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A quantitative study of urban form and its spatial character

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Abstract

Understanding urban morphological processes can help architects and urban designers in urban design, especially in urban renewal projects. Since urban form and urban space are closely integrated, the morphological changing process inevitably causes changes in the spatial characteristics that are of concern to urban designers. This study focuses on analysing the relationship between the building interface and the space between buildings. We have made a tool to quantify the characteristics of urban space by setting viewpoints in the urban space, which can measure the distances and height angles from the viewpoints to the surrounding building interfaces. To verify the effectiveness of the tool, two urban areas in Nanjing are selected for case studies. One is an area located in the centre of the city that has undergone tremendous changes and has many high-rise buildings. The other is an area located in the historic conservation area that has changed little and has many traditional houses. Comparing the two areas with quantitative indicators of spatial characteristics, it is found that different urban forms have different spatial characteristics. Based on an in-depth study of the morphological evolution process and social background, four morphological periods are selected for the morphological study of the two areas. By comparing urban morphological processes and spatial characteristics changing process of the areas on the same timeline, the impact of urban morphological change on urban spatial characteristics in different areas and the role of spatial characteristics indicators are analysed. Comparing the two areas with quantitative indicators of spatial characteristics, it is found that different urban forms have different spatial characteristics. In the measurement of the area in the historic conservation area, some spatial indicators that can be used to control the spatial characteristics are found, which are useful for the urban renewal of the historical area.

Keyword: *urban morphology, urban space, quantitative method, spatial characteristics*

Introduction

Understanding the urban morphological process could help architects and urban designers in urban design, especially in urban renewal projects. There are different methods to describe the urban morphological evolution process. One traditional approach is based on various planimetric representations of urban forms, for example, by analysing urban ground plans that contain complexes of plan elements such as streets, plots, and buildings (Gu and Zhang, 2014). Using the same graphical criteria to depict the urban areas to be studied allows morphological differences to be revealed and morphological evolution to be accurately depicted (Tikhonova and Beirão, 2020). The overhead view of the urban form can contribute to an accurate description of the urban form as a whole. However, from the perspective of a person or citizen, some elements that are explicitly represented in the ground plan are not perceptible, such as plots that mark land-use boundaries or spaces located in private courtyards. Moreover, this plane-based representation hinders the expression of basic information in three-dimensional urban space.

Since Kevin Lynch proposed his theory in urban spatial cognition in 1960, urban researchers began to focus on the urban form as observed by the human eye, using human perception as a criterion for evaluating the built environment (Lynch, 1960; Filomena, Verstegen and Manley, 2019). His research opened up a new perspective in urban studies, and human perception began to be used as a tool to judge the success of an urban design.

Since urban form and urban space are closely integrated, the morphological changing process inevitably causes changes in the spatial characteristics that are of concern to urban designers. Urban spaces are areas where urban residents can engage in their daily life activities and participate in social interactions. The study of spatial characteristics in the evolution of urban form allows for a broader study of urban morphology. Therefore, it is worthwhile to investigate urban spatial characteristics changing process based on the urban morphological process.

Methodology

Research area

First, a suitable study area needs to be selected. Generally, due to social development and other reasons, the form of an area appears to change rapidly or slowly over time. Therefore, there are two requirements for site selection. One is to have two types of sites, one with rapid changes and one with slow changes. The second is that both have map information available for morphological study in the same period.

Two urban areas in Nanjing, China, are selected as case studies (Figure 1). Both areas are in the old city of Nanjing, and after going through the same historical period, they eventually took on different characteristics of urban form.

The Xinjiekou area, where Area A is located, is at the intersection of the city’s axial roads and was positioned as the commercial centre of the city. In 1953, during the period of recovery and transition after the founding of the country, the urban fabric showed the initial transformation from residential land to the central area of the city. In 1988, during the period of reform and opening up and economic recovery, the government adopted a relatively conservative policy on urban construction, and construction activities became active. However, the original structures and forms of the area were retained. Most of the new buildings were built to fill vacant plots and were mainly multi-storey buildings. At this time, the density of urban fabric reached its highest level. In the last decade of the twentieth century, the development of the market economy and the reform of the land use system, along with the real estate speculation boom and the local government's goal of building an "international metropolis", stimulated urban construction. After the consolidation of plots, high-rise commercial buildings were built one after another. By the year 2000, the original structure and form of the area had changed considerably. Most of the construction work and plot consolidation in the area was completed in the late 1990s, with the post-2000s showing fewer plots and building developments.

