Simulation and Optimization of Intelligent Evacuation System for Urban Rail Transit Station

Runyu Wu, Cunjie Dai, Xiaoquan Wang, and Shixiang Wan

***Abstract*—Urban rail transit(URT) has become an important tool to improve the efficiency of public travel services due to its large volume, high punctuality rate, and other characteristics. However, URT's transportation organization work is often affected by sudden large passenger flow, resulting in increased system operation risk, especially for the station emergency evacuation process. In order to improve the efficiency of the emergency evacuation system of subway stations under the condition of sudden large passenger flow, taking the South Station of Shen'an Bridge of Lanzhou Rail Transmit Line 1 as an example, an intelligent evacuation system of urban rail transit station was established by AnyLogic according to the actual operation scenario. The bottleneck area restricting the evacuation efficiency of personnel was found by combining the uncertainty theory, and an optimization measure was proposed based on the location of personnel during evacuation to improve the established intelligent evacuation system. The experimental results show that this measure can improve evacuation efficiency by 13.76%. If combined with other measures, the optimal optimization effect of the designed combination scheme can reach 19.37%. The optimization measures and evacuation schemes proposed in this paper can provide decision support for the design and improvement of an URT station evacuation system.**

***Index Terms*—Urban Rail Transit, Uncertainty Theory, Station Intelligent Evacuation System, AnyLogic.**

I. Introduction

The construction and operation technology of Urban rail transit(URT) in China is becoming more and more mature. However, there is still a phenomenon of URT-related companies paying more attention to construction than operation in practice. In this regard, many scholars have carried out many studies on the core issue of improving transportation efficiency and reducing operating energy consumption based on the management and control level of URT, aiming at realizing the refined management of the entire URT system. Among them, the emergency evacuation management of subway stations is essential to the URT layer of passenger flow forecast and command control. Establishing an intelligent evacuation system and designing and applying a reasonable emergency evacuation plan can further improve the operational safety of URT systems.

Many scholars have researched the evacuation plan that should be adopted when emergencies occur on the subway platform. Hu et al. [1] compared different evacuation strategies and their optimization effects on subway stations under different water intrusion levels and concluded that the number of station exits had the most significant impact on the evacuation efficiency of personnel in the station. Wang et al. [2] simulated the explosion scene on the subway platform. The simulation results show that the group behavior will significantly reduce the evacuation efficiency, and the evacuation plan should be given to prevent the occurrence of confluence nodes or road sections. Zheng et al. [3] considered the state of the evacuees in the subway station. They compared it with the evacuation process of students in the teaching building and personnel in the high-rise building and gave the change of evacuation efficiency. Chen et al. [4] used Pyrosim to simulate the evacuation of personnel in subway stations under fire scenarios. The FED influence model was improved using parameters such as CO concentration and visibility, and the most effective evacuation plan was given. Wei et al. [5] set the evacuation cost as the optimization goal, the design capacity of the shelter as the constraint condition, and the Dijkstra algorithm as the core to construct the earthquake emergency evacuation model. The solution results are visualized by ArcGIS.

In the process of an emergency evacuation, the influence of the internal structure of the station and the layout of facilities and equipment on the evacuation efficiency of personnel in the station should be considered. Li [6] proposed the bottleneck propagation process in the hub by simulating the personal to obtain the space-time transfer characteristics of evacuation under extreme conditions. Based on the principle of the particularity of platform personnel behavior, Li et al. [7] used AnyLogic to construct a subway platform scene with complex interwoven passenger flow and optimized the defects in station facilities and equipment layout. Xu et al. [8] treated the multi-story large-scale rail transit transfer station as a complex system. The simulation of the evacuation process after modeling found that pedestrians would stay in some places in the station, and a more effective evacuation route was designed accordingly. Chen et al. [9] simulated that the stairs and surroundings quickly form arched crowd congestion when evacuating people in complex areas. Li et al. [10] established a building safety evacuation model based on facility layout and dynamic

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information. They used this model to determine the bottleneck location and efficiency of personnel evacuation under various structures. Yu et al. [11] proposed optimization measures for the layout, spatial location, and quantity of transfer equipment. After comparing the optimization effects, it was found that increasing the number of exports can effectively reduce crowd congestion. At the same time, relying on Pathfinder to model the building and simulate the process of crowd evacuation, the research on designing different schemes for evacuation optimization is increasing[12-15].

