Analysis of the Degree of Convenience of Xi'an Metro Station

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Abstract: Urban subways have developed rapidly in recent years and has gradually become the primary choice of public transportation in big cities. Subways can effectively alleviate urban traffic congestion and improve passengers' green travel experience, especially in the old urban areas where urban space is limited, community facilities are aging and historical features are gathered. Subways play a huge role in guiding the expansion of urban space form and improving urban landscape environment. As the only channel for passengers to get in and out of the station, the subway entrance and exit act as a bridge. It is not only the transition space between the subway station space and the urban above ground space, but also an important node for the exchange and circulation of various elements in the urban space. In this paper, the influencing factors of subway entrance and exit space environments in the old city were investigated, and relevant basis for future planning, design, and construction of subway entrances and exits were provided. Firstly, the research results and shortcomings of subway entrance and exit channels were outlined. Secondly, based on the perspective of residents and passengers, this paper uses the analytic hierarchy process to determine six first-class evaluation indexes, including safety, convenience, practicability and aesthetics. This paper constructs the evaluation system of spatial environment index of subway station entrances and exits in the old urban area of Xi'an. Lastly, according to the evaluation results, the paper puts forward the targeted optimization strategies for the current situation of the entrance and exit space environment of the subway stations in the Xi'an.

Keywords: Subway entrance; Space environment; Evaluation system; Optimization strategy

1. Research Background

Urban subways have developed rapidly in recent years due to its advantages of being a high-speed way, having large capacities, as well as being safe and comfortable. Thus, urban subways have gradually become the backbone of public transportation in large cities. The subway has played a huge role in improving traffic congestion in big cities, improving the green travel experience of passengers, improving the efficiency of land development and utilization, guiding the expansion of urban spatial forms, and improving the urban landscape environment. The "four-network integration" in transportation establishes a multi-level rail transit network system, and realize the highly integrated development of rail transit, railways and cities; it connects cities, realizes regional networking, urban integration, one-vote urbanization, and provides a basic realization path for the realization of the construction goal of "city on track" [1–3].

At the end of 2021, Xi'an City has ushered in a new era of large-scale networked operation of lines. The operating mileage was expected to reach 258 kilometers; the number of operating stations and the passenger volume was expected to exceed 159 and 1.02 billion, respectively [4,5]. During the 14th Five-Year Plan period, with the operation of the line under construction and the approval and implementation of the

third-phase construction plan, it was expected that by the end of 2025, Xi'an will form an operating line network with a scale of more than 400 kilometers, and the number of operating stations will exceed 250, and subway traffic will account for public transportation. The share rate will reach more than 60%, and the construction of "Xi'an on the track" will gradually take shape [6,7].

2. Literature review

There are many research angles on subway stations and urban spaces: involving subway and urban land value, composite utilization between subway and urban public space, station passenger flow characteristics and station types, and so on. In the research on the spatial remodeling of different types of subway stations, many scholars also have done targeted research:

Leng Hulin investigated the relationship between subway entrances and exits and the surrounding space, and also the connection between the subway entrances and exits of Beijing and Shanghai and the surrounding spaces [8–10]. The subway entrances and exits mainly reflect the city's history and culture, and the same urban material [11,12]. At the same time, according to the connection between subway entrances and exits and different urban spaces, the advantages and disadvantages of using 3 different spaces including road space, building space and open space to set subway entrances and exits will be discussed [13–15].

It is worth noting that in recent years, many researchers have carried out numerous studies on the site and its surrounding space from the perspective of urban planning and updating, mostly in the following aspects: the evolution of urban space, the integration of commercial complex and site space, integration of urban above-ground and underground spaces, and so on [16–18]. It can be seen that extensive domestic research has been done on rail transit station space, and this research will carry out further research and experiments on this.

3. Convex space fabric accessibility evaluation
3.1. Lijiacun station hall floor
3.1.1. Integration analysis

The degree of integration refers to the degree of agglomeration or dispersion between an element and other elements in a space system, which measures the ability of a space to attract arriving traffic as a destination, and reflects the centrality of the space in the entire system. The higher the integration, the higher the accessibility, the stronger the centrality, and the easier it is to gather people. The integration degree can be divided into global integration degree and local integration degree. The global integration degree refers to the degree of agglomeration or dispersion between an element and other elements in a space system, which measures the ability of a space to attract arriving traffic as a destination, and reflects the centrality of the space in the entire system. The higher the integration, the higher the accessibility, the stronger the centrality, and the easier it is to gather a crowd. The degree of local integration reflects the degree of agglomeration between a certain space and adjacent spaces. In this study, the number of steps, n, is set to 3, 5, 7, and 9. In space syntax, the degree of fit, R, in the mathematical regression line, a trend line was plotted to express the relationship between the degree of global integration and the degree of local integration. The relationship between the global integration degree and the local integration degree indicates the degree of coordination of the overall space; the relationship between spatial structures was calculated by categorizing and using quantitative data calculation methods. The higher the integration value of a space, the better the spatial permeability. The graphs analyzed are from warm to cool colors: The warmer the color, the higher the integration degree and vice versa.
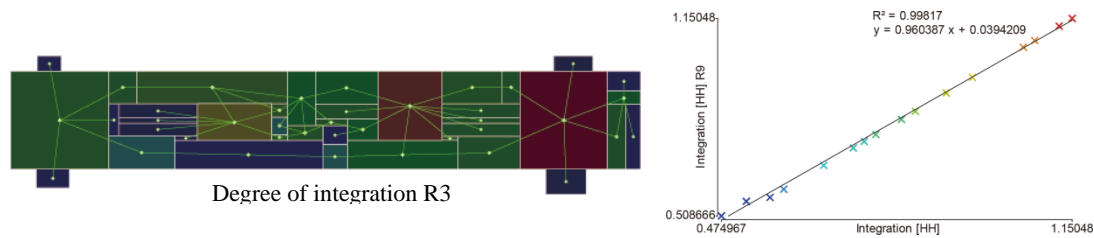
Figure 1. Model simulation of regional integration degree R3 of Lijiacun station hall floor

