>II-1 street building river clearing green bridge quay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-2 street building river clearing green bridge corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II-3 street building river clearing green quay corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 9. Waterside public space types.
As shown in Figure 13, the D/H value of the main street is greater than that of the branch streets as its width is considerably greater (though there is little difference in building height between the main street and branches). Based on the standard deviation, the D/H values of the main street buildings fluctuate relatively substantially and the spatial scale changes are richer than those of the branches.

\[ X_{D/H} = \frac{D}{H} \]

\[ D = \frac{(d_1 \times a_3 + d_2 \times a_4)}{(a_3 + a_4)} \]

\[ H = \frac{(h_1 \times a_1 + h_2 \times a_2)}{(a_1 + a_2)} \]

4. Activity elements

4.1. Upper shelter

Upper shelter refers here to the movable parts above Shantang Street (Figure 14), which hide the street space and directly affect the visual openness of the area. Visual openness is an important index for evaluating space. Jeong and Furuya (2003) divided the visual field into architecture, interior, exterior, and sky factors to study the spatial characteristics of a colony by evaluating visual...
openness. The upper shelter elements of Shantang Street were divided here into attached and detached categories. Attached elements are sunshades, advertisement boards, clothesline poles, air conditioning units, and other features attached to the exterior walls of buildings. Detached elements are trees, mobile parasols, mobile stalls with sunshades, and other features not in direct contact with the exterior walls of buildings.

Upper shelter influences the visibility of the sky to people standing on the street. Sky visibility is introduced here as an indicator of the impact of street upper shelter. An 8-mm lens fish-eye photo was taken at 5-m intervals while standing in the middle of the street and facing its front. The fish-eye photos were then processed and plotted into solid angle images composed of sky, ground, buildings, openings, upper shelter, and overflow for the purposes of this analysis (Jeong and Furuya 2003) (Figure 15). The area ratio of the sky was taken as the sky visibility. The sky visibility of each street unit is the average value of sky visibility in all the fish-eye pictures taken for that unit (Figure 16).

The main street has considerably higher sky visibility than the branch streets. The variation amplitude of sky visibility is also higher in the main street than the branches.

\[
Y_{\text{sky}} = \frac{S_{\text{sky}}}{S_{\text{round}}}
\]

- \(S_{\text{sky}}\): Sky area in solid angle
- \(S_{\text{round}}\): Total area of solid angle

4.2. Commercial overflow

Small stores on Shantang Street are spontaneous. To effectively display goods and expand their commercial space to the greatest reasonable extent, merchants place shelves, tables, chairs, advertisement boards, and other items onto the street. Commercial overflow refers to this behavior. Commercial overflow has created a variety of store front spaces thus increasing the richness of the street. Here, the commercial overflow of Shantang Street was divided into guiding type, expansion type, stall type, and window type (Figure 17).

The projection influence scope of each type of overflow was defined based on a basic map (Wang et al. 2019) (Figure 18). The degree of commercial overflow was defined as the sum of the projection influence scope of all commercial overflow items on the street divided by the street area (Figure 19). The results show that there are no significant differences in the degree of commercial overflow between the main street and the branches, but that the commercial overflow of branches does fluctuate considerably.

\[
Y_{\text{commercial overflow}} = \frac{S_{\text{commercial overflow}}}{S_{\text{unit}}}
\]

- \(S_{\text{commercial overflow}}\): Sum of the projection influence scope of all commercial overflow items on the street
4.3. Life overflow

In addition to commerce as described above, the overflow of items to the street is attributed to residential life. Many personal items (e.g., bicycles, tricycles, unused goods, furniture, household appliances, water channels, sanitary appliances, plants, clotheslines) occupy streets in the target area; the overflow of these items is referred to here as life overflow (Figure 20).

