

The construction of pedestrian network in urban blocks: A case study

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Abstract: In the past decades, the urbanization of China has developed faster. The pedestrian accessibility of large old residential areas with new village-style becomes worse due to the large scale and few entrances and exits for residents. Simultaneously, the closed communities seriously affect the development of urban areas induced by poor urban living atmosphere, incomplete pedestrian system and traditional public space node setting. The public spaces where walking is the mainly activity need optimization urgently. This paper took Anshan New Village as an example and applied spatial syntax to analyze spatial accessibility and integration based on the current investigation. The study demonstrated that the network system should be established to improve the pedestrian environment in large urban blocks and the measurements of construction of pedestrian network were also suggested. Dredging the pedestrian path and increasing public space nodes can better build the urban pedestrian network and realize the balance between privacy, publicity and security. The conclusion of this paper can provide reference for building a good pedestrian environment in the process of urban renewal in Shanghai.

Keywords: pedestrian network; large old residential areas; public space node; spatial syntax

Introduction

In recent years, building green architecture and sustainable cities have become important in all sectors of society. The WELL standard of the United States puts forward seven core systems, i.e., air, water, nutrition, light, fitness, comfort, spirit. It pays attention to the impact of urban environment on human health. The ultimate goal of urban sustainable development is to create a healthy living environment of high quality for human beings. As the most basic mode of transportation in a city, Walking not only plays a key role in alleviating traffic pressure, creating a green city, energy saving and emission reduction, but also promotes interpersonal communication, contributes to health and is conducive to the construction of a healthy city. Currently, construction of walking environment has become a major direction of healthy cities. However, with the rapid development of urbanization, population agglomeration and modern transportation, motor lanes are gradually eroding the traditional pedestrian space. Vehicle lanes, automobile exhaust, dust, haze and other factors affect our walking environment in varying degrees. Poor air quality and lack of exercise seriously affect people's health. Therefore, a good walking environment is the foundation of building a healthy city.

In the early days, industry developed rapidly and the working class population doubled due to the influence of Soviet. In order to solve the problem of accommodation for the working class, a new construction model for

workers villages emerged all over the country. The construction process of Shanghai Workers New Village had spanned from 1949 to 1978. During this period, about 11 million square meters of newly added housing area in Shanghai were workers new villages, accounting for two-thirds of total newly added housing area. In the past decades, the workers new villages have always been the important component of figure ground in Shanghai. However, the construction of workers new villages such as Anshan New Village has been existed more than 30 years and the surrounding urban areas are becoming mature. Residents in the new villages need more diverse daily life and demand higher quality of space. There is a huge contradiction between the old physical space and the needs of residents. How to change the current situation and improve the quality of space has become a top priority (Song, 2018). Currently, many studies have been addressed on this kind of urban phenomenon for more healthy pedestrian system.

Since Perry put forward the theory of Neighborhood Unit, this model has been used in residential areas, i.e., transit traffic avenues are arranged around the border, and the internal road system does not connect with the external. Although the latter traditional neighborhood units add other living facilities to create rich community life, centralized living has been developed under the guidance of the idea of neighborhood units resulting in the inadequate function of residential areas. In addition, the closed residential mode in China induces the split of urban pedestrian transportation system and brings great inconvenience to our daily life. Domestic research on the openness of residential areas begins with the criticism of closed residential areas. A large number of scholars criticize the closed residential areas and residential areas under the traditional planning theory mode. With the continuation of relevant research, the focus of research on the openness of residential areas has shifted from the criticism of closed residential areas to the practice of solving the closed problems. In recent years, the government has increasingly encouraged and supported the construction of open residential areas. Xinhua News Agency proposed that in principle, new residential areas should no longer be built in closed residential areas, and residential areas and unit courtyards that have been built should be gradually opened. It is pointed out that community opening can alleviate traffic pressure, stimulate community vitality, promote urban harmony and improve urban ecology, and can effectively solve urban diseases (Xinhua News Agency, 2016).

