Renovation mode for growing underground pedestrian system within station area: a case study of Shanghai Jing'an Temple Station

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Abstract. The underground pedestrian system within Jing'an Temple Station area in Shanghai provides convenience for local pedestrians and promotes the compact development of surrounding urban area by building connections between the metro station and surrounding underground public spaces. On the other hand, deserted spaces and congested spaces still exist in this system. In this paper, based on the space syntax methodology, we first study the spatial configuration of this pedestrian system by conducting segment analysis. It is found that the system is roughly in a radial shape, with concentrated traffic pressure on the core and low accessibility on each end. Renovation alternatives are then developed towards those defects. By analyzing and comparing topological features, such as spatial configuration, accessibility and transit activity, among renovation alternatives, a renovating mode of the growing underground pedestrian system within station area is put forward that small walkable ringways are constructed successively and weaved into an underground walking network.

Keywords: space syntax, station area, Jing'an Temple, renovation mode, growing underground pedestrian system

1. Introduction

Rapid urbanization usually leads to sharp increases in urban population together with intense traffic pressure, and elicits the demand of promoting public transportation which has higher efficiency of transport. The underground rail transit, one of the most efficient public transportation, has therefore been vigorously planned and constructed. At the same time, the principle of mixed use and high compactness in urban development has made it a mainstream to build underground pedestrian systems within metro station areas to get nearby buildings closely related. The CRYSTA Nagahori underground pedestrian system in Osaka, Japan connects five subway stations on four subway lines with pleasant underground shopping arcade. It is 730-meter-long in linear shape and uses well-designed decoration and plazas as joints to strengthen the sense of rhythm and direction of the space. The underground pedestrian system within Tokyo Station area, built gradually during the past one hundred years, encompasses dozens of JR lines and subway lines and is connected to the Yaesu Parking Lots through the underground Yaesu Shopping Mall. It is centred around the underground public square of Marunouchi and radiates in all directions to connect commercial spaces under most of the land plots nearby, forming a network of fine grid with different scales of underground streets weaved together. Within Montreal Indoor City, one of the most famous underground pedestrian systems in the world, the subway stations deliver large pedestrian flow and feed the system. The harmonious development of the complex underground
The underground pedestrian system was promoted originally by the construction of these subway stations and their connections to department stores, hotels, cinemas and etc. nearby [1]. The metro station areas can be moulded largely by the underground pedestrian systems within. In this respect, it is significant that the spatial configuration of the underground pedestrian system within station area is reasonable.

The theory of space syntax based on topology depicts space with the influence of social behavior and economic activity. It can not only be used to analyze the spatial configuration of a city or building quantitatively, but also show the relationship between spatial configuration and human activities within [2]. In recent years, it has gained more and more attention and successful application in the field of urban planning and architectural design. This paper aims to adopt the space syntax theory to analyze the underground pedestrian system within Jing'an Temple Station area which is facing a chance of renovation with a new metro station under construction in the area. Several renovation alternatives are raised in the logic of the growth of pedestrian network. Based on the comparative analysis, a renovation mode is then put forward.

2. Research background

Jing'an Temple area is one of the most significant central business and commercial district in Shanghai, with the Jing'an Temple stands at the core as shown in figure 1. Metro Line 2 and Line 7 pass through the area and form a metro transfer station which is the Jing'an Temple Station. Meanwhile, a stop on the metro Line 14, which is still under construction, is also going to be set here and upgrade the Jing'an Temple Station to a three-line transfer station of even larger scale.

The present underground pedestrian system generated from the Jing'an Temple Station connects many important underground spaces within the area, including the Jing'an Sunken Square, the underground part of Yimei Fashion Plaza, the Jing'an Kerry Center, the Park Plaza, the Jiuguang Department Store, the Crystal Galleria and the Jing'an Temple Transportation Hub. It was planned to be part of a three-dimensional pedestrian system in the Jing'an Temple area according to the urban design made in 1996, together with overpasses and ground sidewalks. Huashan Road was at first planned to be buried underground to avoid blocking between the Jing'an Temple and the Jing'an Park and to provide a more pleasant environment for walking. However, due to the changes in land developers and ownership as well as objections from local residents, the urban design was not fully realized. The design of overpasses for pedestrians and underpass roads for vehicles was abandoned, which partly leads to the traffic pressure in the intersection of Huashan Road and Nanjing Road West nowadays [3,4]. Additionally, though business thrives in the area, the Yimei Fashion Plaza performed poorly and was closed when the new metro station was planned to be constructed. The city terminal was also shut down for lack of customers.
The construction of the new Jing'an Temple Station on metro Line 14 and the reconstruction of some buildings in the area provide an opportunity that can be seized to make general renovation in the underground pedestrian system, so as to remedy those defects above. Moreover, some underground spaces, such as that of the 1788 Square, remaining isolated in the area, are also in need of joining in the underground space network.