Life overflow was quantified in the same way here as commercial overflow. The degree of life overflow was defined as the sum of the projection scope area of life overflow items in the street unit divided by the street unit area (Figure 21). The life overflow of the main street is significantly lower than that of the branches, indicating that residents are more accustomed to spilling over onto branches rather than the main street.

$$Y_{\text{life overflow}} = \frac{S_{\text{life overflow}}}{S_{\text{unit}}}$$

$S_{\text{life overflow}}$: Sum of projection influence scope of all life overflow items on the street.
Tourists in the target area were counted over four days, four times per day (9:00, 12:00, 15:00, and 18:00). Multiple persons stood in the middle of the street at an interval of 5 meters and took photos while facing the street front. The average value of the 16 statistical results of the number of people in each street unit was defined as the number of tourists per unit street, and then was divided by the area of the unit street to calculate tourist density. The average tourist density values of the main street and the branches are similar, but the tourist density of the main street is relatively uniform while that of the branches fluctuates considerably. The number of people in the area on weekends is significantly larger than that on weekdays. Tourist density is highest at 9:00 am, then begins to decline; this value is smallest at 15:00 and begins to increase again at 18:00 (Figure 22).

**Figure 19.** Results of the commercial overflow.

<table>
<thead>
<tr>
<th></th>
<th>Main Street</th>
<th>Branch Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.0258</td>
<td>0.0269</td>
</tr>
<tr>
<td>σ</td>
<td>0.0010</td>
<td>0.0277</td>
</tr>
</tbody>
</table>

**Figure 20.** Life overflow types.

**Figure 21.** Results of the life overflow.

<table>
<thead>
<tr>
<th></th>
<th>Main Street</th>
<th>Branch Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.0679</td>
<td>0.1704</td>
</tr>
<tr>
<td>σ</td>
<td>0.0855</td>
<td>0.2094</td>
</tr>
</tbody>
</table>

**5. Tourist density**

Tourists in the target area were counted over four days, four times per day (9:00, 12:00, 15:00, and 18:00). Multiple persons stood in the middle of the street at an interval of 5 meters and took photos while facing the street front. The average value of the 16 statistical results of the number of people in each street unit was defined as the number of tourists per unit street, and then was divided by the area of the unit street to calculate tourist density. The average tourist density values of the main street and the branches are similar, but the tourist density of the main street is relatively uniform while that of the branches fluctuates considerably. The number of people in the area on weekends is significantly larger than that on weekdays. Tourist density is highest at 9:00 am, then begins to decline; this value is smallest at 15:00 and begins to increase again at 18:00 (Figure 22).
6. Correlation between street spatial elements

Store density, facade opening degree, water proximity, and D/H elements were next input as $X_{\text{basic}}$ data while commercial overflow, life overflow, and sky visibility elements were input as $Y_{\text{activity}}$ data. Canonical correlation analysis was then conducted to explore the correlation between the basic elements and activity elements. The results are shown in Figure 23.

One set of canonical variables was significant among these results per statistically significance of $P = 0.001$. The first canonical variable was analyzed accordingly. The canonical correlation coefficient was 0.748, indicating that there is a significant positive correlation between the basic elements and activity elements assessed here, that is, that the basic elements have a great impact on the activity elements. In addition, the canonical variable $X_{\text{basic}} = 0.796 \times \text{store density} - 0.104 \times \text{facade opening degree} + 0.591 \times \text{water proximity} + 0.122 \times \text{D/H}$, and the canonical variable $Y_{\text{activity}} = -0.493 \times \text{sky visibility} + 0.785 \times \text{commercial overflow} + 0.293 \times \text{life overflow}$. Store density is negatively correlated with sky visibility, but positively correlated with commercial overflow and life overflow; a higher store density results in lower sky visibility, higher commercial overflow, and higher life overflow. The facade opening degree is positively correlated to sky visibility and negatively correlated to commercial overflow and life overflow; a higher facade opening degree thus indicates higher sky visibility, lower

![Figure 22. Results of the tourist density.](image)

![Figure 23. Results of the canonical correlation analysis.](image)
7. Correlation between street space elements and tourist density