The existing research shows that the simulation and analysis of emergency evacuation in URT stations are mostly based on the macro level. More research must be done on the difference between pedestrian behavior selection and the corresponding adaptive space division during evacuation. In the study of sudden large passenger flow in URT, the existing research mainly focuses on optimizing the transportation organization scheme of the line where the station is located and even the whole system. However, there are few studies on the division of passenger flow evacuation areas in specific stations. Therefore, in the context of sudden large passenger flow, this paper takes Lanzhou Shen'an Bridge South Station as an example, uses AnyLogic to establish an intelligent evacuation system for subway stations, and combines the uncertainty theory to find the bottleneck position restricting pedestrian evacuation efficiency. After analyzing the experiment results, the optimization measures for dividing the crowd and specifying the target area during an evacuation are proposed, and different evacuation schemes are designed accordingly. The simulation results can provide decision support for designing and improving the evacuation system of URT stations.

II. Theoretical Overview

A. Research framework

Based on the existing pedestrian social force model of AnyLogic, combined with the relevant data and operation data collected in the previous field, the daily operation model of Shen'an Bridge South Station is established first, and then the intelligent evacuation system model of the station is established by adjusting the relevant parameters and internal logic. After many experiments, the bottleneck of personnel evacuation in the station is obtained by combining the uncertainty theory, and various evacuation schemes using different measures are designed accordingly. Finally, the influence of different schemes on the evacuation effect is analyzed according to the optimization results.

B. Station emergency evacuation time

The time (unit: minute) of personnel safety evacuation in subway stations under the background of sudden large passenger flow can be calculated according to the existing national standards and research [16-17]. The evacuation time is mainly divided into two parts: platform evacuation time and station hall evacuation time.

B.1 Platform evacuation time

Personnel on the platform layer respond to evacuation signals after a certain amount of delay. Then look for escalators or straight ladders to take away from the station. The passing capacity and number of stairs and escalators impact the evacuation time. At the same time, the non-standard symmetrical structural characteristics of the platform layer will also affect the personnel evacuation time. Personnel on the platform layer start to move after receiving the evacuation signal until the time of leaving the station T_1 (unit: minute) is shown in (1):

$$T_1 = \sum_{i=1}^{4} t_{1i} \tag{1}$$

$$t_{12} = L / v \tag{2}$$

$$t_{13} = Q / 0.9\left(\sum_{i=1}^{2} A_i N_i + A_3 B_3 \right) \tag{3}$$

$$t_{14} = \max\{L_{valid} / V_{absolute}\} \tag{4}$$

$$t_{15} = L_{\max 1} / v \tag{5}$$

Among them, in (1), t_{11} indicates the average time for the station to send an evacuation signal until the personnels receives the signal and responds with a value of one minute; in (2), t_{12} indicates the walking time of personnels before entering the escalator or stairs after receiving the evacuation signal (unit: minute), L is the longest distance from the evacuation starting point of personnels in the station to the escalator or stairs (unit: meter), v is the average speed of movement of personnel , v = 90(meter/minute); in (3), t_{13} is the time for personnels to pass through stairs or escalators (unit: minute), Q is the number of people who need to be evacuated on the platform layer, A_1, A_2 are the passing capacity of escalators when they are running and stopping (unit: number of people/minute), N_1, N_2 is the number of escalators that are running and suspended during evacuation (unit: number of people / minute) , A_3 is the passing capacity of stairs (unit: number of people/meter), and B_3 is the total width of stairs; in (4), t_{14} is the average residence time on the stairs or escalators (unit: minute), L_{valid} is the effective length of the escalator between the platform layer and the station hall layer (unit: meter), $V_{absolute}$ is the absolute speed of personnel on the escalator; in (5), t_{15} is the non-uniformity deviation time of the structure (unit: minute), and $L_{\max 1}$ is the maximum distance between the escalators on the platform floor (unit: meter).