Streets have always been an important area of urban research. Jacobs compared hundreds of streets around the world and lists the best street models in the world. A great street should contribute to the formation of neighbourhood relations, be safe and comfortable in the physical environment, encourage the participation of the public, imprint on people's minds, and become a representative model (Jacobs, 2009). Lu discussed how to explore the visual order law in the design of building layout from the natural characteristics, aesthetic laws and humanistic characteristics of streets (Lu, 2006). Gail suggested the public communication in the street and emphasized the study and evaluation of the quality of public space in cities and residential areas from the perspective of the requirements of people and their activities on the physical environment. When social behavior and incidental behavior occur, it is necessary to create suitable space for social interaction for these behaviors (Gehl, 2002). Jacobs argued that street safety cannot be achieved by public security, but by street eyes, that is, people's conscious (subconscious) supervision. It challenges the traditional urban planning theory, deepens our understanding of the complexity and development orientation of the city, and provides a basic framework for evaluating the vitality of the city (Jacobs, 1961). In recent years, Street guides have been made around the world considering the importance of urban streets. The United States has put forward complete street guides, which are designed to make them safe for all users, regardless of age, physical condition or mode of transportation. More emphasis is placed on safe walking environment (Chen and Liu, 2017). The Guidelines for Shanghai Street Design emphasizes the construction of street interface, street pavement and the size of street space to create safe streets, intelligent streets, vigorous streets and green streets for Shanghai citizens.

This paper took Anshan New Village in Shanghai as an example and aimed to optimize the internal pedestrian structure of the old and new residential areas in Shanghai New Village and build a walking environment

conducive to people's health. Based on spatial parsing, this paper evaluated the original walking system of Anshan New Village and put forward corresponding solutions to the problems of the original walking system. The finding shows that the network pedestrian system of Shanghai blocks can be well constructed and the urban renewal of Shanghai can be promoted according to dredging pedestrian paths and adding public space nodes.

The study area

As shown in Figure 1 and Figure 2, Anshan New Village is located in Yangpu District, Shanghai, within the boundaries of Jiang-Controlling Road, Dalian Road, Siping Road and Zhangwu Road. This area was founded in the 1950s. In the past decades, Anshan New Village has been expanding continuously and has eight residential areas currently. Anshan New Village was once one of the largest and earliest workers new villages in Shanghai. The interior of the community is mostly a six-storey determinant slab building. Because of the long construction time, the social background and the main body of the construction are more complex.



Figure 1. Macrolocational map of Anshan New Village, Shanghai



Figure 2. Microlocational map of Anshan New Village, Shanghai

As shown in Figure 3, Anshan New Village has a larger neighborhood scale and dense buildings than the residential areas built in recent years. The figure ground of the buildings is arranged in parallel in determinant form, which retains the characteristics of low-rise and high-density construction in the old worker's residential areas. There is a thick wall between the residential area and the city, which severely separates the connection with the urban environment. The scale of eight residential districts in Anshan New Village is different. The main structure of residential districts is large and severely fragments the urban pedestrian road system. There are Tongji University Station, Siping Road Station of Metro Line 10, Siping Road Station of Metro Line 8 and Anshan New Village Station in Anshan New Village District. The dense distribution of bus stations and rail transit system has become the barrier for the pedestrian environment in the area. In addition, since the residential areas are close to the main roads of Siping Road, Dalian Road and Zhenjiang Road, the internal pedestrian environment and accessibility are poor and public space is scarce. The relationship with the surrounding urban environment is very negative due to lack of reasonable pedestrian system. As shown in Figure 3, Anshan New Village only has one direct pedestrian road between Siping Road and Fuxin Road and the region only has four entrances and exits along Siping Road for people living in the community. The street interface is closed and the

relationship with the city is weak. Usually, people have to go around reaching Siping Road from the residual area due to the unreasonable pedestrian system.

