

# Analysis Method of Historical Urban Fabric for Urban Design

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**Abstract:** In the urban historical area regeneration, the key task of urban design is to inherit the characteristics of the historical fabric. Thus urban design makes guidelines to control the street structure/space, buildings layouts and buildings form/type, etc. according to the understanding of the morphological characteristics of the fabric. In this process, urban morphology plays a very important role in providing a scientific and systematic approach to the representation and explanation of the historical urban fabric. However, the subject and even the object of urban morphology are different from urban design. The analysis method of urban morphology is not enough to provide the most direct basis for the design decision of urban design. Therefore, taking the historical area in Nanjing, China as the case, the paper proposes a method to analyze the characteristics of the fabric at three hierarchies: street structure and space, plots and buildings layouts, building type and form. Morphological characteristic features of each hierarchy are selected, mapped and quantitative analyzed. Through quantitative analysis, the paper puts forward some characteristic indexes which can be used in urban design.

## 1. Introduction

Urban design shall inherit or continue the texture morphological features of historical urban blocks through physical forms in the renovation process, which is one of its major missions. For this reason, urban design guidelines were worked out to supervise street structure and space image, manage the modes by which buildings are organized, and monitor building volume and texture types. Urban morphology provides scientific and systematic methods and knowledge for urban design.

It makes a deep introduction to the morphological features of historical textures and their variants from the perspective of streets, blocks, plots and buildings by means of a systematic approach. Whitehand, Gu *et al.* discussed the applicability of morphological methods including plane analysis and type variants to describe the texture of historical Chinese cities in a series of morphological studies on the texture of historical Chinese blocks (Whitehand and Gu, 2007; Gu *et al.*, 2008; Gu and Zhang, 2014; and Whitehand *et al.*, 2016). Based on the typological theories of the Italian school, Li and Gauthier made a case study on the old blocks in Guangzhou, China, where a morphogenetic process was revealed after analyzing building types and their variants, and identi-

ifying relationships between issue configurations, inherited geomorphological conditions and old settlement patterns (Li and Gauthier, 2014). Such studies focus on architectural types involved in the development process of architecture.

In addition, the urban morphologic methodology is based on the epistemology that types are dynamically changing forms resulting from social, cultural, economic and other conditions in different historical periods. A host of studies were thus made to explore why morphological features were formed in different periods. The study mentioned in the previous paragraph is within the framework of morphology, involving such exploration to some extent. But some studies are beyond the historical morphological framework because they were not intended to interpret morphology and morphological changes as in the above works. Certain studies may be grouped together based on the same objective to analyze the formation causes in the historical process, including typical cases of the influence of historical social systems and family concepts on architecture and texture types (Ding Qingjun, 2008; Yong Zhenhua, 2010).

Both descriptive studies and cause analyses are objective works on forms or form evidence based on historical facts and conducted in the historical environments. However, a direct use of their findings is not suitable in urban design practice because knowledge of what the history was and how it was formed will not give an exact picture of the future. In this context, Han Dongqing proposed the third analysis method – formal interpretation. Compared with the former two, it based itself on morphological descriptions to turn it into a graphical mechanism of morphological generation, preparing for the formal generation of future urban design (Han, 2013). A formal interpretation of historical urban texture is to provide possible elements for future texture variants after distinguishing the morphological features and causes of historical architecture and texture. This is a move to inherit historical humanities while adapting to contemporary society, economy and culture. The paper was designed to explore methods for the formal interpretation of historical urban texture oriented to urban design.

## 2. Methodology

### 2.1. *Research Subject*

Urban fabric is the physical aspect of urbanism, emphasizing building types, thoroughfares, open space, frontages, and streetscapes but excluding environmental, functional, economic and socio-cultural aspects.

### 2.2. *Descriptive hierarchy and objects of urban morphology*

In urban morphology, the word that most like urban fabric meaning is urban tissue. In Caniggian analysis, the urban tissue is the ensemble of aggregated buildings, spaces and access routes. Urban morphology emphasizes the cognitive hierarchy of street/block/plot/building. The primary elements of the urban fabric are plot, street, constructed space, and open space. The urban fabric consists of the relationships between the different elements (Levy, 1999). Caniggia, on behalf of the Italian school sorted architectural types that constitute urban texture and contribute to texture variants and changes in types into a descriptive hierarchy. For the British school with Conzen as a representative, texture components in the texture component plan should include street and street systems, plot and plot combinations and building block planes. In summary, the descrip-

tive hierarchy was composed of streets, plots, external spaces and building types (building planes, structures, materials) (Kropf, 2014) and their induction and differentiation.

