The Application of Pedestrian Microscopic Simulation Technology in Researching the Influenced Realm around Urban Rail Transit Station

Dongzhu Chu¹, Shuxiang Wei² and Yanyu Lin³

1. Faculty of Architecture and Urban Planning, Chongqing University, Key Laboratory of New Technology for Construction of Cities in Mountain Area, Chongqing 400030, China

2. Faculty of Architecture and Urban Planning, Chongqing University, Chongqing 400030, China

3. Faculty of Architecture and Urban Planning, Chongqing University, Chongqing 400030, China

Abstract: Under the background of urban rail transit's rapid development, urban rail transit station, as the only connection of urban space and rail transit, undertakes the responsibility of traffic organization and passenger volume distribution. Influenced urban realm around station becomes the focus of the optimization of the sustainable urban development. Pedestrian microscopic simulation method establishes the comprehensive dynamic behavior rules in a part of urban space through simulating the behavior law by digital tools, in which the internal demand and motive mechanism of the development and change of urban space fairly well by digital representing and analyzing relevant laws can be explained. After that, the research with the realm as the carrier analyzed the demand of each simulation level and the choice of simulation parameters based on analyzing the walking connection behavior characteristics, and then further established the methodology system of pedestrian microscopic simulation. At last, the research taking the study of influenced urban realm around typical station for sample explored the application method of optimizing of urban space and traffic organization based on AnyLogic platform.

Key words: Urban rail transit, optimization of traffic organization, influenced urban realm around station, walking connection behavior, pedestrian microscopic simulation.

1. Introduction

In transportation design and analysis, pedestrian microscopic simulations are common. The different behaviors of pedestrians can be simulated based on different mathematic models. In urban design, by digital simulation of individuals and the interaction between them in the urban area, pedestrian microscopic simulation illustrates the bottom-up dynamic mechanism and process of urban space development and introduces the technology into urban design, optimizing and updating to a great extent, so as to effectively improve the ability of problem-solving of urban design on the micro level.

In urban design, the natural conflict between human demands and space requirements is prioritized. Among features related to behavior law, it has become the key element relating to urban space. It is a key point in future research on urban space features.

Currently, the social force model is perhaps the best known. In 1995, physicists Helbing and Molnar first proposed their embryonic form, and later published a model in the journal *Nature* in 2000. The social force model can simulate the self-organization process of pedestrians, and thus vividly reflect behavior features of the pedestrian flow. Representative software includes AnyLogic, SimWalk and NOMAD, etc.

It is a quite challenging and very urgent problem to organize stations and the surrounding urban space from the micro perspective. Applying the pedestrian

Corresponding author: Yanyu Lin, master of architecture, research fields: urban design simulation, virtual reality technology and building design.

microscopic simulation technology to the urban design of influenced urban realm around station is the current application of self-organization planning. Among various self-organization planning methods abroad, multi-individual simulation centered on pedestrian microscopic simulation is a practical and increasingly mature method. There have been successful examples regarding multi-rail transit and comprehensive development of surrounding urban environment based on the technology in several countries and regions including Hong Kong, Japan and the UK.

2. Research and Application Foundation

2.1 Simulation Requirements of Pedestrian Connection Behavior

This research focuses on the influence of a station on the urban space based on pedestrian timings. The influenced urban realm around station refers to a certain urban space around a specific station, in which various behaviors of individuals will be influenced by this station. From the 1950s, the research on pedestrian behavior features shifted from macro features to micro ones. Pedestrian micro behavior three-level theory proposed by Hoogendoorn and Bovy from Delft University of Technology in the Netherlands divided pedestrian micro behavior into

three levels [1], namely strategy level, tactical level and operational level, corresponding to the psychological decision-making process of pedestrians, and received relatively wide recognition. Referring to the three-level theory, pedestrian behavior features in the micro simulation can also be divided into the perception level, option level and action level (Fig. 1). Different levels have different simulation requirements [2, 3].

2.2 Characteristic Parameters of Pedestrian Connection Behavior

Pedestrian behavior feature parameters can be divided into macro and micro parameters. According to the area of urban design, together with current studies by relevant scholars, the simulation requirements level and the simulation feasibility of every parameter were summed up [4].

In the specific simulation process, it is impossible and not necessary to take all behavior feature parameters into consideration [5]. Therefore, the simulation parameter needs to be simplified to some extent, as long as the major features of pedestrian connection behavior can be demonstrated. As for the requirements of the simulation, some simulation parameters are preserved or eliminated. Finally, walking speed, space requirements, walking influenced

Fig. 1 The relationship between psychological decision and behavior simulation.

scope, accelerated speed, destination, active link, turning actions, queuing, waiting, and facility influence are included in the major parameters of simulation.

3. Applications for Pedestrian Micro-simulation Technology

Exploring the methodology for introducing pedestrian microscopic simulation into the micro process of urban design is a key stage in connecting urban space and rail transit. The application of the technology consists of three stages, namely urban survey, survey statistics and simulation analysis. This research chose AnyLogic 7.0 as the software platform and used the social force model to conduct the pedestrian micro-simulation study (Fig. 2).