Methodology

Space Syntax theory was first put forward and used by Hillier and the study object is spatial ontology (Hillier, 1984). The method applies quantitative analysis to describe the spatial structure of cities and buildings and abstracts the spatial relationship through modeling. Additionally, the theory explores the relationship between spatial ontology and other non-spatial factors, such as the accessibility of space, the relationship between space structure and human activities. Spatial syntax has been widely used in various aspects of urban space, i.e., urban land use, urban morphological development and road accessibility.

This paper firstly extracted the central line of pedestrian path in Anshan New Village area based on spatial syntax and draws the axis map. Thereafter, integration, selectivity, global depth, connectivity and comprehensibility were analyzed and the existing pedestrian system in Anshan New Village was evaluated. In general, when the travel radius is less than 1000 meters, it is completed by walking (Xia, 2018). Therefore, this paper took 10 minutes walking distance, namely 800 meters, as the travel radius to study Anshan New Village. Then, a new scheme to build a more efficient walking system was proposed and the new walking system was presented based on the existing walking system problems.

Problem analysis of current pedestrian system of Anshan New Village in Shanghai

Through field investigation and spatial syntax, the problems existing in Anshan New Village are analyzed and summarized as follows.

1. As shown in Fig. 4, Fig. 5 and Fig. 6, the large size of neighborhoods results in inadequate pedestrian links between urban roads. Fewer entrances and exits along Siping Road and closed interfaces induce unobstructed pedestrian links between urban roads. The area is located between Siping Road Station of Metro Line 10 and Tongji University Station. Although the traffic volume is large, the routes to subway station, bus station and other public facilities in the district are more circuitous. The larger scale of closed unit causes the situation of pedestrian bypass;



Figure 3. Figure ground of Anshan New Village, Shanghai



Figure 4. Lot division of Anshan New Village, Shanghai

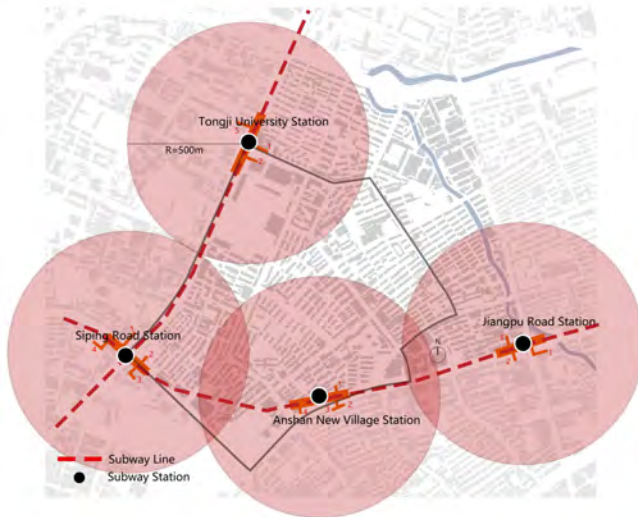


Figure 5. TOD nodes of Anshan New Village, Shanghai

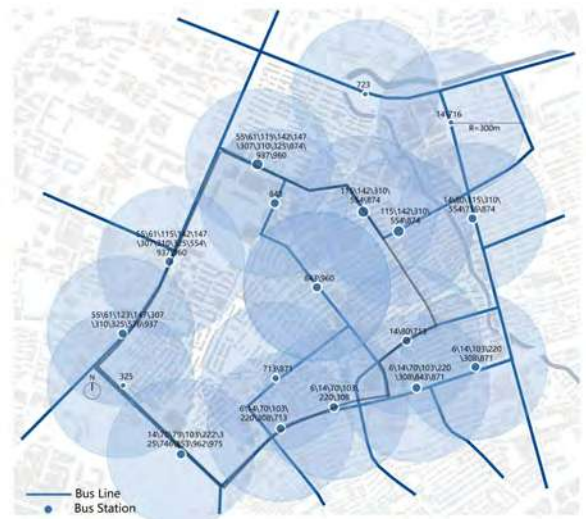


Figure 6. Bus stations of Anshan New Village, Shanghai

2. As shown in Fig. 7 and Fig. 8, surrounding urban road interface mainly consists of fencing wall, and building interface is scarce. Walking paths such as Siping Road, Zhangwu Road and Dalian Road are surrounded by fences. Walking paths lack functional support and interface and result in poor quality of walking around major external urban roads. The existing public space and the sidewalk system are close to the enclosed wall, which weakens the relationship between the neighborhood and the city;