3. Segment analysis on present situation

The first floor of the underground pedestrian system within Jing’an Temple station area is picked for study since it is the main plane that assembles most of the underground pedestrian activities. The segment analysis here is weighted by metric distance and turning angle to take into account the scale and behaviour law of pedestrians. Common measures in space syntax such as topological depth, choice, integration and intelligibility are adopted as the basis of analysis.

3.1. Accessibility and selectivity

Choice is a parameter in the space syntax that measures the potential of a space to be walked through by all pedestrians in the network. It can be seen in figure 2 that, with the increase in analysis radius, location of the highest choice moves gradually towards the T-shape center of the network from the surroundings, indicating a geometric center in a radial network with spaces on ends of the network being rather isolated. Further, the north aisle of the Reel Department Store in the T-shape center undertakes...
most of the through traffic pressure in the global scale. The integration in the space syntax represents the ability of places to attract pedestrian flows. The highest integration in the case of Jing’ an locates in the Z-shape area as shown in figure 3, making up the integration core which possesses the highest accessibility in the pedestrian system.

![Figure 2. Segment length weighted choice in different radii](image)

![Figure 3. Segment length weighted integration in different radii](image)

However, the reality is that the center of traffic function here lies to the west of the T shape and Z shape, close to the station hall on metro Line 2, because the passenger flow of Metro Line 2 is far greater than that of Line 7. The stagger of function center and configuration center may has alleviated the pressure of pedestrian flow in station hall on Line 2 to a certain extent, but may also be a cause of the Jing’an Sunken Square and the Yimei Fashion Plaza being weak in gathering crowd and activities. In addition, when in the noon and evening, off-duty flows between metros and malls collide because of the eccentricity, the north aisle of the Reel department store is prone to be congested for being the only passageway. The efficiency of traffic is therefore greatly reduced.

From the perspective of business, the INSHOP Commercial Street and the Reel Department Store, located near the center of the network, have a degree of penetration advantage in attracting external traffic, since other commercial spaces remain relatively independent on the margin of the underground pedestrian system. For example, the Crystal Galleria in the north looks almost isolated in every sense.

3.2. Intelligibility
The intelligibility of a place describes the matching degree between local configuration and global configuration, and further indicates whether or not pedestrians in the place can understand the spatial context. The comparisons between local measures and global measures in the case study show that there is rather low level of intelligibility throughout the pedestrian network in the case of Jing’an, resulting in difficulties for pedestrians to think of spaces beyond sight. As analyzed above, the global configuration of the underground pedestrian system in the Jing’an Temple station area is radial, while the configuration of each commercial space on the margin of the network is roughly circular or reticular. If links can be established between commercial spaces, forming ringways of different scales for walking, there may be a chance for the intelligibility to be enhanced and the accessibility as well as the compactness of the network to be improved.
4. Renovation mode analysis
With a new metro station under construction, several renewal objectives have been proposed for the Jing’an Station area: (1) expanding the service area of the underground pedestrian system within station area and improving its accessibility; (2) enhancing the appeal of the Jing’an Sunken Square and the Yimei Fashion Plaza towards pedestrians; (3) relieving the traffic pressure in the intersection of Huashan Road and Nanjing Road West, as well as providing convenience for people in the Wheelock Square to enter the commercial spaces within Jing’an Temple Station area; (4) energizing the 1788 Square which is rather isolated on the edge of the station area; (5) avoiding increasing, or trying to alleviate, the pedestrian traffic pressure in the station hall on metro Line 2. Additionally, based on the defects analyzed above, the current spatial configuration is also in demand of transformation, otherwise a more severe collision of off-duty flows may occur when traffic increases and complicates after the three-line transfer station is formed.

A long-term plan designed for the transfer among three Jing’an Temple Stations suggests building a transfer passageway (within paid area) under Yan’an Road West or the Jing’an Park, connecting the Jing’an Temple Stations on Line 14 and Line 7 directly [5]. Therefore, it is reasonable to conceive building an unpaid passageway simultaneously to connect the east and the west parts of the pedestrian system. Moreover, some underground spaces, such as that of the 1788 Square, remain isolated in the area, are also in need of joining in the underground space network. Therefore, the following four local renewal schemes (in the west part of the network) and four global renewal schemes in figure 4 and 5 are proposed following the logic of growing for comparative study.

Figure 4. Local renewal schemes
Figure 5. Global renewal schemes

4.1. Functional space unit model
As has been found in analyzing the underground pedestrian system at present, the connectivity of segments is highly correlated to the local integration at a radius of 100 meters (correlation coefficient being 0.231623, which is ten times that of the connectivity and the global integration), so it is assumed that pedestrians can have an understanding of the surrounding space within 100 meters. Such scale is
just similar to the scale of functional spaces such as metro stations, shopping mall aisles and long passageways. Therefore, functional spaces of such scale are taken as research units in the following analysis. The underground pedestrian space within the Jing'an Temple Station area is roughly divided into spatial units with appropriate scales and certain functions in the first place. Then, slight adjustments are conducted in the division of units, in order to make the distribution of choice and integration in the new model similar to that in the original segment model. The model built is thus called the functional space unit model, and the following study is carried out based on this model.

