An Experimental Approach to Mapping the Urban Street Spatial Form

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Introduction

The street space plays an important role in urban fabric studies since it not only expresses the characteristics of urban form in the meso-level, but also reflects the features of spatial form in the micro-level (Ding & Tong, 2011). Especially the street spatial form has the decisive influence on the urban microclimate (Oke, 1988; Steemers et al, 1997; Ratti et al, 2003). However, the exact character of the relation between the street spatial form and the microclimate remains unsolved because of the differences in buildings heights and body masses, specifically in the heterogeneous urban fabric. One of the most difficult factors is the quantitative description of the street spatial form. Neither the macro-indicators (Floor Area Ratio, Building Density) nor the micro-indicators (Shape Coefficient, Building Height, Height/width Ratio) could exactly represent the urban spatial form. The 3D model of the buildings is still the principal way to be used in the computation of the fluid dynamics of the wind or the exchange of energy. This method is usually used to evaluate the design, but can't be used to aid the design because of its complexity.

Sky view factor (SVF) is a distinctive quantitative indicator which can effectively describe the street spatial form regardless of the complexity of the street space (Watson & Johnson, 1987). It also has a close relationship with the urban heat island effect (Bourbia & Boucheriba, 2010). Based on the similar principle of SVF, this research sets up a new approach to mapping the street spatial form. The research converted the complex 3D street space into serial sequential lines based on one viewpoint. These lines have the attributes (length, area, shape) which can be described with quantification. Therefore, the character of the different spatial form can be extracted. The new mapping approach can be used to establish a quantitative

descriptive system of urban morphology which not only is helpful to optimize the urban spatial form, but also is helpful to improve the quality of urban microclimate.

Method

Modeling the Street Space in AutoCAD and Exporting the Data

Firstly, the street model is built in AutoCAD. In the model, the buildings along the street were separated by its form and height. The outline of the building with the same height was drawn with a closed Polyline. The thickness of the Polyline was set as the height of the building. Then the viewpoint was drawn as a Point with the correct elevation (figure 1).

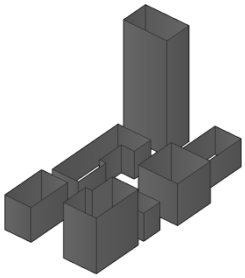

Figure 1: Street space model in AutoCAD

Based on the AutoCAD model, the coordinates of the buildings and viewpoint were exported as two text files. In the buildings file, the format of every line is set as "*X Y Z M*". *X* and *Y* are the coordinates of the vertex of the building plan, and *Z* is the elevation of the roof. *M* is the index of the building. The vertexes of one building have the same value of *M*. The vertexes of one building were sorted by their order in the Polyline. In the viewpoint file, the format of the line is set as "*X Y Z*" to represent the coordinate of the viewpoint.

Generating the Street Space Outline Diagram

In Matlab, the buildings file and viewpoint file were imported, and the scan resolution *n* was set.

Starting from the viewpoint, a series of rays was generated. The angle between two rays is *n* degree. For every ray, the intersection points between the ray and the

building's plan were extracted. The *Z* coordinate of the intersection point was coming from the height of the building.

The horizontal distances between the viewpoint and the intersected points were calculated and the minimum distance was recorded as *d*. The angles of elevation between the viewpoint and the intersected points were calculated and the maximum angle was recorded as θ.

Setting the angle of rays as X-axis, the distance as the positive Y-axis, the angle of elevation as the negative Y-axis, the Street Space Outline Diagram (SSOD) was generated (figure 2).