Figure 7. Residents roundabout travel paths

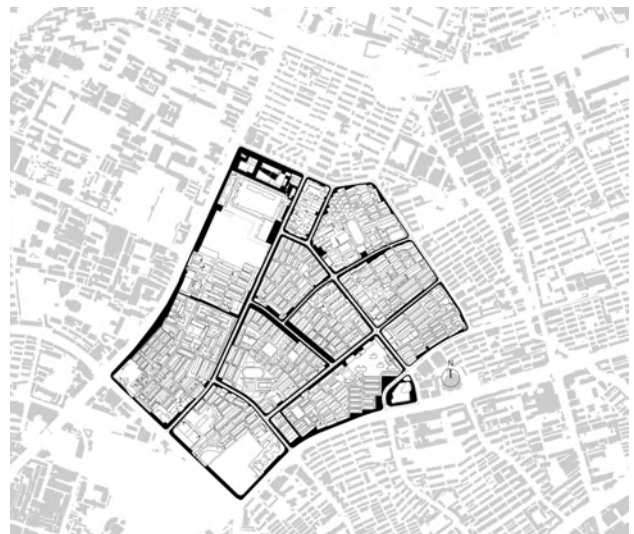


Figure 8. Public pedestrian space

3. As shown in Fig. 9, community public living places are scarce. There is no regional public space within the area and the whole area is homogeneous, especially lack of overall community space awareness and self-identity of community public places. Residents are in an undirected state lacking centripetal cohesion. In order to change this situation, relevant departments have carried out several rounds of renovation, such as forming a small amount of public space along Siping Road and on both sides of Sujiatun Road. Currently, these public spaces have become a favorite place for people to walk, yet the number of these areas is far from enough.