B.2 Station hall evacuation time

From receiving the evacuation signal to leaving the station, the number and layout of some business equipment in the station hall layer will affect evacuation efficiency. The capacity of the exit ticket gate is directly related to the exit structure and evacuation effect. Personnel on the station hall floor begin to move after receiving the evacuation signal until they leave the station, as shown in (6):

$$T_2 = \sum_{j=1}^{4} t_{2j} \tag{6}$$

$$t_{21} = T_1 \tag{7}$$

$$t_{22} = L_{\max 2} / v \tag{8}$$

$$t_{23} = Q / 0.9\left(\sum_{j=4}^{5} A_j B_j \right) \tag{9}$$

$$t_{24} = Q / 0.9\left(\sum_{j=1}^{3} A_{cj} B_{cj}\right) \quad (10)$$

Among them, in (7), t_{21} is the personnel evacuation time on the platform layer; in (8), t_{22} is the walking time of personnels in the station hall during the evacuation process (unit: minute), $L_{\max 2}$ is the farthest walking distance of personnels in the station hall layer (unit: meter); in (9), t_{23} is the time for personnel to pass through the ticket gate (unit: minute), A_4 is passing capacity when the ticket gate is opened (unit: number of people/min), A_5 is passing capacity of the artificial channel (unit: person/min), B_4 is number of ticket gates , and B_5 is the width of the population channel (unit: meter); in (10), t_{24} is the time of personnel pass through the safe exit of the station hall layer (unit: minute), A_{cj} is passing capacity of No. j exit (unit: number of people/(minute· meter)), B_{cj} is the width of No. j exit(unit: number of people/(minute ·meter)).

C. *Uncertainty characteristic analysis*

It is worth noting that the research on promoting industrialization and informatization according to fuzzy conditions has gradually entered the public eye[18]. In this paper, the uncertainty theory suitable for solving random problems in the field of transportation is selected to describe the evacuation time in the station[19].

When organizing the evacuation of personnels in the station under the condition of sudden large passenger flow, the evacuation efficiency will drop sharply. Q_{ti} is evacuation time of the platform layer of the No. i simulation, Q_{pj} is evacuation time of the hall layer of the No. j simulation and Q is evacuation time of the whole station are all uncertain variables, and they obey the uncertain distribution on the specific reliability. The constraint equations are established by using the uncertainty theory [20]. After setting different confidence levels, the bottleneck position in the process of evacuation of personnels in the station is determined according to the numerical results.

The reliability that the evacuation simulation time of the platform layer does not exceed the theoretical evacuation time of the platform layer T_1 is set as λ_1, and the reliability that the evacuation simulation time of the station hall layer does not exceed the theoretical evacuation time of the station hall layer T_2 is assessed as λ_2. The constraint conditions are established as (11) (12). The floor determines the evacuation simulation results of the entire station with ample evacuation time. Combined with the principle of event reliability calculation in uncertainty theory, (13) is listed:

$$M\{Q_{ti} \le T_1\} \ge \lambda_1, \ i = 1,2,...,5 \quad (11)$$

$$M\{Q_{pj} \le T_2\} \ge \lambda_2, \ j = 1,2,...,5 \quad (12)$$

$$M\{Q \le T\} = M\{Q_{ti} \le T_1\} \vee M\{Q_{pj} \le T_2\} \quad (13)$$

III. Simulation Modeling Based on AnyLogic

The South Station of Shen'an Bridge is located at the intersection of the three border areas of Qilihe, Xigu and Anning districts in Lanzhou City, as shown in Fig.1, many large shopping malls and residential areas around it. With the Lanzhou Olympic Sports Center being used as a large-scale event hosting site, the South Station of Shen'an Bridge, as the only rail transit station nearby, will further increase its transportation organization pressure.