Area B, with an area of 13.4 ha, is in the core area of South Old Town, which is a Historic Preservation Area. South Old Town has been the most prosperous residential area and traditional handicraft area in Nanjing since the Six Dynasties and has been home to many historical celebrities, making it a major concentration of historical and cultural resources. Building heights were controlled and the traditional style was required to be preserved. Area B is now a high-end residential and tourist cultural area, known for its traditional residential style that attracts locals and visitors from other places. Therefore, the development of the two areas is completely different.

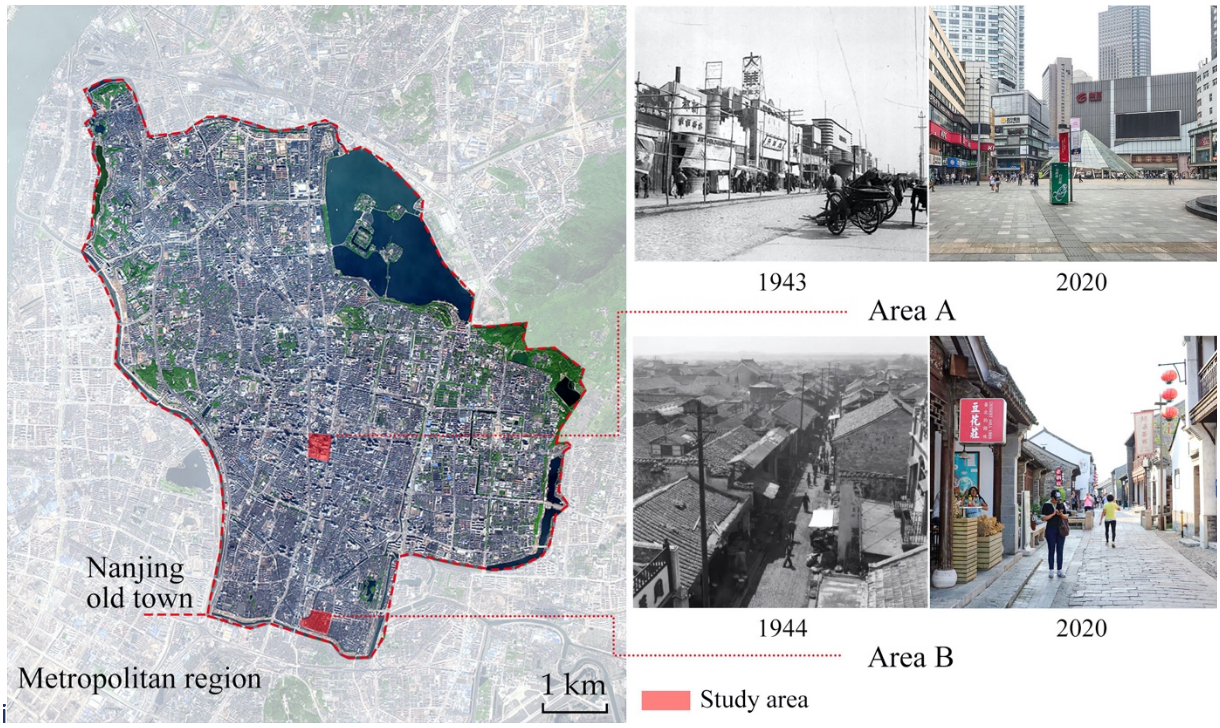


Figure 1. *Location of research area (Source: Google Earth in 2021).*

Plots and street space structure

We first follow the urban morphological study and compare the changes of the plots (Figure 2a). The development of the plots in the central area does conform to the morphological pattern, with the plots of public buildings constantly merging and getting bigger. In the historic preservation area, the plot was initially slow to change due to urban planning constraints and the difficulty of development. Finally, after 2000, a large development project demolished most of the buildings in the area and consolidated the plots. Statistics on the number of plots show that the number of plots in both areas has gradually decreased as the city has grown and capital has become involved. The urban centre has seen the most change. The historic preservation areas changed slowly.

The street space structures are mapped (Figure 2b). For Area A, although the plots were merged, the main streets were still widened according to the past street structure. Some past street structures are still preserved. For Area B, at first, the historic fabric was not changed, and the historic streets were preserved. After 2000, although most of the buildings in the area were demolished and the smaller plots were combined into larger plots, the developer kept the original streets, because of the city planning regulations. We counted the changes in the number of streets. In Area A, the number of streets became smaller as the plots were merged. In Area B, the number of streets remained the same at the beginning. In the final development, most streets were kept, and some streets were added to improve the public nature of the area.