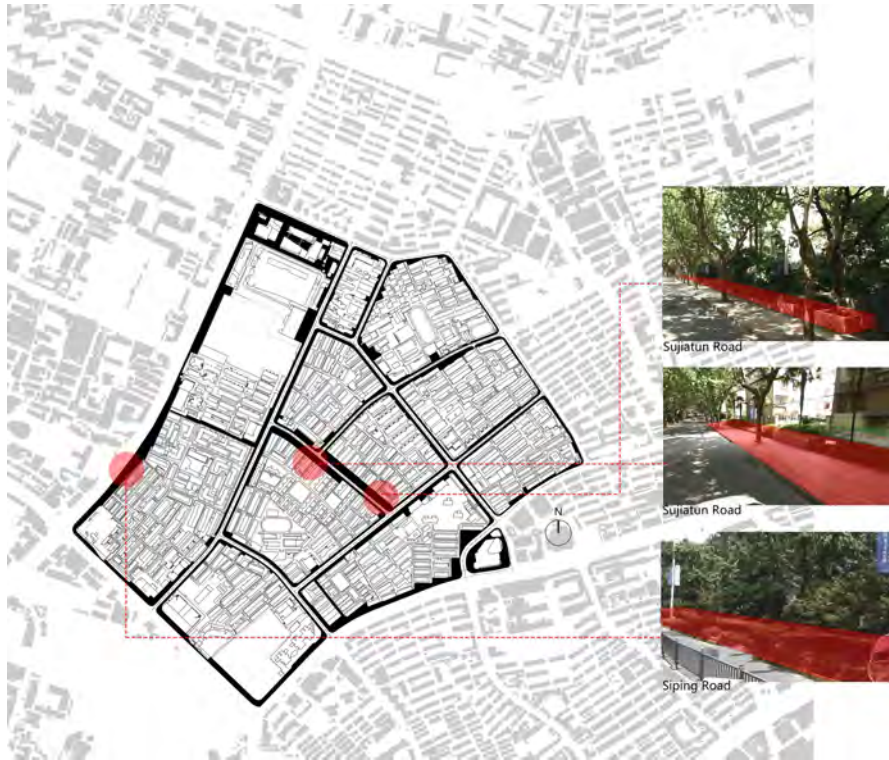


Figure 9. Public space nodes

Strategies for construction of new pedestrian system of Anshan New Village in Shanghai

For large new village residential areas with long construction time, it is a challenge to upgrade the spatial quality of urban renewal. According to the analysis of actual cases and results of spatial parsing, it is necessary to build a network system of pedestrian system and public space nodes to effectively update large-scale new village residential areas. When the pedestrian system and public space are connected into a network, the residual area will have higher connectivity and more route choices. The network space system can effectively guide people's travel and increase people's walking movement. To establish the network system of pedestrian system and public space nodes, the following principles should be met first.

1. Increase pedestrian path density. Based on comparing the areas with good walking experience, i.e., Puxi people's Square, Tianzifang, the Bund, Wu Kang Road and the areas with poor walking experience, i.e., Pudong Oriental Pearl, Shanghai science and Technology Museum and Lian Yang community, we found that when the length of the road in each square kilometer is about 10 kilometers, it is the most suitable way to create a pleasant walking environment. As shown in Figure 10, for better increasing the accessibility of internal roads in large residential areas, it is important to open up the broken roads in large-scale new village residential areas, build new path links relying on the original path, divide the large-scale plots into small plots with moderate scale and convenient access;



Figure 10. Comparison of route density in different areas in Shanghai (Sun and Xu, 2017)

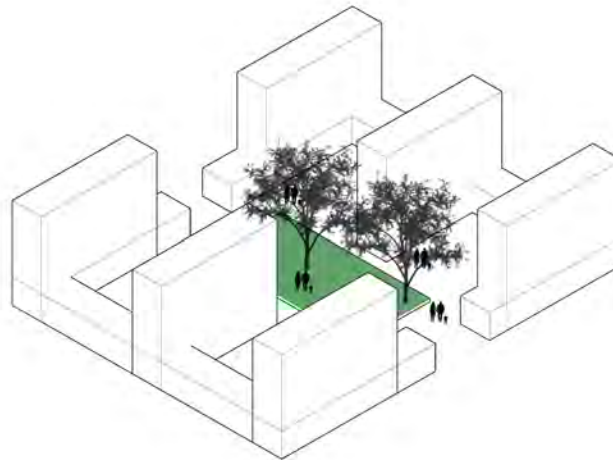


Figure 11. Enclosed unit of residual area

2. Increase public space nodes, i.e., add urban public space nodes at the junction of blocks, street corners and the center of public space structure, add community public space nodes between districts and districts, and add neighborhood public space nodes within groups. Public space nodes and walking paths form a tensioned network of public space network structure, which constructs a pedestrian space environment for urban people. There should be functional interface support around public space nodes, and the interface should be open to the public;
3. Create a reasonable open neighborhood size to achieve a balance between public and private. Closed residential district has the characteristics of quiet and safe, but it is difficult to meet the growing demand for physical space due to the lack of public facilities. People hope to open up enclosed residential areas and create open blocks. However, it is easy for the idle and miscellaneous people to enter after the opening of

the community, which challenges the security of the residential area. So we should create a new mechanism and reasonable size of the neighborhood to provide a small range of privacy for residents and meet the requirements of openness. As shown in Figure 11, the original determinant slab dwellings are partially enclosed by increasing the volume of the edge buildings. The interior is a private space, while the exterior is a public space. At the same time, the underlying functions will be replaced into commercial space, and businesses will become "street eyes" to ensure the safety of the community;

4. Improve the quality of walking space. Along the pedestrian path, trees can be planted, seats and other urban furniture can be placed, public facilities, business interfaces and public places for daily life can be increased, and water-permeable hard pavement can be laid on the pedestrian road. Through a series of detailed considerations, we can improve the quality of walking space and provide a good walking experience for travelers and create a vibrant urban living place.