Fig. 1. Station geographical location diagram

This paper is based on the realistic background of the sudden large passenger flow at the end of the fireworks show in Lanzhou Wanda City during the Spring Festival of 2022, significantly impacting the operation of Lanzhou rail transit. Taking Shen'an Bridge South Station as an example, an intelligent evacuation system for the URT station is constructed.

A. *Station plane model drawing of each layer*

There are three floors in the south station of Shen'an Bridge. In addition to the ground floor, the first underground floor is the station hall layer of Line 1, and the second underground floor is the platform layer of Line 1. The ground floor has three entrances, A, B, and D, and a barrier-free straight ladder entrance and exit. Between the ground floor and the underground first floor, the entrance and exit corridor constructed by three escalators and stairs is connected with a straight ladder. The underground first and second floors are connected in various ways, such as straight ladders, escalators, and stairs.

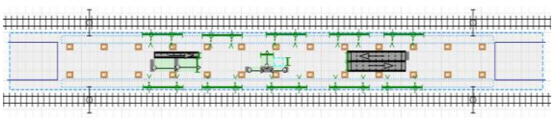
Fig. 2. Platform layer plane diagrammatic drawing

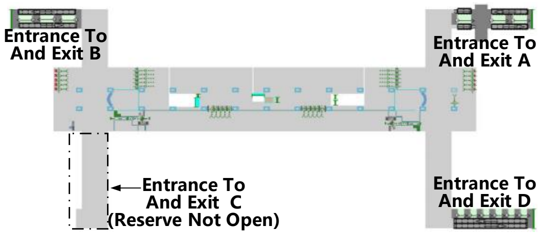

Fig. 3. Station hall plane diagrammatic drawing

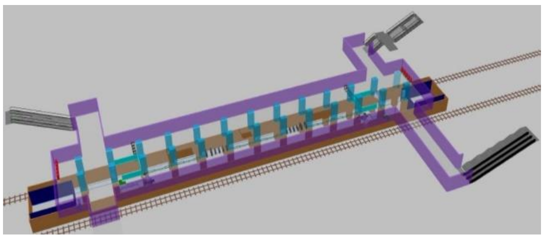
Fig. 4. Station stereo diagrammatic drawing

When drawing the three-layer station model in AnyLogic, each entrance and exit of the ground layer is placed in the station hall layer for drawing to reduce the number of agent modules used. The station model drawn is shown in Fig.2.-Fig.4. The green arrow in the figure indicates the service received by personnel there, the green target line indicates the end point of personnel walking, and the blue dotted frame shows the area where personnel waits.

B. Key parameter settings

Before constructing the evacuation logic in the station, it is necessary to set the corresponding parameters of the business equipment and personnel characteristics in the station. The details are shown in Table I and Table II.

TABLE I
BUSINESS EQUIPMENT FACT SHEET

Equipment Name	Amount	Single Service Duration
Self-Help Machine	10	Uniform(10,15)
Inbound Ticket Gate Machine	10	Uniform(2,3)
Exit Ticket Gate Machine	10	Uniform(2,3)
Metal Security Door	2	Uniform(3,5)

TABLE II
BUSINESS EQUIPMENT FACT SHEET

Entrance to and Exit	Functional Module	Personnel Generation Rate/(number of people·h)	Branch Weight
A	pedAD	3040	0.6
B	pedB	1520	1
D	pedAD	3040	0.4

This paper takes the sudden large passenger flow as the research background; that is, the number of personnel in the simulation modeling scene far exceeds the service capacity of the station supporting facilities. This part draws on the results of Zhang et al. [21] on the social force model, that is, due to an increase in the number of people, the repulsion between personnel reaches the limit, making the personnel walking speed extremely low, as shown in Figure.5. So, the description of personnel speed, gender, and other parameters is not considered in this paper.