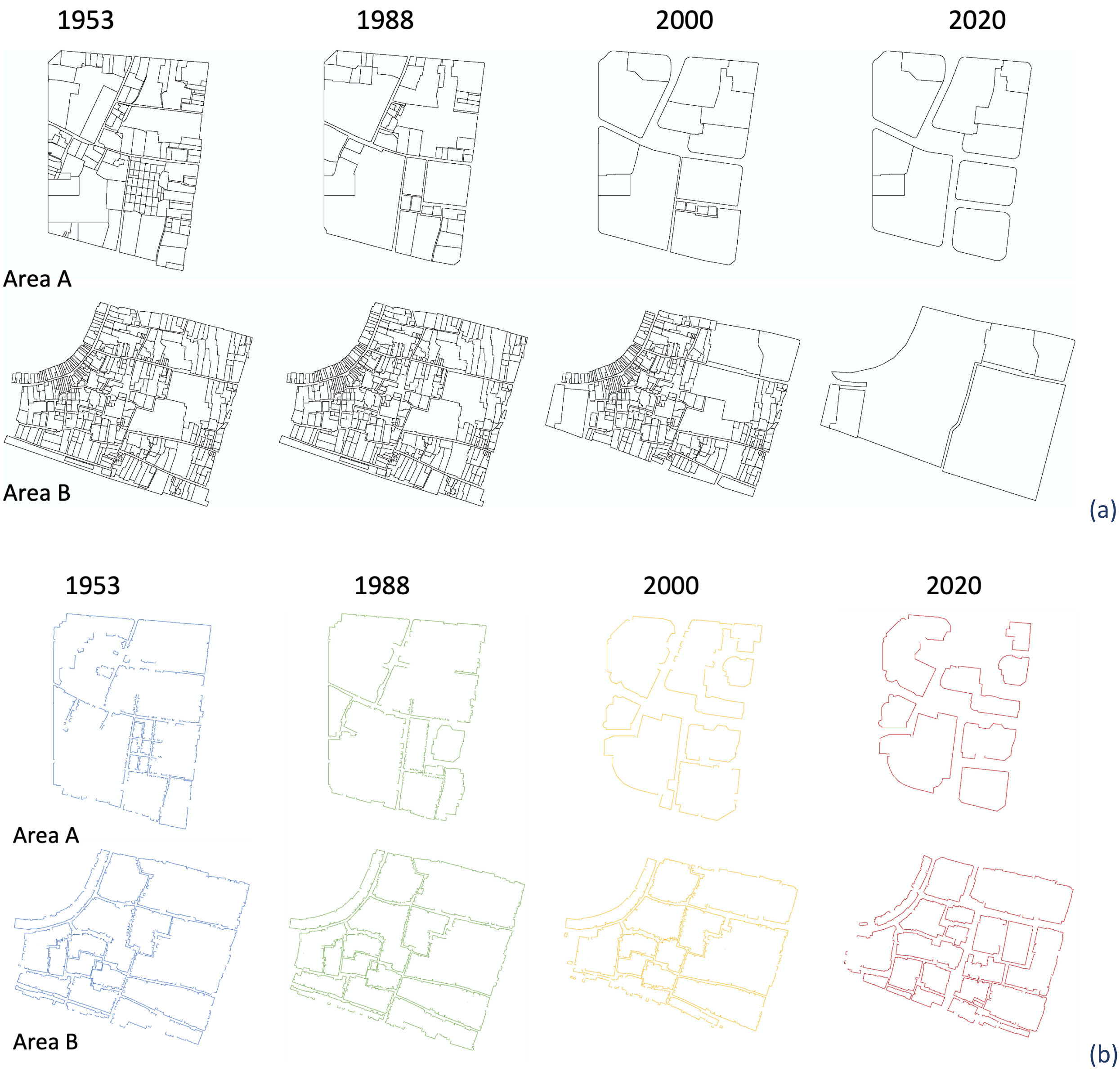


Figure 2. *(a) Plot maps of Area A and B in 1953, 1988, 2000, and 2020. (b) Street space structure maps of Area A and B in 1953, 1988, 2000, and 2020.*

