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Research on Safety Assessment of Urban Rail Transit Station Simulation Operation Based on Multi-Source Data

Lin ZHOU[a1], Yuan LU[b], Nan HE[c], Fei XUE[d]
[a]*School of Automotive Engineering, Beijing Polytechnic, Beijing 100176, China,*
[b]*School of Architecture and Design, Beijing Jiao tong University, Beijing 100044, China*
[c]*Beijing Mass Transit Rsilway Operation Corp.LTD., Beijing 100044, China*
[d]*Beijing Municipal Supply and Marketing Institute, Beijing 102400, China*

Abstract. In order to improve the operation safety management efficiency of urban rail transit stations, a study on simulation operation safety evaluation of urban rail transit stations based on multi-source data is put forward. Firstly, this paper starts with the construction principle of evaluation system, fully considers the characteristics of each region of the station, selects evaluation indicators for each region, analyzes the indicators and divides them into standard grades, and constructs a safety state evaluation model for station simulation operation. Secondly, taking a transfer station as an example, combined with the specific scene, the parameters of the evaluation model are estimated, and the passenger transport organization scheme of the station is simulated, and the existing problems are analyzed and the optimization scheme is put forward, which provides strong support for the station operation safety and optimization decision. Finally, a line area of a transfer station is selected for example verification and test analysis. The station is a two-line transfer station, in which the line area is an underground station with an east-west layout, and the platform is a side platform. Two lines are transferred by escalators, straight ladders and passages in the transfer building. By connecting the real data of the station to the simulation system, the analysis and evaluation of the safety state of the station operation driven by data can be realized, and the rationality and efficiency of the station operation organization scheme can be effectively improved, thus improving the digitalization and informatization level of the station.

Keywords. multi-source data; Urban track; Simulation operation

1. Introduction

Urban rail transit system has become the first choice for residents in large and medium-sized cities because of its advantages of fast, convenient, punctual and large volume. The scale of its network is constantly expanding, and it has gradually entered the stage of networked operation, with increasing passenger flow. As an important place where passenger flow is distributed and lines cross, improving the operation level of the station is an important guarantee for the safe and efficient operation of the road network. At present, it is still difficult for the station operation management to grasp the detailed

[1] Corresponding Author: Lin ZHOU, School of Automotive Engineering, Beijing Polytechnic; e-mail: 13811972472@163.com

passenger flow in the station in time, and the station operation safety state evaluation has not been systematically carried out. How to verify the effectiveness of the station operation organization scheme, evaluate the station operation safety level, and realize the active management and control of operation safety is still an important problem to be solved urgently. On the basis of intelligent simulation of urban rail transit stations, combined with specific simulation scenarios, a scientific and reasonable evaluation method of station operation safety state is constructed, which can realize the analysis and evaluation of station operation safety state, effectively improve the timeliness and fineness of digital simulation of stations, and provide scientific and systematic support for the evaluation of station operation safety state [1-2].

2. Calculation Method Based on Multi-Data Fusion

Taking TOF passenger flow counter as the coaching unit, the accurate stereoscopic image in the same field of view as the binocular sample image is obtained, and the binocular stereoscopic image is trained and calibrated by the intelligent learning unit. One monocular image, a matching cost map and a binocular stereo vision image are used as the three-channel alignment inputs of the deep convolution neural network, and the corrected coach unit stereo vision image is used as the positive sample image to start training until the deviation between the output stereo vision image and the positive sample image meets the threshold condition, otherwise, each pixel of the positive sample image is corrected according to Formula (1):

$$T_{(x,y)} = \left\{ k_1 T_{(x,y)} + K_2 L_{(x,y)} + K_3 D_{(x,y)} \right\} \tag{1}$$

Where: T(x,y) represents the pixel value of the pixel point with the coordinate of (x,y) in the output stereoscopic image; L(x,y) represents the pixel value of the pixel with the coordinate of (x,y) in the corrected stereoscopic vision image of the coaching unit; D(x,y) represents the pixel value of the pixel point with the coordinate of (x,y) in the corrected binocular stereo vision image; Tmax and Tmin respectively represent the maximum and minimum pixel values of pixels with coordinates (x,y) in the stereo vision image trained by neural network; k1, k2 and k3 are the weight coefficients corresponding to T (x, y), L (x, y) and D (x, y) respectively.

When the training is completed, the binocular passenger flow counter can produce high-precision stereoscopic vision images similar to those of the coach unit, and the counting accuracy of the binocular passenger flow counter can be improved without increasing the cost.

3. Evaluation System Construction

In order to better evaluate the safety management level of station operation, according to the relevant specification documents and existing research results, the station is divided into four areas, namely, the station hall area, the hall-platform connection (escalator) area, the platform area and the transfer corridor, by using the methods of expert interview and field investigation, based on the technical characteristics of dynamic passenger flow simulation and the station operation scene. According to the regional characteristics, the evaluation indexes are selected from the aspects of passenger flow, facilities and equipment capacity, transfer situation, etc., and the evaluation index system of urban rail transit station operation safety state is constructed, as shown in Figure 1.