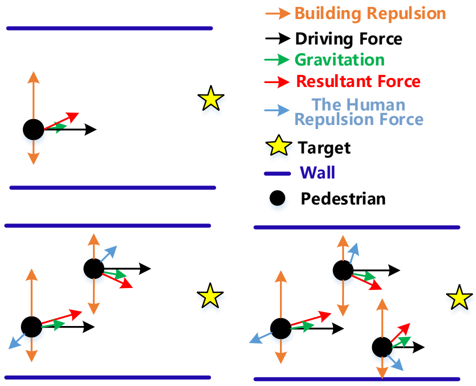

Fig. 5. Social force model diagram

C. Model logic design

According to the station structure and related parameters obtained from the actual scene, the station's personnel behavior and equipment usage is analyzed. Considering the physical and logical connection between the layers, the process logic diagram of the subway station is designed, as shown in Figure .6.

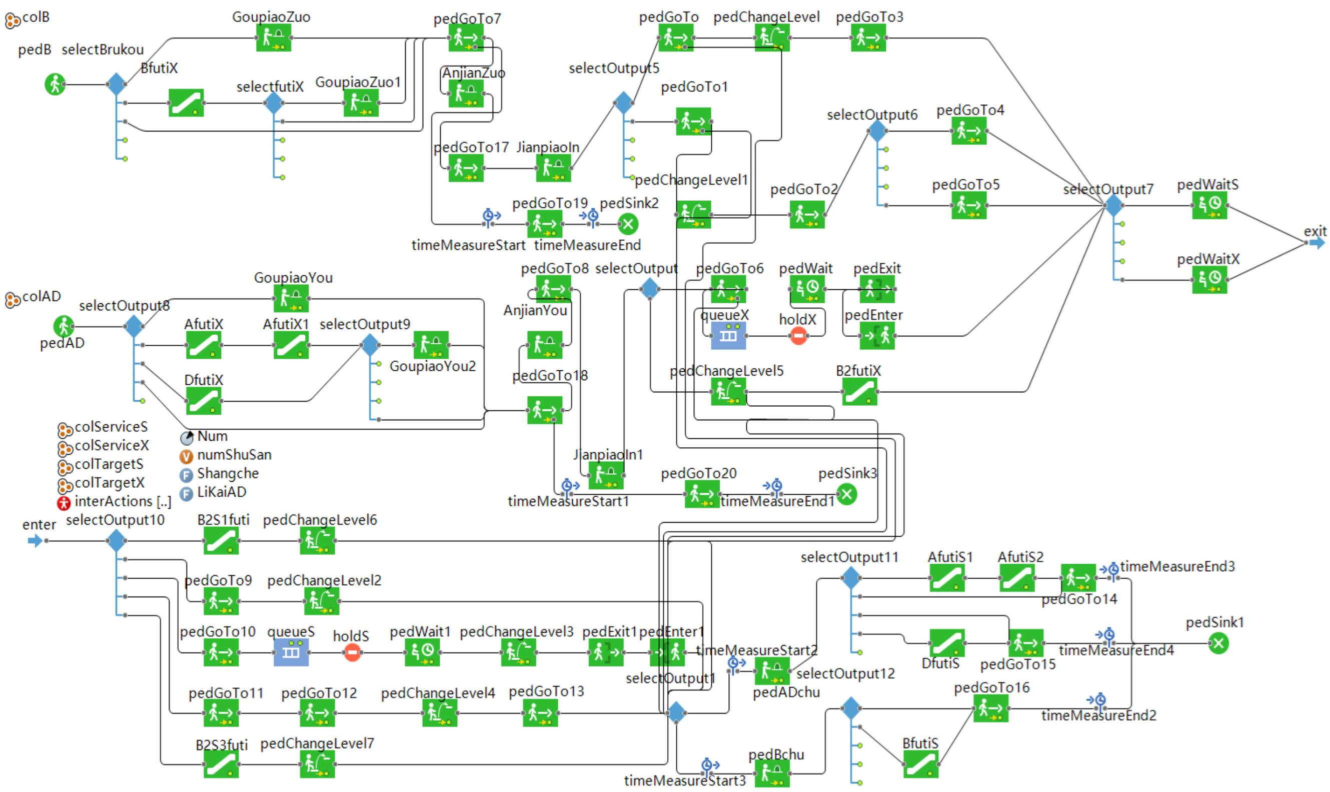

Fig. 6. Evacuation process logic diagram

TABLE III
PART OF THE EXPERIMENTAL RESULTS DATA TABLE

Floor \ Frequency		Experimental Value 1	2	3	4	5	Effective Mean Value	Calculated Value
Platform Layer Plane	Q_{ti}	11.133	10.811	11.053	11.106	10.986	11.110	T_1
	λ_1	0.857	0.882	0.863	0.859	0.868	0.866	9.540
Station Hall Plane	Q_{pj}	13.428	13.592	13.798	13.845	13.812	13.680	T_2
	λ_2	0.917	0.909	0.896	0.893	0.899	0.903	12.360

IV. SIMULATION RESULTS AND OPTIMIZATION DESIGN

A. Analysis of the original model results

Based on the established model and logic, this study selected a data set with a capacity of five and a normal distribution after multiple simulation experiments. The specific data are shown in Table III. According to the analysis of uncertain characteristics, the constrained model is established to solve the reliability of the simulation results of each floor. After processing the numerical results, it can be concluded that when the person in the station is evacuated, the evacuation bottleneck of the whole station is located on the station hall floor.

The reason why the local area of the station hall becomes the evacuation bottleneck can be intuitively found by the personnel density map generated by the model operation, as shown in Figure .7. There are many passengers transport business equipment in the station hall layer. Under the condition of large passenger flow, personnel quickly form severe queuing congestion at the self-service ticket vending machine and the entrance security check. At the same time, the connection between the platform layer and the station hall layer, namely the stairs, escalators, and straight stairs, will also form congestion, resulting in a higher risk of secondary accidents.