A multiple regression analysis was performed using tourist density as the dependent variable with the seven sets of data including store density, facade opening degree, water proximity, D/H, commercial overflow, life overflow, and sky visibility as independent variables (Figure 25). The $R^2$ is 0.825, indicating that 82.5% of the tourist density can be explained by the seven independent variables. Facade opening and sky visibility were not correlated with tourist density (Sig. values of 0.289 and 0.427, respectively); store density, water proximity, D/H, commercial overflow, and life overflow were indeed significantly correlated (Sig. values of 0.001, 0.003, 0.007, 0.007, and 0.016, respectively, suggest statistical significance). Store density and commercial overflow values are positively correlated with tourist density. This suggests that higher store density and commercial overflow result in higher tourist density. Water proximity, D/H, and life overflow are negatively correlated with tourist density, which suggests that higher water proximity, D/H, and life overflow decrease tourist density. The absolute values of standardized regression coefficients were 0.531, 0.394, 0.293, 0.407, 0.322, respectively, indicating that store density has the greatest impact on tourist density followed by commercial overflow, water proximity, life overflow, and finally, D/H. The total absolute value of the standardized regression coefficients of the basic elements was 1.218 and the total absolute value of the standardized regression coefficients of the activity elements was 0.729, which indicate that the basic elements have greater impact on tourist density than the activity elements.

8. Conclusions

The spatial elements and tourist density of a target area in Suzhou, China, were quantitatively evaluated in this study. The correlation between basic and activity elements, as well as the correlation between the spatial elements and tourist density, were investigated.
via canonical correlation and multiple regression analyses. The conclusions can be summarized as follows.

1. Tourist density in the target area varies significantly within a given day, reaching its maximum at 9:00 a.m., declining at 12:00, reaching its minimum at 15:00, and starting to increase again at 18:00. The tourist density in a given day is affected by the type of commerce available and the weather. There are numerous food shops on Shantang Street, and hot weather at noon, causing significantly more tourists in the morning and evening than mid-day. The tourist density on weekends is significantly greater than that on weekdays, which is in line with the characteristics of general commercial streets. There are no significant differences in tourist density between the main street and branch streets.

2. There are differences between the main street and branch streets in store density, facade opening degree, water proximity, D/H, sky visibility, and life overflow; there is no significant difference between street types in commercial overflow. Branch streets have higher store density, water proximity, and life overflow than the main street. The mains street has higher facade opening degree, D/H, and sky visibility than the branch streets.

3. There is a set of canonical variable pairs with significant correlations between the basic elements and activity elements with Sig. = 0.001 and canonical correlation coefficient of 0.748, indicating that the two sets of elements are closely correlated. The basic elements, inherent and pre-existing, can affect the activity elements. Merchants in the area set up awnings and sale items in the space in front of their stores to attract customers, resulting in greater store density, lower sky visibility, and more overflow. When there is a large openness of the facade, merchants seeking to emphasize the indoor space desire passers-by to directly see inside their store rather than being attracted by items overflowing onto the street from store. Thus, greater facade opening degree results in higher sky visibility, lower commercial overflow, and lower life overflow. Parts of Shantang Street with high water proximity often have a wide open spaces. Canopies set up to create space also create more overflow. When the D/H is larger, the space is more open, but people are more likely to set up upper shelters to block sunlight and divide the space, driving down sky visibility. Similar to open spaces by the water, open streets also promote overflow.

4. Facade opening degree and sky visibility are not correlated with tourist density. Store density, water proximity, D/H, commercial overflow, and life overflow are significantly correlated with tourist density. Store density has the greatest impact on tourist density followed in order of intensity by commercial overflow, water proximity, life overflow, and D/H. Store density and commercial overflow are positively correlated with tourist density, indicating that these elements are attractive to tourists. This is in line with the laws of commercial streets and also confirms that merchandise placing goods in front of stores can attract customers. Water proximity, D/H, and life overflow are negatively correlated with tourist density, indicating that they have inhibitory effect on tourists. The inhibitory effect of water proximity on tourists is inconsistent with the richness of public activities in Suzhou’s waterside space in the past. However, the decline of Suzhou waterway traffic, the low utilization rate of the waterway, the poor sanitary environment of the waterside area, and a general unwillingness to stay by the river account for this. Tourists tend to prefer spaces with lower D/H, and fewer visitors go to wide spaces. In terms of life overflow, excessive life overflow delimits private areas and inhibits tourists. The effects of the basic elements on tourist density were also found to be altogether stronger than those of activity elements.

9. Discussion

9.1. Research generalization

Compared with European streets, Asian streets often have obvious secondary contours. This is especially true in traditional districts created after the bottom-up transformation in China. Additional activity elements are an important part of street space, and Shantang Street is a highly representative example.