Under the basic principles of pedestrian system and public space node network system, aiming at how to carry out effective urban renewal and build high-quality pedestrian space network in Anshan new area, this paper uses spatial syntax to assist specific urban renewal strategies, which are summarized as follows.

1. Increase the path density. According to the design principle of 10 kilometers per square kilometer of land in pedestrian area, the pedestrian path is added to the interior of Anshan New Village to optimize the way of path connection. The pedestrian path in the original community will be opened as an open urban pedestrian path. As shown in Figure 13 to Figure 15, through the spatial syntax analysis of the integration and connectivity of pedestrian roads in Anshan Xincun area, Fuxin Road, as the only street in the area that can directly connect Zhangwu Road and Dalian Road, has the highest integration, selectivity and connection value. Tieling Road, Jinxi Road and Sujiatun Road have higher integration, and Jiangpu Road, Anshan Road and Tieling Road have better connectivity. However, the internal road network of large-scale residential areas is not fully opened and the integration degree and connection value of pedestrian roads is extremely low. The main roads to Siping Road of the city are few and the integration degree is low, so the pedestrian system network has not been formed. Fuxin Road, Zhangwu Road, Tieling Road, Fushun Road, Anshan Road, Jinxi Road and Sujiatun Road are all the main roads with large traffic volume, but the interior of the district is closed and deep. So we should increase the density of road network in places with low integration and open the urban pedestrian path system in places with high connection value. The new road network system was shown in Figure 16 and the measurements were summarized as follows.
- Chifeng Road will be connected with Fuxin Road. Three axes in series will be built between Dalian Road and Zhangwu Road, along Siping Road. Break the barrier between Fuxin Road and Siping Road. These strategies will increase the opening degree of the interface along the street. According to increasing the entrances and exits along Siping Road and opening the interface, people can easily and quickly reach the main road of Siping Road. The opening of the interface improves the integration of the road network system and increases people's choice of roads.
 - Connect Jinxi Road with Dalian Road and Yanji West Road. Connect Sujiatun Road with Jiang-Controlling Road. Connect Tieling Road with Jiang-Controlling Road. Fuxin Road and Tieling Road will be extended northward to intersect the central node space in the new bus village. Meanwhile, the north-south, East-West of the new bus village will be connected to form a cross-axis pedestrian road network system. Finally, create open blocks and dredge the city capillaries.



Figure 12. Integration



Figure 13. Choice



Figure 14. Total depth



Figure 15. Connectivity

2. Add public space nodes. The places with high integration degree should be active, but some areas with high integration degree are crowded and have poor quality. It is necessary to expand public space and form node squares. Fuxin Road, Anshan Road, Sujiatun Road and Dahushan Road have a high degree of integration, which makes them easy to gather traffic. Simultaneously, they are also places where people have a strong understanding of space and a high degree of comprehension. They are suitable to construct public space nodes. The new pedestrian public space was shown in Figure 17 and the measurements were summarized as follows.
 - Focus on building Jinxi Road, Fuxin Road, Anshan Road, Sujiatun Road and Tieling Road and make them become pedestrian streets. Widen the pedestrian roads on both sides of Sujiatun Road and Dahushan Road and remove the fences on both sides of the road. Increase the openness of the interface. By replacing the functions of the bottom floors of the buildings on both sides into commercial shops, residents are allowed to declare functional replacement so as to provide merit for the pedestrian roads. Jinxi Road and Sujiatun Road will be built to pedestrian roads and Fuxin Road will be built to a pedestrian priority road. Fuxin Road before and after two sections can allow motor vehicles to pass and the middle part can be used as a pure

pedestrian road. Fuxin Road, Jinxi Road, Zhangwu Road, Anshan Road and Sujiatun Road have become the main spatial topological structures, and the public spaces along them will be strengthened.