Liziba Station on the Chongqing light rail network's Line 2, is located by the Jialing River in the city's central Yuzhong District. It is housed within a large residential tower block. The station is on the 6th floor due to the local hilly landscape. Exit B of the station connects to an upper road running along a ridge behind the building at 6th floor level while Exit A is down on the first floor. The station is close to

residential areas and bus stops with a large population flow, complicated traffic routes and unusual space.

3.1 Survey of Urban Information

According to the requirements of the research and software simulation, the survey consists of two major parts: physical environment and pedestrian behavior (Fig. 3). There are four major aspects:

- (1) Work out the isochrone zone, so as to identify the simulation scope and the urban elements;
- (2) Establish the mathematical model. In this way, the base map of the simulation region is generated and all functional regions are identified;
- (3) Calculate the traffic volume and the pedestrian component ratio at every key point in the simulation region according to the record;
- (4) Survey the movement, capacity of buses and taxis within the simulation region, so as to identify the operational ability of this transferring method.

3.3 Simulation Analysis

AnyLogic provides a visualized simulation observation mode, enabling designers to better grasp the micro behavior of pedestrians. However, AnyLogic

Fig. 2 Simulation process of AnyLogic.

Fig. 3 The isochrone zone and landscape of Liziba Station.

Fig. 4 The pedestrian simulation flow diagram and present situation of influenced urban realm around Liziba Station.

does not provide a section mode. Hence, the section simulation effect of Liziba Station is drawn according to the simulation result, reflecting some problems (Please refer to Fig. 4 for the pedestrian flow simulation result of urban design on a micro-level). The following conclusions can be drawn in line with the pedestrian flow figures of Liziba Station and surrounding pedestrian channels (Fig. 4).

Comparing the AnyLogic simulation results and real scene images, they can be seen to be very close indicating that AnyLogic can go on to help improve pedestrian flows. Based on the above analysis of the simulation results, several recommendations for the Influenced Urban Realm around Station at Liziba and for further simulation are as follows:

- (1) Broaden the width of stairways connecting Liziba Station platform and hall;
- (2) Given that the function of the station hall is

ensured, the collecting and distributing space at the station hall level can be enlarged via the subsidiary room so as to control pedestrian density at Exit A efficiently;

- (3) Try best to cut down parking spaces along the street to the north side of Exit B, and enlarge the walking area for pedestrians to improve access for nearby residents.

- (4) Creating a platform bridge by making use of the height differences of the station and vertical transportation at Exit A could separate pedestrians from vehicles, and eliminate security risks without adding a new line.

In summary, recommendations from the analysis of the influenced urban realm around Liziba Station can solve the problems established in the first simulation. Should they did not achieve expect, analysis shall be carried out for the new problem with optimization

again. This research is only the first exploration of pedestrian simulation method, in hope that solution of microcosmic problems can facilitate the optimization in the influenced urban realm around station from macro level.

4. Conclusions

Here we may draw the following conclusions:

(1) The rapid expansion of cities and dramatic increase in complexity is undeniable. What should be ensured is that people's physical condition and behavioral competence will not be altered negatively due to the expansion of cities, nor will they see significant cultural/societal changes. While paying attention to urban macro system question, we shall also pay attention to the minutiae of the quality of people's lives;

(2) By exploring pedestrian micro simulations, the method of "simulation—optimization—re-simulation—re-optimization" was created. It has updated the methodology of urban design, perfected the appraisal system of urban design based on digital tools, and contributed refinements to urban design on a micro level. Meanwhile, by introducing pedestrian microscopic simulation into urban design, this method

has been applied in wider aspects, broken through its original traffic auxiliary analysis field, made a marked and positive effect on space comparison and rational decisions regarding urban design.

Acknowledgments

This research was supported by National Natural Science Foundation of China (Project No.51478055) , and Foundation and Frontier Research Project of Chongqing (Grant No. cstc2015jcyjA00047).

References

- [1] Hoogendoorn, S. P., and Bovy, P. H. L. 2004. "Pedestrian Route-Choice and Activity Scheduling Theory and Models." *Transportation Research Part B* 38: 169-90.
- [2] Hu, M., and Shi, Q. 2009. "Comparative Study of Pedestrian Simulation Model and Related Software." *Journal of Transport Information and Safety* 4: 122-7.
- [3] Jia, H., Yang, L., Tang, M., and Meng, D. 2009. "Micro-characteristics and Modeling Requirement of Pedestrians in Multi-modal Transport Hub." *Journal of Transportation Systems Engineering and Information Technology* 2: 17-22.
- [4] Helbing, D., Farkas, I., and Vicsek T. 2000. "Simulating Dynamical Features of Escape Panic." *Nature* 7: 487-90.
- [5] Zhang, G. 2009. "Pedestrian Traffic Behavior and Microscopic Simulation Research on Station Square of Synthetical Passenger Transport Hub." Master's thesis, Beijing Jiaotong University.