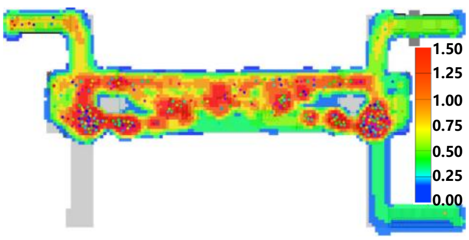

Fig. 7. Original model personnel density map

B. Personnel evacuation streamline design

In the designed initial station intelligent evacuation system, no passengers get off after the train arrives at the station. The arriving train is only used for the passengers who have arrived at the platform layer to leave the station. The rest of the passengers who are not in the waiting state need to be evacuated from the station by the station organization. The entry and exit gates that personnels need to pass through during the evacuation process verify that the gates are in an open state. The evacuation streamline design is shown in Figure .8.

The personnel flow line is designed to randomly generate personnel from three entrances and exits of A, B, and D to select the straight ladder or escalator to the station hall layer. After arriving at the station hall layer, select the self-service ticket vending machine to purchase tickets or a mobile phone code to enter the security check queuing sequence, complete the security check, and pass the inbound verification gate. Then select the straight ladder, escalator, or stairs to the station hall layer to wait for the train. After the target train arrives, take the train to leave the station.

After the station issues the evacuation instruction, the appropriate business equipment, such as security inspection, verification, and walking in the station evacuation system, will make scheduled adjustments (such as escalators changing the direction of operation, verifying the opening of gates, etc.), and personnel in the station will leave the station from each entrance and exit after passing through evacuation system.