- Public node squares are built at new openings along Siping Road. City squares are constructed at TOD nodes between Tongji University Station and Siping Road Station. The turning points of Jinxi Road, Anshan Road and Fuxin Road form public space nodes. The core node square is set at the junction of Jinxi Road and Tieling Road.
- When the building is densely textured and there is no public space reserved, the buildings with poor living conditions and suitable transformation will be dismantled through functional replacement. the bottom part will be removed and public facilities will be increased to form public places of activity.



Figure 16. New road network



Figure 17. New public pedestrian space

3. Build a reasonable neighborhood size. The largest, smallest and average neighborhood size in Anshan New Village are 600*500 meters, 100*200 square meters, and 400*300 meters, respectively. Via segmentation of existing neighborhoods, about six determinant buildings are partially enclosed to form a private unit. The new size is about a quarter of the size of the current neighborhood and there is a branch between 80 and 100 meters. The inner part of the private unit is a community garden, which is only for the leisure and enjoyment of the people in the unit. Private units become public space outside through the replacement of the underlying functions into shops to create street eyes. Retail stores not only support pedestrians purchase needs, but also play the role of community safety monitoring, which is conducive to the formation of community atmosphere. According to the enclosure of small blocks, the unit is more private inside and has commercial function support outside. The specific measurement was summarized as follows.
 - The five villages in Anshan, six villages in Anshan and seven villages in Anshan are re-divided to form three residential groups. The plots along Siping Road are re-divided for high-intensity development. At the same time, the four villages in Daanshan will be re-divided to create a reasonable size of the neighbourhood.
4. Improve the quality of walking space. As shown in Figure 18 and Figure 19, the synergy between global and local integration of Anshan New Village is 0.56. Current road synergy is relatively general, indicating that it is difficult for residents to recognize the whole through local. The degree of synergy between connectivity and integration is 0.25. In the pedestrian road, there are many broken roads, T-shaped roads and so on. The comprehensibility of the pedestrian road is very poor. It is difficult for the pedestrian to feel the surrounding space environment. The lack of highly identifiable node space in the regional road network

system leads to the lack of perception of the overall form of the city. Therefore, we must rely on several main development axes to complete the subjective perception of urban form. The vision of city life was shown in Figure 20 and the specific measurement was summarized as follows.

- In the places with higher integration, the node public space with perceptible urban intentions is arranged. On the main spatial topological structures along Siping Road, Fuxin Road, Jinxi Road, Anshan Road, Sujiatun Road and Tieling Road, the main development axes and urban intentions are formed by expanding public space, increasing commercial interfaces, setting up external swing areas and planting street trees to improve the quality of pedestrian space.

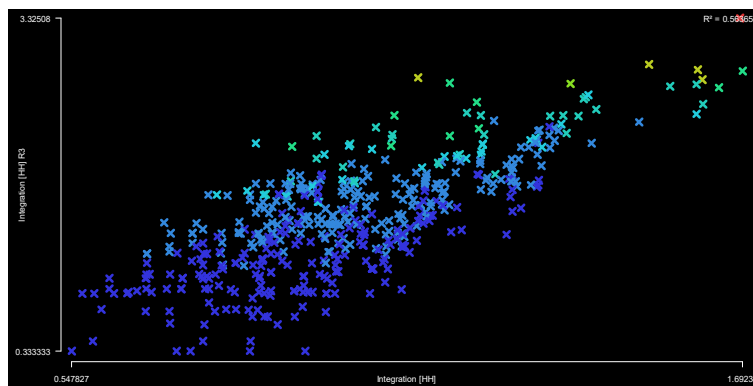


Figure 18. The synergy between global and local integration of Anshan New Village