### *2.3. Graphic technique of urban morphology – Plan analysis*

According to Conzen (Conzen, 1960), the definition of plan is the “topographical arrangement of an urban built-up area in all its man-made features”, comprising three complexes of plan elements, streets, plots and the block plans of buildings. Street boundary, plot boundary and building boundary were included in the basic elements used in the plan analysis. The plane components are commonly re-described by zoning and typing methods with reference to analysis, classification and induction of these plane features and based on plot patterns, building patterns, and the identification of invariants in morphological variants (such as fringe belt). Alniwick led the English school to create a mature mapping method for plan analysis (Conzen, 1960).

### *2.4. Exploration of Graphic Elements*

The graphic technique in morphology is descriptive, so that the same graphic technique cannot be used in different designs to deduce architectural forms. For example, a certain area has a certain plot pattern, but nothing can determine whether this pattern should or should not (can or cannot) continue. Therefore, the paper was completed by the method of first selecting a possible plan (or space) elements according to the morphological features of historical urban texture, then illustrating and quantifying the characteristics of historical texture elements and finally verifying the possibility of applying quantitative features into the design; which elements are worth describing and which features are worth preserving and continuing in the historical texture renovation; and which elements can be described and transformed are two major issues to be addressed. The former issue has almost been given a consensus in a large number of documents, which is the basis of the latter. The latter still leaves room for open discussions.

## **3. The Goal of the Urban Design in the Historical Urban Fabric Regeneration**

In the process of the protection and regeneration of historical urban fabric, urban design takes on the task of form control, which is embodied in three levels: the whole fabric (view from the high point), building type and the public space. The overall goal of the urban design is, first of all, to continue historical characteristics, to determine how to continue and which forms and spatial images deserves to be conserved. Meanwhile urban design needs to take into account more stakeholders and formulate distribution strategies and implementation methods for morphological objectives.

There are generally several modes in the existing urban design. For example, in order to preserve the integrity of the historical urban fabric, there are three strategies. The first one is to completely regenerate new fabric based on the understanding of the historical fabric characteristics. The second one is to mend the fabric according to the preserving historical buildings. The third one retains the fabric characteristics, but increase the height of the buildings. For all these practices it is needed to summarize the morphological characteristics of the historical fabric, which includes the understanding and interpretation of the street structure, the building type, streetscape, and etc.

From the analysis of the goal of urban design, it can be seen that urban design mainly controls the appearance of the historical urban fabric. The function of the buildings should be

Table 1. *Urban design strategy and the morphological knowledge it needs.*

	Strategy 1	Strategy 2	Strategy 3	Goal of the urban design	Morphological Description/ explanation /interpretation
The integrity of the fabric	Completely regeneration	Height unchanged, partly regeneration	Height increased, regeneration	Historical fabric to be continued and identifiable	Morphological Characteristics of Fabric Structure Unit Relationship with plots
Building Type	Complete change in plan; Little change in roof	Little change in plan and roof	Change in plan and structure	Match with the fabric; meet the requirement of the public space and actual function	Architectural typology and design
Open Space	The space left after maximizing the residential area	Public space reorganization and expansion	Public space reorganization; Operation of the underlying business	Conform to historical spatial imagery; evoke memory	Streetscape characteristics Building detail, material

adapted to the contemporary usage while the appearance conforms to the characteristics of the fabric. So the interpretation focuses on the characteristics of the fabric, from the site plan perspective as well as the streetscape one.

#### 4. The Morphological Characteristics of the Historical Urban Fabric

##### 4.1. *Building Type*

###### *Ridge of a Roof*

A ridge of a roof is the peak where two opposing roof planes or sides meet (Figure 1). The right ridge is the highest point on a roof, represented by a horizontal line where two roof slopes intersect, seen from the front elevation of the building. The main ridge is also called “Large Ridge” as it is the largest, longest and most prominent among the ridges of a building. The roof ridge, especially the large ridge, is the key to a building. The ancient people by convention would take a bath and put on clean clothes to build the ridges of the house on auspicious days, and then throw steamed buns from the beams and step on a ridgetop. The importance of roof ridges may be traced back to the age when buildings were made of wood. Wooden frame structures have long prevailed in Chinese architecture mainly in that it has been recognized as the most reasonable and is a tested technical standard by choice (李允铎, 1982).