Spatial elements were divided in this study into inherent basic elements and additional activity elements, which is inspired by scholars such as Ashihara Yoshinobu. Other streets can be observed similarly. Although individual factors (such as water proximity) are not available in all streets, D/H, store density, facade opening degree, commercial overflow, life overflow, and upper shelter are all common spatial phenomena in this type of street. The method used in this study to divide spatial anatomy into different elements can be applied to further research of this type of street, such as analyzing the differences of streets in different areas in terms of basic elements, activity elements, and correlations.

9.2. Characteristics of bottom-up transformation present in this study

Compared with other areas in Shantang Street that have been planned under government standards, the spatial elements of the target site are more abundant, especially in the areas of store division, commercial overflow, life overflow, and upper shelter. This is an effect of bottom-up transformation. The results have shown that space elements interact with each other. In the context of bottom-up transformation, life space is closely integrated with commercial space. This is an
interesting phenomenon that is consistent with the inherent logic of the natural growth of space.

However, the shortcomings are also very obvious. Bottom-up transformation is prone to lack of management and the consequences of messy environments. For example, messiness has driven down the vitality of the waterside space resulting in significantly lower tourist density.

9.3. Problems and prospects

This research was conducted to explore spatial characteristics, tourist density characteristics, and correlations from objective phenomena such as spatial elements and the number of tourists. The evaluation indicators were secured mainly by surveying and mapping data. However, there was no survey of individuals’ subjective experiences (such as the use of questionnaires to gather self-reported evaluations in the street space). In the future, a questionnaire can be used as the main research method or combined with the method used in this study for comparative research.

The influence of the axis of the sun can also be introduced in subsequent studies, especially in multidirectional street studies. Further, the effect of spatial characteristics on tourist density was investigated in this study, but the factors that affect tourist density are not restricted to spatial elements, they also include commerce type and social environment, which can be introduced in subsequent studies to enrich the regression model.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Natural Science Foundation of China [Grant ID:51978616].

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Annotation

(1) Ashihara Yoshinobu proposed primary contour as the inherent form of the building, inspired by him, the basic elements refers to the spatial elements that appear in the street space upon the completion of the construction project, (e.g., the street pattern, the building itself) which fundamentally comprise the street space and are characterized by antecedent existence and relative stability. Store density, facade opening, water proximity, and D/H were selected as the basic elements in the street space of Shantang Street, because these elements exist inherently and will not be easily changed in the future for a period of time. They play a fundamental role in shaping the street space and are the most obvious basic elements of the target area.

(2) Ashihara Yoshinobu proposed secondary contour as the space form formed by the protrusions and temporary additions of the outer wall, inspired by him, the activity elements refers to the additional spatial elements related to commercial or life activities in the street space. They are dependent on the basic elements and have high variability. Upper shelter, commercial overflow, and life overflow were selected as the activity elements in the street space of Shantang Street because these elements are temporary and variable. For example, the stalls in front of the store, clothes put out to dry, furniture, awnings, and other such items can be displayed, retracted, or moved to various positions. These are the universal activity elements in the target area.

(3) The Statistical Package for the Social Sciences (SPSS) is a modular data management and analysis application created and produced by SPSS, Inc., in Chicago, Illinois. (Nie and Norman 2003). Canonical correlation and multiple regression tools in SPSS were used in this study.

(4) The canonical correlation analysis is a method of calculating a canonical variate for each variable set by obtaining a linear combination of two sets of a variable group X containing p variables and a variable group Y containing q variables. This is a method for examining the relationship between variable sets by finding
a variable of a linear combination that maximizes the product moment correlation (canonical correlation) between canonical variables. In other words, a variable set that takes a high canonical correlation is interpreted as having a high degree of similarity in spatial arrangement, and can be said to have high commonality (Liu, Nakamura, and Konishi 2004; Masahiko 2018).

(5) Multiple regression analysis is a statistical method for studying the relationship between a single dependent variable and one or more independent variables (Allison 1999). It is a statistical analysis method that works by establishing a linear or non-linear mathematical model quantitative relationship between multiple variables and subjecting sample data to analysis.

References