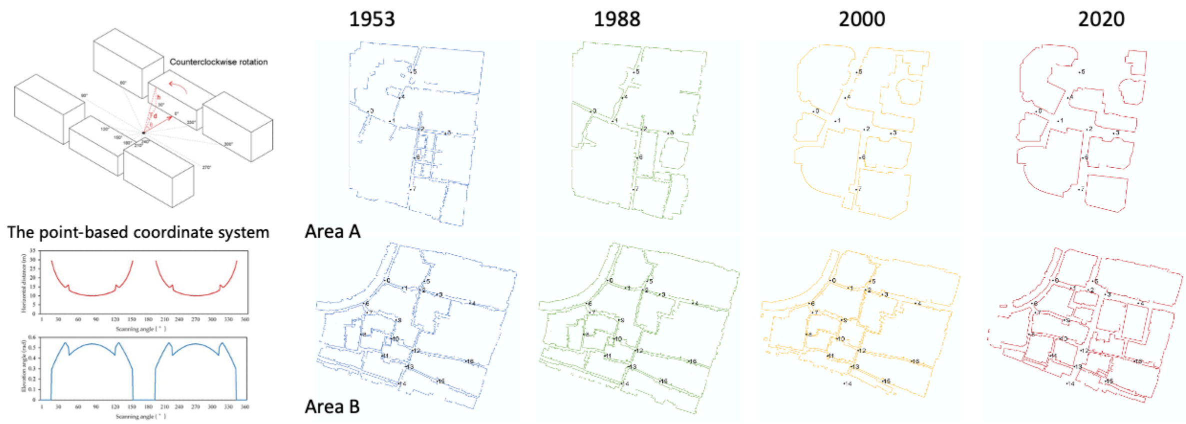
Quantifying spatial characteristics

Traditionally, research in urban morphology is based on observation and representation of the evolution of plan elements such as buildings and plots. In this study, we use an alternative perspective, that of urban space, to study the evolution of urban form. We have made a tool to quantify the characteristics of urban space by setting viewpoints in the urban space, which can measure the distances and height angles from the viewpoints to the surrounding building boundaries (Figure 3a).

There are two reasons for choosing to measure the space by horizontal distances and height angles. One is that based on the two indicators, the location and dimensions of the building boundaries that enclose the space can be known. Second, the two indicators can relate to people's spatial perception to a certain extent. Horizontal distance can reflect the width of the street. Space with low height angle value gives people the feeling of spaciousness, while space with high height angle value gives people the feeling of narrowness. To use computer programming to improve the computation efficiency, we have developed a tool to acquire the data of the indicators and establish a point-based coordinate system (Figure 3a).

To quantitatively describe the changes in the spatial characteristics of the two areas during this time, the locations where to place the measuring points need to be determined. Since the urban form of the two areas has changed during this time, it may appear that the void space that used to be there is now occupied by buildings. Therefore, we chose to set measuring points in spaces that have always existed. For this purpose, we overlaid the street space structure maps to identify the street spaces that have always existed and to set measuring points. In this experiment, we set 8 points in Area A and 17 points in Area B (Figure 3b).

For ease of description and analysis, we take the direction perpendicular to the street as the starting scanning angle. Analysing the 360 horizontal distances and elevation angles is rather complicated. For simplicity, we selected the horizontal distances and elevation angles of viewpoints at every 30 degrees to analyse the spatial variation.



(a) (b)

Figure 3. *(a) The point-based spatial geometry data coordinate system. (b) The places to set the measuring points.*

Results and Discussions

For the 8 measuring points set in area A and 17 measuring points set in area B, we measured the Horizontal distances and height angles for the next analysis.

Comparison of typical spaces

First, we selected a typical space in each of the two areas for comparison. In area A we chose a street in Xinjiekou central area. In area B we chose a street in Changledu Community. The horizontal distance in 12 directions is analysed (Figure 4a). From 1953 to 2000, the horizontal distance in each direction of the space of Area A decreases and then increases; from 2000 to 2020, there is no change. On the other hand, the space of Area B has no change from 1953 to 2000, while there is a slight increase from 2000 to 2020. Then, the elevation angle in 12 directions is analysed. The space in area A, from 1953 to 2000, has an increasing elevation angle on one side of the street. While the elevation angle on the other side of the street becomes larger and then smaller. And there is no change from 2000 to 2020. The change of elevation angle in each direction of space in area B is always insignificant. We used the standard deviation to compare the amount of change in the horizontal distance and elevation angle of the two spaces. It shows that most of the horizontal distances and elevation angles change more significantly in area A than in area B.