### Gable

The exterior walls of old Chinese wood frame buildings only function as an enclosure and partition of internal and external space, but do not bear a load, as a folk proverb stated, “Exterior walls fall but houses do not collapse”. A need for safety is found while constructing external walls or enclosing walls on which windows and doors shall not be opened arbitrarily, so the courtyard for lighting and ventilation shall not be left out. In China, a sole building is flanked by solid gables, a fireproof partition that prevents a fire from spreading quickly.

### Plan layout

The separation of door and hall is the pivot of “the door and hall system” in ancient China, which is a major feature of Chinese architecture. All layout modes have been developed along with this basic principle, which is theoretically derived from the “courtesy” separating the inside and the outside, up and down, guests and hosts (李允鈺, 1982). Doors become the exterior of the building and a representative form; The hall expresses what the house is and is the place where the real function needs to be. While the door and hall system was taken as a convention, sole buildings were abandoned in Chinese architecture. Each suite of “door and hall” refers to a level or section on the plane of the architectural complex, where the scene transits from one to another in an enclosed space. A door is often together with a house, constituting comparable size to a hall in a major building.

In response to the demand of commercial activities, outward buildings have been put up along the street, usually in multi-storey (Along the River During the Qingming Festival), building forms emerged at the historic moment.



Figure 1. Historical photos in the early 20th century.

In the plane organization, buildings rarely merge or centralize, are always separated and scattered. By increasing the number of buildings the plane can be scaled up, but with factors regarding “systematism” and “standardization”, as well as demand for the structure, construction, fire prevention and seismic performance.

### “Bay” and “Rafter”

“Modularity” and “standardization” are common in architectural design, causing the “structural plane” to be almost universal. With a fixed column grid, the number of “bay” and “rafter” is sufficient to show the plane form of a sole building. The part between parallel longitudinal column grids is generally called a compartment or bay, whereas the frame is laid between horizontal column grids and refers to the rafters. Standardized rafters have fixed positions and spacing with rarely random changes and thus can be used to work out the depth of the building.

### Courtyard and Patio

The layout around the courtyard meets the demands for lighting and ventilation and is the most economical solution for combining the enclosing wall with the house. “Door”, “hall” and “corridor” are the three major components in the plane of Chinese architecture, which together enclose the “courtyard”. The “courtyard” is considered as a basic organizational unit in the architectural complex. The scale of an architectural complex is described with “the number of yards and houses” other than by the number of buildings.