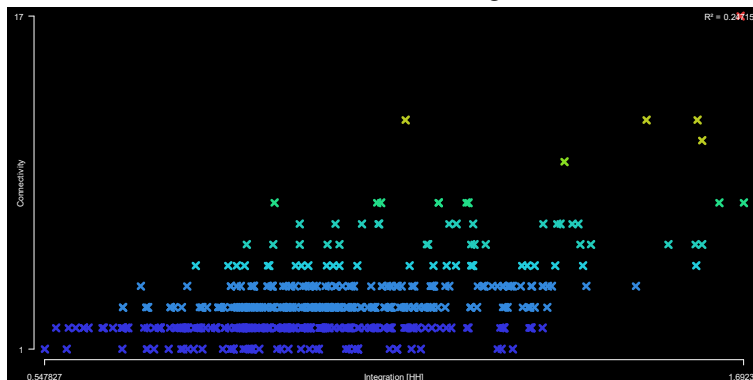


Figure 19. The synergy between connectivity and integration of Anshan New Village

Based on spatial syntax analysis, it is proved that after the formation of pedestrian space network in Anshan New Village area, the integration of internal roads, Fushun Road and Sujiatun Road along Siping Road has been significantly improved, and the accessibility of internal pedestrian roads in large old residential areas has been enhanced. Especially, when the 10-minute walking distance, namely 800 meters, is used as the travel radius calculation, the regional center integration degree has been significantly improved, and the global integration degree has also been improved to varying degrees. Fuxin Road is still the most selective street. However, under the 800 meters travel radius scale, residents obviously have more choices. In addition to the main roads such as Jinxi Road, Zhangwu Road and Tieling Road, there are more roads with the potential to attract cross-traffic. People can go through the interior of super-large-scale residential areas, and travel efficiently and conveniently. Many large-scale plots also have high traffic attraction after being re-divided. Additionally, the connection value of pedestrian structure roads in residential areas has also been significantly improved and the clear pedestrian network has been formed. The degree of synergy between local integration and global integration has also been significantly improved, and the system has good comprehensibility.

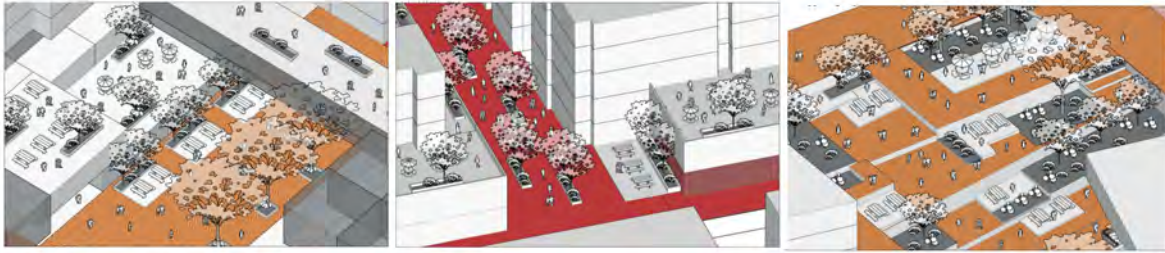


Figure 20. The vision of city life

Conclusion

Walking is the most basic mode of transportation in a city. Walking not only alleviates traffic pressure, saves energy and reduces emissions, but also promotes interpersonal communication and health. Walking is conducive to the construction of a healthy city. In the future, metropolitan cities will face the trend of more dense population and more dense buildings. Many cities will face severe environmental pollution and lack of resources. We should pay more attention to the friendly environment and create comfortable and natural urban pedestrian traffic space.

This paper studied the current network of pedestrian system in Anshan New Village and built a more friendly and healthy urban pedestrian system through increasing the density of pedestrian paths, optimizing the way of path connection, adding public space nodes, and dividing reasonable open neighborhood size. The results can provide a reference for how to establish a good pedestrian environment in the process of urban renewal in Shanghai.

Acknowledgements

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