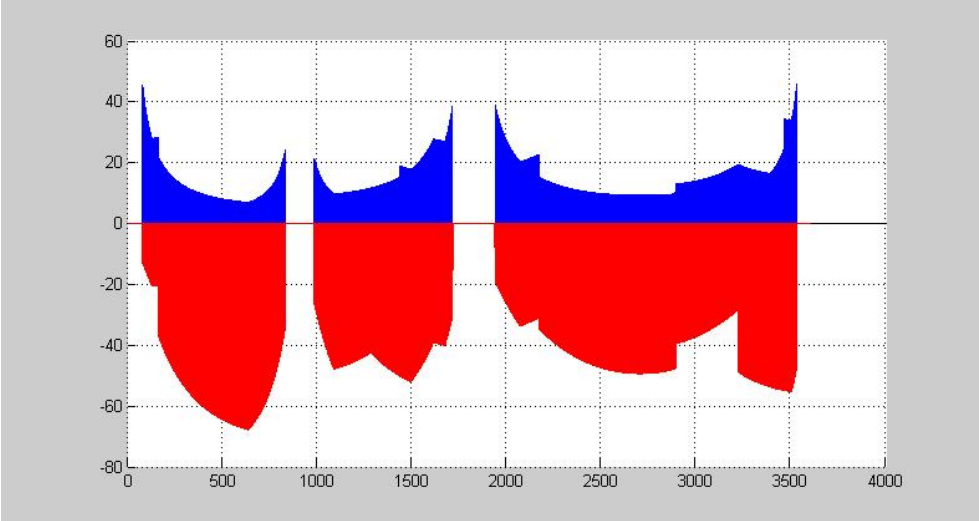

Figure 2: Street space outline diagram (SSOD)

Because of the mapping method, the distance and the angle of elevation have the relationship through the angle of the ray. The SSOD can also be used to calculate the height of the buildings and the width of the street. Then the street outline also can be regenerated (figure 3).

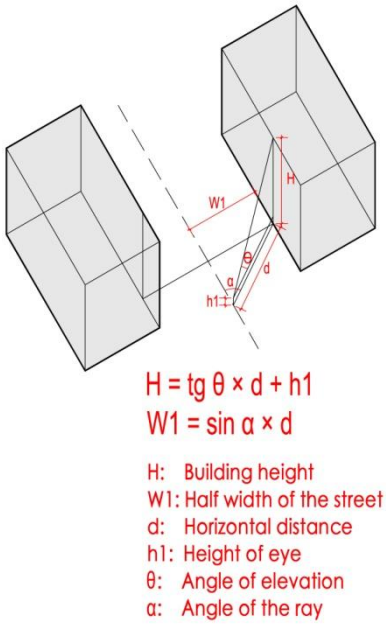

Figure 3: Formula used in regenerating the street outline

Case study

We take Hanzhong Road as the study area, which is located in the Central Business Distract of Nanjing City. The form of this street is irregular and very complicated (figure 4). The heights of the buildings along the street are also variable (figure 5).