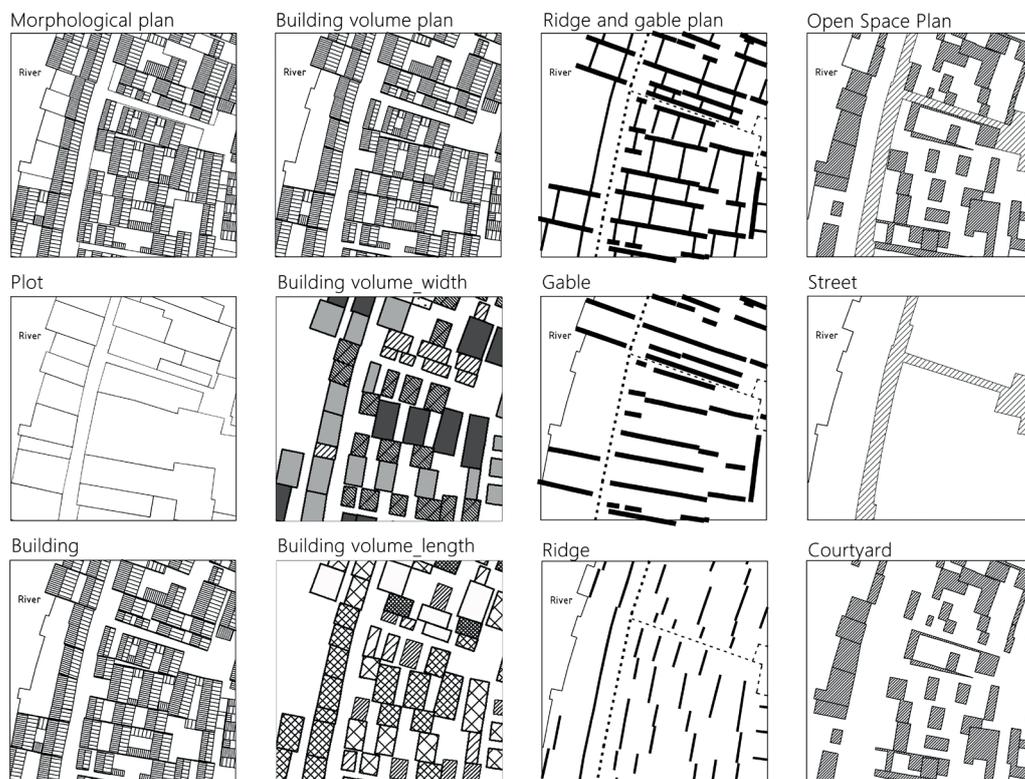


Figure 2. Traditional feature extraction and interpretation.

#### 4.2. Streets/Open Space

Historical Chinese architecture was inclined to linear open spaces, such as streets, roadways, and alleys. “Roads” and “lanes”. A road is created when a series of courtyards are connected in series in-depth. A lane is an auxiliary seamless transfer, forming another system in a well-organized building. It is recommended that the morphological features of streets and lanes in historical texture can be described through street structure, spatial scale (width and proportion), entity elements (interface, node, facility).

Street structure generally refers to the hierarchical organization of main streets, secondary by-lanes, public courtyards and households. The hierarchical organization includes the direction of main streets, the way in which secondary by-lanes are connected with main streets, the density of the secondary by-lanes, the relationship between the public courtyards and the secondary by-lanes, and the density of the public courtyards. Space syntax is a mature way to introduce street structure, except for the lack of accurate dimensions.

#### 4.3. Streetscapes

Miao Pu found that the images of historical Chinese architecture featured “simple context” and “two-dimensional linear composition”. For old architecture and cities, images were composed of “core parts” and “contexts”, among which the core parts often account for a little, while the majority in the images were simple contexts (Miao, 1989). In some images of typical historical cities, a large number of bare exterior walls set off roof cornices and exquisite flower windows. The elements forming the context are similar and unified, but are not purely copies. Looking closely, there are delicate differences, which make the context not monotonous. And the Chinese people place more emphasis on “the form with stories,” who, therefore, attach great importance to the symbols and cultural significance contained in the context. For example, Geomancy, regarded as a culture by ancient China, affects the orientation of the gate, the number of steps, the shape of the plane and other specific architectural forms. It was commonly seen in old images of Chinese architecture.

#### 4.4. Feature extraction and interpretation

The above analysis shows that building volume, ridge, gable, courtyard and so on can become the characteristic elements of historical fabric. In contrast to the plan analysis of traditional urban morphology, these elements can be extracted independently and mapped. Then the length, width, area, density, etc. could be calculated (Figure 2).

### 5. Case studies: Quantitative Description of the Morphological Characteristics

Based on the understanding and extraction of the morphological features mentioned above, the paper tries to extract and illustrate these features, and then quantify them. To do this, the paper selects a typical historical urban fabric of Nanjing City, puts forward a quantitative description of the elements of morphological features, and explores the possibly and feasibility of urban design to continue these elements, based on the 1929 aerial map (Figure 3).

Description and statistics of building volume: Combining the site survey of the existing buildings, the regular bay width of buildings are about 3.6m, 3.3m and 3m, and the horizontal

spacing between rafters is generally 1.1m. Statistics on the sizes of main buildings show that the areas of main buildings stay between 20-140 square meters, 75% of which are mainly 20-80 square meters. Buildings with the façade width of about 9-12 meters take up the highest proportion, corresponding to three bays. Buildings with depth of about 7.7 m take up the highest proportion, corresponding to seven rafters.