From the superimposed panoramas of these two spaces, we can visually see the change of space (Figure 4b). That is, the space in Area A changed a lot, from empty and low at the beginning, to narrow, and then to tall and spacious. In contrast, the space in Area B did not change much. This confirms the analysis of the change of spatial characteristics we just made through the data.

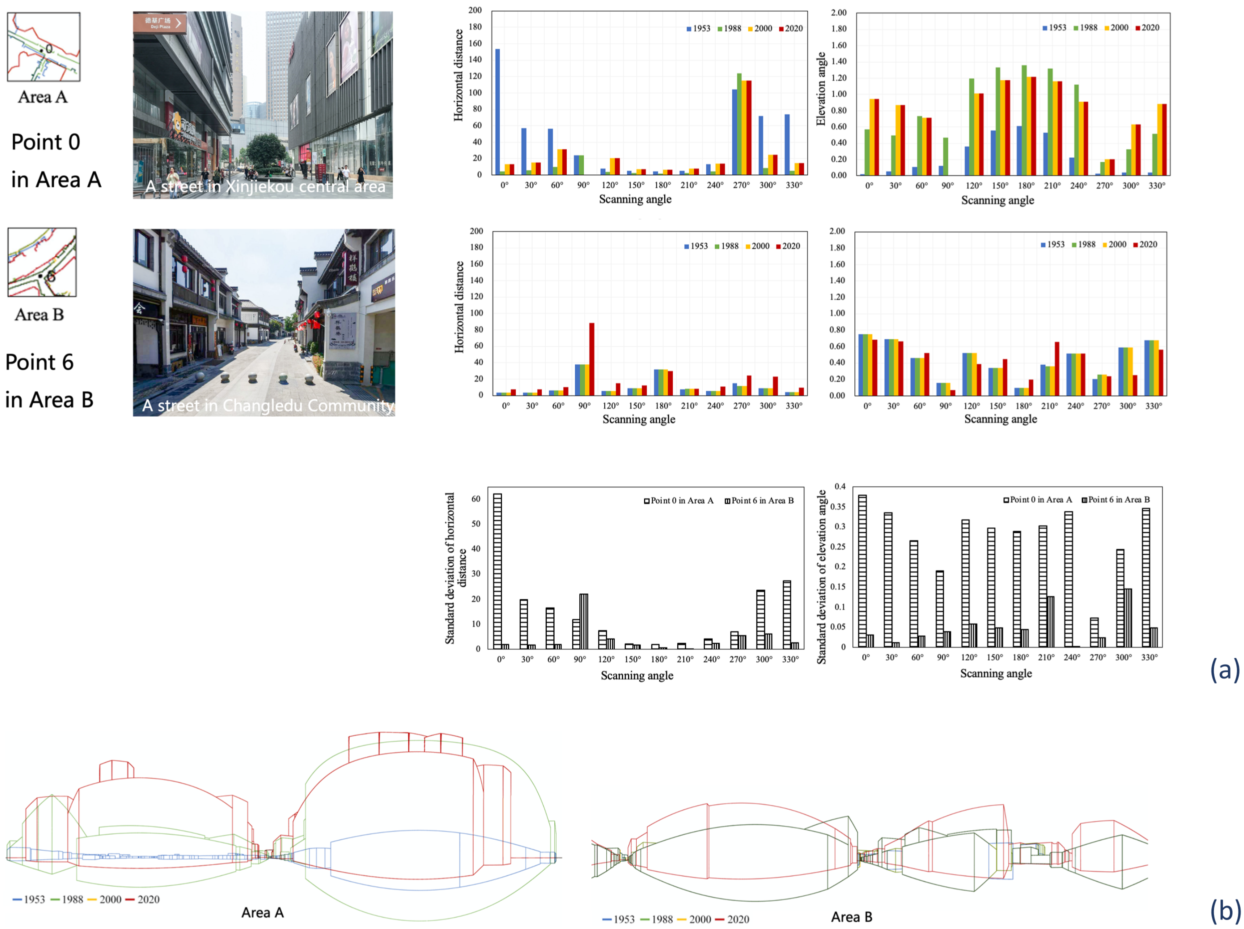


Figure 4. *(a) Typical space in Area A and B for comparison in terms of the horizontal distance, the elevation angle, and the standard deviation. (b) Superimposed panoramas of the two spaces in 1953, 1988, 2000, and 2020.*

Comparison of the entire area

Next, we compare the changes in the spatial characteristics of the entire area (Figure 5). First, the average street widths of the two areas were counted over the years; the average street widths in Area A changed considerably, and the changes occurred mainly in the first three periods; the average street widths in Area B did not change much. The average elevation angle in Area A increases from 0.4 to 0.7 year by year, while the average elevation angle in Area B remains approximately the same. As the horizontal distances and elevation angles remain largely unchanged, the traditional spatial characteristics of Area B are preserved.