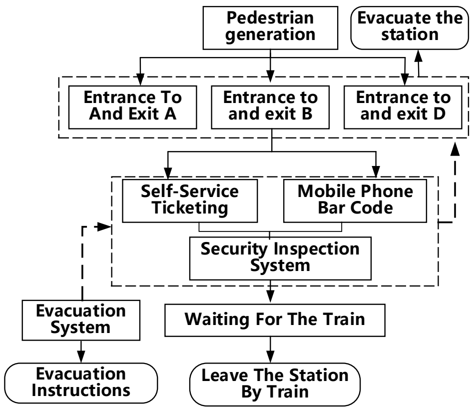

Fig. 8. Personnel evacuation streamline design map

C. Intelligent evacuation system optimization

According to the statistical results of the initial model, this study takes the equipment use and personnel organization of the station hall layer as the optimization object and designs a variety of evacuation schemes.

Due to the randomness of the evacuation signal time of the station in the face of sudden large passenger flow, when the station's intelligent evacuation system responds, the status of passengers in the station hall layer can be divided into the queue sequence that has entered the station without entering the security check and the platform layer that has passed the security check. Before evacuation, personnel in different states are divided. Their evacuation areas are stipulated, as shown in the red-filled area in Figure .9. To avoid cross conflict between personnels during an evacuation, the personnel walking path in the evacuation organization process is specified, as shown in the green dotted line in the red marker in Figure .10. At the same time, to improve the speed of personnel leaving the station, the station emergency evacuation system will adjust the direction of escalator operation at each entrance and exit, as shown in red mark in Figure .11. Correspondingly, the evacuation schemes designed according to different optimization measures are shown in Table IV.

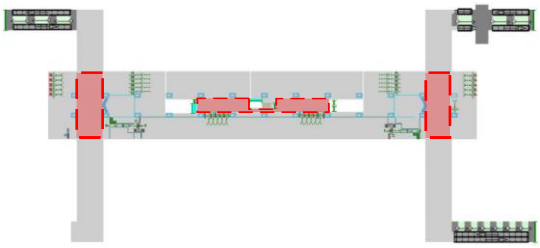

Fig. 9. The schematic diagram of dividing evacuation area in advance

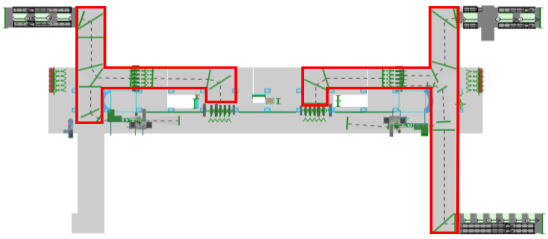

Fig. 10. Specified walking path diagram

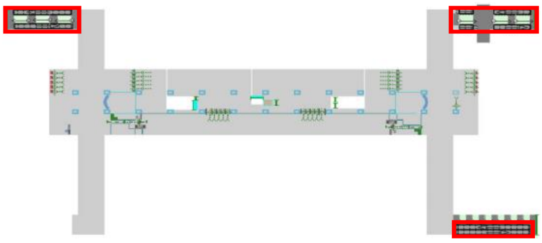

Fig. 11. Change direction of escalator diagram

TABLE IV
EVACUATION PLAN DESIGN TABLE

Scheme. No	Not Optimized	Dividing Evacuation Area in Advance	Specified Walking Path	Change Direction of Escalator Diagram
1	√	--	--	--
2	--	√	--	--
3	--	--	√	--
4	--	--	--	√
5	--	√	√	--
6	--	√	--	√
7	--	--	√	√
8	--	√	√	√

V. OPTIMIZATION RESULTS AND ANALYSIS

A. *Single measure optimization scheme*

After 30 minutes of operation, the model is set to organize evacuation of passengers who are not waiting in the station, and the number of people who can be evacuated from the station within 6 minutes is taken as an essential evaluation index[22]. The original model's simulation results, scheme one without any optimization measures, show that the number of people evacuated from the station within 6 minutes is 998, accounting for 43.8% of the total number of people in the station. The simulation results of the evacuation optimization scheme designed by single measures are shown in Table V. Fig .12. to Fig .14. indicate that scheme No.2 to scheme No.4 corresponds to the model to trigger the evacuation of the station hall layer. The deeper the color in the diagram, the higher the personnel density; congestion is more serious.