Figure 1 shows the model simulation of the integration degree R3 of the Lijiacun station hall area, which refers to other convex spaces that can be reached from a certain convex space within three topological space distances. Due to the different topological relations between the various convex spaces, the spatial depth of each convex space is different. Topological space depth can be simply understood as the reach ability of its convex space. The space with strong accessibility is easy to be used as a distribution center and a space for traffic flow. The right side is the linear regression analysis of the integration degree of R3 and the global integration degree. The overall R² value is greater than 0.5, which indicates a linear correlation, indicating that the research is representative of the actual situation with insignificant differences.
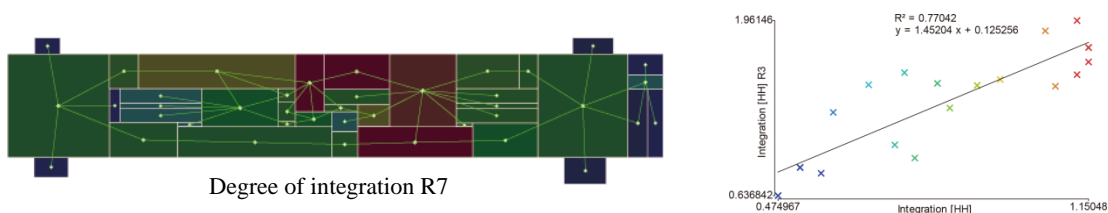

Figure 2. Model simulation of regional integration degree R7 of Lijiacun station hall floor

Figure 2 shows the model simulation of the regional integration degree R7 of the Lijiacun station hall layer. The deeper the topology, the closer it is to the global integration degree. The direction of divergent topological spaces is limited, which sometimes affects spatial depth and accessibility. Based on accessibility of each space at different topological depths, the R value is above 0.5, which means that the degree of fitting and spatial accessibility is good. The fit axis reflects the fit of the two different spaces.

3.2.2. Selectivity analysis

The degree of selectivity refers to the frequency of an element in the space system as the shortest topological distance between two nodes. Considering the advantages of the space unit as the shortest path for travel, it reflects the possibility of the space being traversed. The higher the degree of selectivity, the more likely to be traversed by people. The degree of selectivity refers to the relationship between the topological depth of each space and the degree of selection of people flow, and also represents the importance and accessibility of each space.
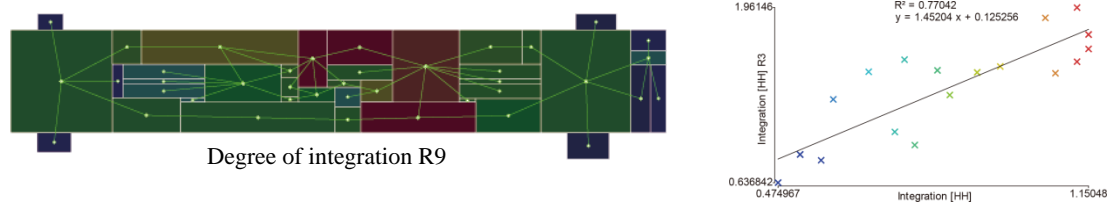
Degree of integration R9

Figure 3. Degree of choice R9 and simulation diagram

Figure 3 is the model simulation of the selectivity R9 of the Lijiacun station hall floor. Based on the upper and lower figures together, a similar conclusion can be drawn. The replacement space in the middle is affected by the accessibility and activity of the stairs, elevators and straight ladders, making this area the most selective space. In other words, it can be called a must-pass place for people; the second focus is on the east and west distribution sites and the connecting corridor to the north. Compared with the previous selectivity analysis, the inaccuracy of the topological depth of the edge convex space was removed, so that the overall core area has a higher selectivity.

It can be seen here that in the convex space where the core space of people flow interaction is located where the east and west elevators are located [19]; secondly, it extends outwards. Since there are more choices of routes to go to the east and west ends, people will choose to stay in the middle, which is also a crowd control problem that will occur in practice. For example, at the peak of people-flow, certain carriages will be crowded and others would be uncrowded [20].

4. Conclusion

Xi'an faces various problems such as lack of public space, traffic congestion, aging community facilities, and the need for protection of historical features. The construction of the subway has improved the mobility and accessibility of the urban area, and the environment of subway entrances and exits has improved the tolerance and connection of the urban area. The integration and re-creation of rail transit and urban space will greatly promote the vitality and recovery of the urban area.

In conclusion, this paper uses the environmental spatial evaluation index system of subway entrances and exits based on AHP to evaluate a representative subway station entrance and exit in Xi'an urban area. Among them, Lijiacun Station is a transportation hub station, and the efficiency of the entrance and exit needs to be further improved. This includes improvement in walking time and walking distance; the evaluation results reflect the applicability of subway entrances and exits in various first-level indicators.

Disclosure statement

The authors declare no conflict of interest.

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