Due to the simplification made in the interior of units, the integration of each unit in the new model (as shown in figure 6) is generally lower than that in the segment model. Therefore, in the subsequent analysis, an integration above 0.62 is seen as relatively high and an integration above 0.88 is regarded particularly high.

![Figure 6. Global integration of present pedestrian system based on convex map](image)

4.2. Scheme analysis

4.2.1. Local renewal schemes (in west part of the network) As can be seen in figure 7, although the limited growing of pedestrian network in the west does improve the integration of the existing underground spaces of Jing’an Temple station area, the integration in east part of the network is declining continuously with the growth, with only a slight rise after a ringway is formed in the west. The spatial units with declined integration include the Reel Department Store, the INSHOP Commercial Street and the Jing’an Kerry Center, among which the INSHOP Commercial Street is highly dependent on the pedestrian flow in the underground space network. Additionally, the 1788 Square, though connected to the underground pedestrian system in scheme 3 and 4, turns out to have rather low level of choice and integration, especially in scheme 3, because it is buried deep in the end of the radial system. In this way, it is still difficult for the 1788 Square to benefit from the underground pedestrian network, due to the fact that other commercial spaces in the network are richer in commercial formats and in appeal. Scheme 4 with a ringway is the better of the four local renewal schemes, having the largest improvement in integration generally and providing an acceptable position for the 1788 Square in the network. Nevertheless, in scheme 4 there is also a sharp increase of choice (which indicates the through traffic) at the metro station hall on Line 2 (unit 8) and will result in enormous pedestrian traffic pressure. Obviously, this is inevitable with the underground pedestrian system remaining in a radial shape.
4.2.2. Global renewal schemes

It can be seen in figure 8 that there are more remarkable improvements in integration in all the four global renewal schemes than in the local renewal schemes. The construction of an alternative passageway between the west and the east part of the pedestrian system can ease the traffic pressure in the north aisle of the Reel Department Store greatly by sharing the through traffic in the T-shape centre while placing no adverse effect on its integration, which is crucial for its commercial function. It should be noted that scheme 5 seems to result in a rise in choice on unit 13 (the Reel Department Store) which means increased through traffic, yet there are actually two parallel aisles in the Reel Department Store and the present through traffic tends to be gathered in the north one since it is on the shortest path. In other words, the passageway planned in scheme 5 should be linked to the south aisle, generating a more balanced pedestrian distribution in the Reel Department Store underground other than aggravating the congestion. Therefore, although scheme 7 and 8 are developed based on scheme 6, it does not mean that scheme 5 is infeasible. In the meantime, the Yimei Fashion Plaza and the Jing’an Sunken Square can also be greatly energized by the global renewal schemes, owing to the reduction in their topological depths.
On the other hand, whether or not to connect the underground space of the SOHO Donghai Square and the United Plaza into the underground pedestrian system hardly makes any impact on integration or choice in the west or central part of the network. In purely topological terms, it is therefore unnecessary to connect the Crystal Galleria with the SOHO Donghai Square underground if a ringway is not formed. With a ringway in the east, scheme 8 can otherwise bring about a general increase in integration throughout the network including the two underground spaces newly connected. In conclusion, the connection or disconnection here is better not subjected to the spatial configuration, but to the plans of business development. Due to the imperfection of the model, it is difficult to reflect the effect of the city terminal and the Swissotel Grand Shanghai (unit 21) being connected to the underground pedestrian system in place of the original passageway. However, the improvement should be predictable in replacing a plain long passageway with an aisle set along commercial and public service spaces.

5. Discussion and conclusions
Underground pedestrian systems within metro station area are usually of radial shape in the initial stage, simply taking the metro stations as the centre and connecting the underground spaces nearby with cul-de-sacs. With the increased intensity of urban development and sometimes also the construction of metro stations on new lines, opportunity as well as demand in renovation is faced by the underground pedestrian systems. To extend simply on the basis of the original configuration will lead to excessive topological depth of the spaces on ends of the underground space network, weakening their appeal to pedestrians and making it inconvenient to travel between those spaces underground. This goes against the primary intention of constructing the underground pedestrian system within station area. Network in grid pattern is therefore the expected form for the system expanding towards a larger scale. However, existing layout of the connected and isolated underground spaces can sometimes look entirely unrelated to what is called grid, which is the case with the underground pedestrian system within Jing’an Temple Station area.

It should be noted that the network in a grid pattern is composed of smaller square units, and each unit is balanced and flexible for bearing no end. For pedestrian systems underground, where there are
many space limitations and irreversibility in construction, a prudent and economical mode of renovation is to successively construct walkable ringways of appropriate scale just like the square units in the grid, and weave the ringways into an underground net.

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