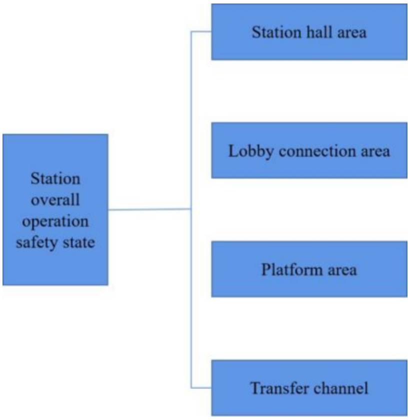

Figure1. Construction of evaluation index system

3.1. Evaluation Index Analysis

3.1.1. Maximum passenger flow density

The maximum passenger flow density refers to the maximum value of the ratio of passenger flow to area in the detection area. This index is the core index for evaluating passenger flow safety, which reflects the density of passenger flow. The greater the maximum passenger flow density, the lower the passenger flow safety. The calculation formula is Formula (2):

$$\mathrm{P}_{\max} = \max\left\{\frac{P_1}{S_1}, \frac{P_2}{S_2} \frac{P_k}{S_k} \frac{P_n}{S_n}\right\} \tag{2}$$

In formula (2), Pmax is the maximum passenger flow density in the detection area; Pk is the passenger flow passing through the k-th detection area at a certain moment; Sk is the area of the k-th detection area at a certain moment.

3.1.2. Capacity Load of Facilities and Equipment

The capacity load of facilities and equipment is the ratio of the passenger flow through facilities and equipment to the capacity of facilities in a unit time, which reflects the matching degree between the passenger flow and the maximum capacity of facilities and equipment. The calculation formula is Formula (3):

$$\lambda = \frac{P_s}{N} \tag{3}$$

In Formula (3), Ps is the passenger flow of the facility S in unit time; N is the maximum capacity of facilities and equipment.

3.2. Evaluation Scope and Standards

Because the station simulation evaluation has not yet formed a systematic and applied index system, the evaluation standards are scattered and not uniform. According to the relevant norms, standards and research results, this paper sets the index range and evaluation standard grade according to the above evaluation indicators and the regional characteristics of the station [3-4]. The evaluation indexes, standard sources, index ranges and evaluation grades of station simulation operation safety state are summarized in Table 1.

Table 1. Evaluation Scope and Grade

Assessment area	**index**	**Indicator source**	**Index range and evaluation grade**
Station hall area	Maximum passenger flow secret Capacity load of facilities and equipment	Refer to the Manual of Public Transport Capacity and Service Quality. On-the-spot investigation and study, combined with the opinions of experts and operators	A B
Hall-platform connection area	Maximum traffic flow per unit time	Refer to the Manual of Public Transport Capacity and Service Quality.	A

4. Example Testing and Analysis

4.1. Example Test Verification

A line area of a transfer station is selected for example verification and test analysis. The station is a two-line transfer station, in which the line area is an underground station with an east-west layout, and the platform is a side platform. Two lines are transferred by escalators, straight ladders and passages in the transfer building. There are three entrances and exits in the south, north and east of the station, of which two entrances and exits in the south and north can be used for entering and leaving the station[5].

The entrance and exit on the east side are only for exit, and under normal circumstances, each exit population is open. Diversion barriers are set outside the toll area at the entrance and in front of the transfer escalator. By changing the opening or closing form of the diversion barriers, passengers can enter the next area directly or around, so as to control the passenger's walking path and distance. According to the data of the transfer station plan, train operation diagram, passenger organization and passenger flow, the station simulation model is built, and three simulation schemes are designed, including working day morning peak mode, weekend mode and holiday mode for simulation test research [6-7].

4.2. Simulation Evaluation Results Analysis

After simulation, taking the morning peak mode and weekend mode as examples, the simulation and evaluation results are analyzed.

In the morning rush hour mode, passengers mainly need to commute after work on weekdays, and the passenger flow at this station presents a typical double-peak distribution feature on weekdays. Select the morning rush hour (7:00-9:00) of a working day for simulation, and dynamically adjust the passenger flow behavior characteristics by Poisson distribution mode during this time period. The statistical analysis and evaluation of the simulation results are shown in Table 2.

Table 2. Statistics of total passenger traffic

Station passenger traffic/person-times	**320000**		
Inbound passenger flow/person-time	12000	Outbound passenger flow/person-time 8500	Passenger flow/person-time of station change: 12,500
Number of people waiting in line for 15 minutes and value area	Entrance diversion column on the north side of the station hall area	Number and value of people waiting in line for 15min/person 120	Average number of people queuing in 15min/person 70
Extreme value area of 15min passenger flow density	The hall and platform connect the escalator of the transfer building on the north side of the district city.	15min passenger flow density extreme value/person m-2 0.86	Average passenger flow density in 15min/person m- 20.39

During the morning rush hour on weekdays, the overall operation safety assessment level of the station is Grade B, and the safety level of all areas in the station, including the station hall, platform, hall-platform connection area and transfer corridor, is Grade B.. During the morning rush hour on weekdays, the key areas of the station are the diversion column area of the station hall area, the escalator area of the transfer building and the transfer passage area of the hall-platform connection area, with high passenger flow density, and the load of facilities and equipment on the station hall floor is 0.80, and the passenger flow distribution in other areas is relatively balanced[8-10].

5. Conclusion

Based on the construction principle of simulation evaluation system of urban rail transit station and the background of station operation safety management, this paper makes in-depth analysis and research on the evaluation index system of operation safety state. Firstly, the station is divided into station hall area, platform area, hall-platform connection area and transfer corridor area. According to the characteristics of passenger flow in each area, evaluation indicators are selected to evaluate the operational safety status. Then, by constructing evaluation models and calibrating weights, the overall operational safety status grades of each area and station are obtained, which makes the evaluation results more effective, hierarchical and comprehensive. At the same time, the feasibility and effectiveness of the index system and evaluation criteria are verified by using the station simulation system and combining with specific stations to verify the feasibility and effectiveness of the established index system and evaluation criteria through digital simulation of operation organization schemes in different scenarios. By studying the scientific and reasonable evaluation method of safety state of urban rail transit station simulation operation, it provides quantitative basis for the improvement and optimization of station operation organization scheme, and enhances the refined degree and information level of station operation organization management.

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