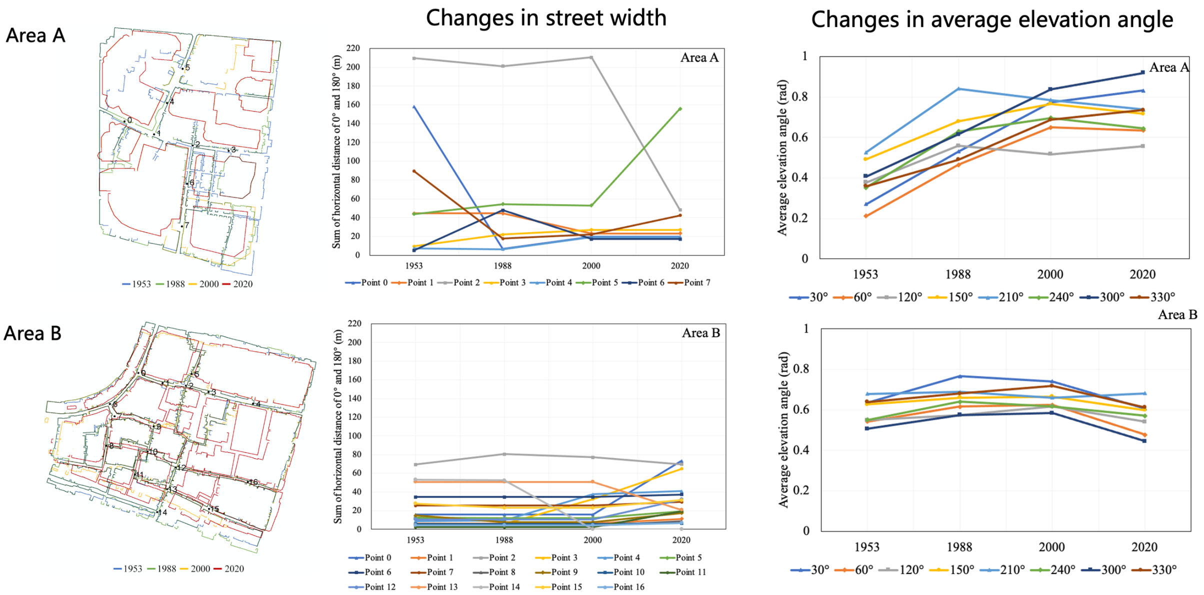


Figure 5. *Statistics of the average street widths and the average elevation angle of the two areas in 1953, 1988, 2000, and 2020.*

Conclusions

The quantification of urban space needs to be based on the study of urban morphology. Only based on correct urban morphological research can we generate a correct understanding of urban space. On the other hand, the quantitative study of urban space can enrich the results of urban morphological research.

The significance of quantitative research on urban space is that it is closely related to citizens' perceptions of space in their daily lives and can be used to evaluate urban space.

Through integration with urban morphological research, the quantification of urban space can provide methods for design control. For example, in Area B, although the old city regeneration approach based on large plots led to the loss of historical plots and the consolidation of plots, eventually, after following planning policies and design, the traditional spatial characteristics of the area were preserved and were able to conform to the residents' perception of traditional spaces. Planning and design are often the most direct ways to change the urban form. This example shows that planning and design can also preserve the urban form to some extent which illustrates the importance of planning and design.

Acknowledgements

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References

1. Filomena, G., Verstegen, J. A. and Manley, E. (2019) 'A computational approach to "The Image of the City"', *Cities*, 89, pp. 14–25.
2. Gu, K. and Zhang, J. (2014) 'Cartographical sources for urban morphological research in China', *Urban Morphology*, 18(1), pp. 5–21.
3. Lynch, K. (1960) *The image of the city*. Cambridge, MA: MIT Press.
4. Tikhonova, O. and Beirão, J. N. (2020) 'A tale of two cities - A comparative study of historical urban cores', *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 13(4), pp. 448–465.