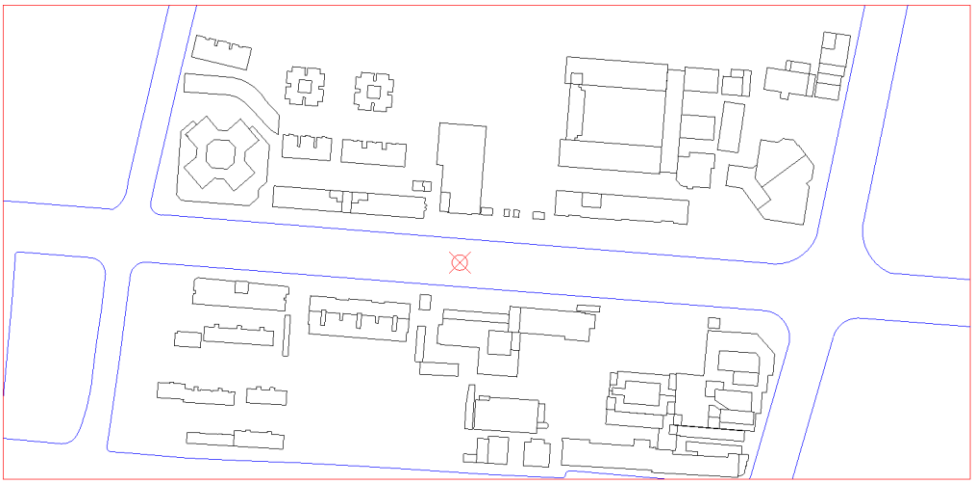

Figure 4: Plan of Hanzhong Road, Nanjing

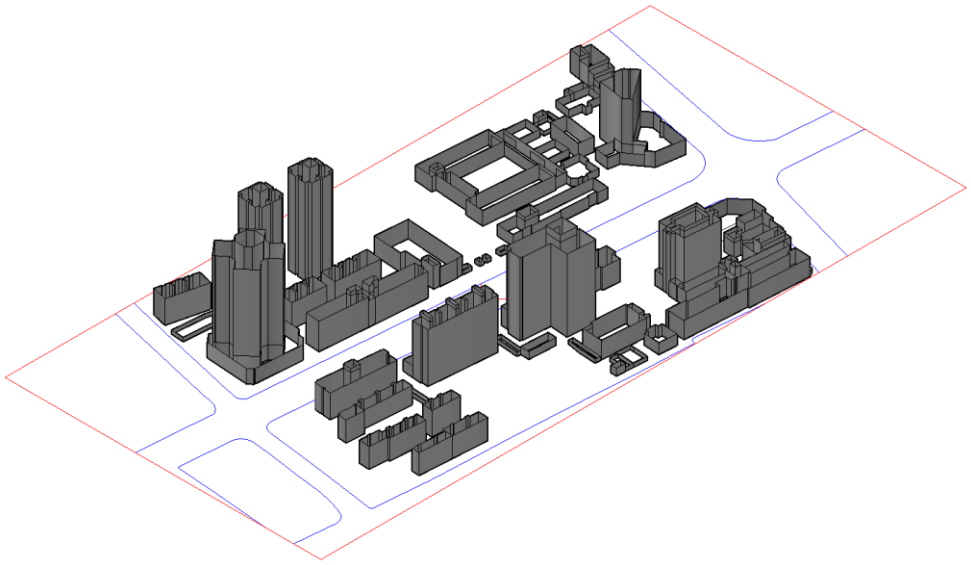

Figure 5: 3D model of Hanzhong Road, Nanjing

After building the model in AutoCAD, the data of all buildings and viewpoint were exported. Then the SSOD was generated in Matlab (figure 6). The blue part represented the horizontal space of the street based on the viewpoint, and the red part represented the skyline of the street based on the viewpoint. In the diagram, the profile of the two zones showed the street spatial form, and the areas of the two zones quantitatively describe the characteristics of the street space.

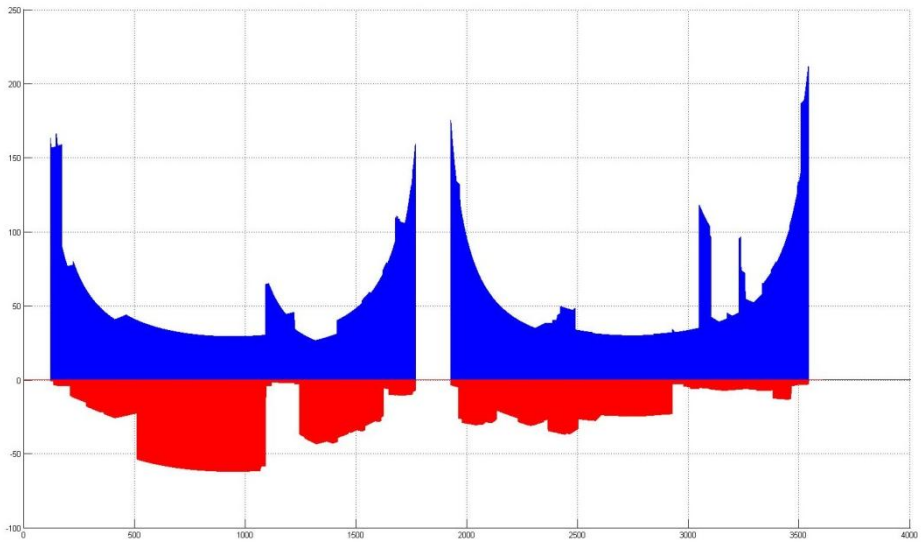

Figure 6: SSOD of Hanzhong Road, Nanjing

Conclusion

This is still an ongoing study. However, the results already obtained shows that, the novel approach to mapping the urban street spatial form is effective and has more potentialities. It could be used for quantitative describe the street space with the attributes of the graph in the diagram such as length and area. It is very easy to calculate the SVF through the diagram. It could also be used to regenerate the original street outline. Therefore, SSOD bridges the gap between the form and the quantification of the street space.

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