Description and statistics of building sequences: Statistics on gable lines show that the lengths of gable lines vary from 2.5m to 73m, of which, 64% are less than 10m, 25% are 10m-30m, and 11% are more than 30m. Statistics on the directions of gables show that 88% of gables are vertical with adjacent roads, with only 12% of them independent of roads. Statistics on distribution locations and their coverage of different types show that the gables of 95.9% tissue are parallel with each other, and consistent with roads, which makes the tissue sequence can be identified, while the gables of only 4.1% tissue are slightly disordered. Gables are distributed in parallel but not entirely homogeneously. The length of the roof ridgeline corresponds to the façade width of the building volume, the roof ridgeline is vertical with the gable line and generally distributed in parallel between two gables, and 97% of roof ridgelines are parallel with the corresponding roads. The result coincides with the result of statistics on gable lines.

Description and statistics of building courtyard: Statistics on the area of courtyards in this sample area show that the average area of courtyards in combination with buildings reaches 50 square meters, with the home garden area of 1200-3000 square meters. In addition to home gardens, there are 192 courtyards distributed in an average area of 1 square meters in the building-covered area.

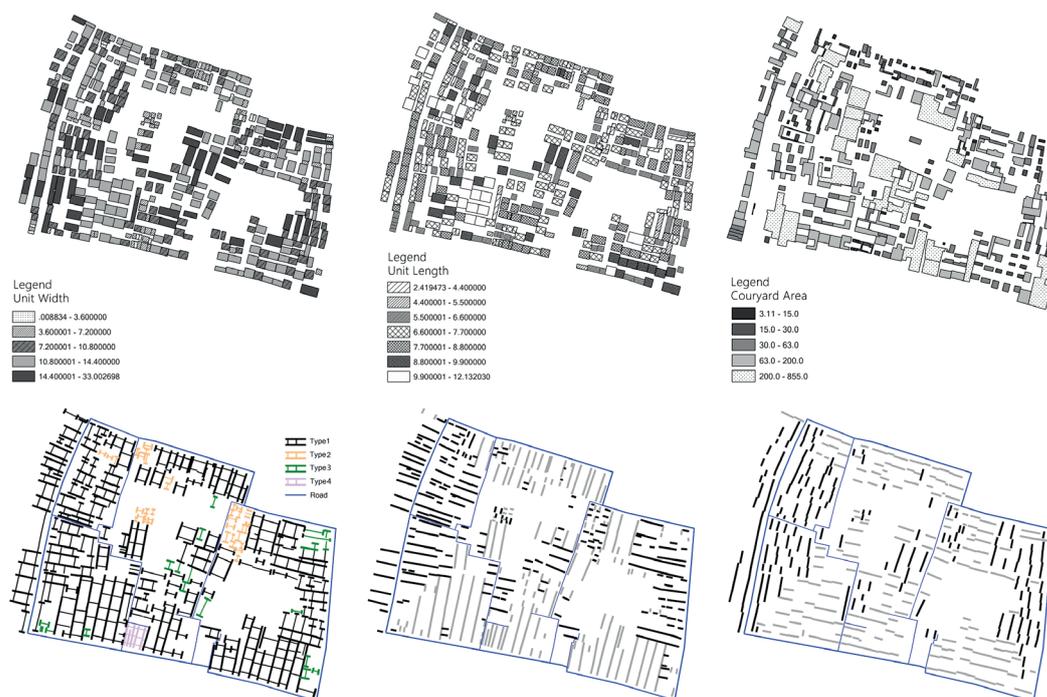


Figure 3. Case studies of typical historical urban fabric in Nanjing, China.

## 6. Discussion/Conclusion

The interpretation of urban fabric provides basis and knowledge for urban design. Different from description and explanation of the urban form, the interpretation reveals the logic of the form, tries to classify them, describes the relationship between the forms and tries to quantify the characteristics to provide a basis for the later urban design. Chinese historical urban form has unique morphological characteristics, which are the results of culture, politics and economy. The regeneration of historical urban fabric does not mean to give up modern life to return to the past time, but rather to preserve the traces of the history and arouse people's memory through the inheritance of historical "images". In this paper, a number of morphological elements are proposed, illustrated and quantified to come into being some indicators, through which urban design can control the form more effectively. This paper puts forward and demonstrates these elements, the effectiveness of these indicators is worth exploring in the follow-up research. Meanwhile how to translate them into the forms under the new social, economic, technical and other conditions will be the further design question.

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