TABLE V
OPTIMIZES RESULTS OF SINGLE MEASURE

Scheme. No	Number Of People Leaving the Station within 6 Minutes	Evacuation Ratio /%	Total Duration of Evacuation
1	998	43.8	13minutes41s
2	1159	50.8	11minutes48s
3	1135	49.8	12minutes3s
4	1060	46.5	12minutes54s

From Fig. 12, it can be seen that evacuation Scheme No.2 stipulated that the unchecked personnel in the entrance hall layer choose the nearest entrance and exit leave the station. The unchecked personnel in the entrance hall layer still under the stairs, escalators, and straight stairs determine the entry and exit to leave the station after passing the nearest exit gate. This can effectively reduce the personnel density from the security equipment to the entrance gate during evacuation.

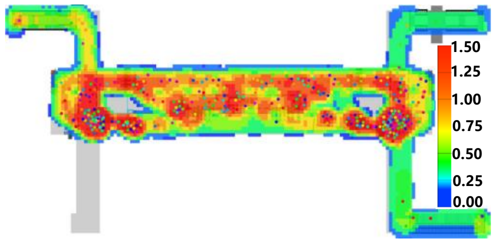

Fig. 12. Personnel density map of scheme No.2

From Fig. 13, it can be seen that in scheme No.3, the diversion bar is used to limit the walking path of passengers during an evacuation. It is stipulated that there is no personnel passing through the area between the two groups of entrance gates on the station hall floor after the walking path. Still, the personnel who have not been checked and have been checked and waited for the car choose the entrance and exit when the way is crossed and conflicted, which makes the B and D entrance and exit corridors connected with the walking path and the escalators and stairs have high personnel density and are prone to congestion.

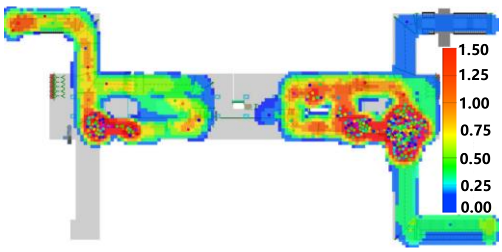

Fig. 13. Personnel density map of scheme No.3

It can be seen from Fig. 14. that scheme No.4 sets the operation direction of all escalators at each entrance and exit as upward, and the congestion reason is similar to scheme

No.3. However, the subjective heterogeneity is prominent when personnels leave the station to choose the path, resulting in congestion throughout the entire station hall layer. Personnels are blocked in the station hall and cannot enter the corridors of each entrance and exit, thus the optimization effect is poor.

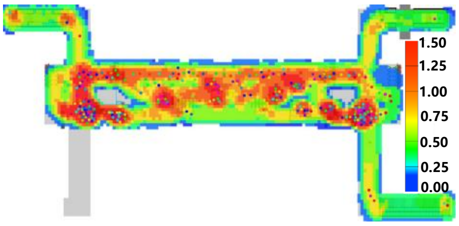

Fig. 14. Personnel density map of scheme No.4

B. *Optimization scheme of combined measures*

To further improve the efficiency of the station emergency evacuation system, the optimization schemes composed of various optimization measures are simulated individually. The simulation results are shown in Table VI, and the personnel density corresponding to each scheme are shown in Fig. 15. to Fig. 18.

TABLE VI
OPTIMIZE RESULTS OF COMBINED MEASURES

Scheme. No	Number of People Leaving the Station within 6 Minutes	Evacuation Ratio /%	Total Duration of Evacuation
5	1275	55.9	11minutes16s
6	1216	53.3	11minutes34s
7	1193	52.3	11minutes49s
8	1339	58.7	10minutes51s

Scheme No.5 specifies the evacuation area after personnel classification and stipulates the walking path of personnel evacuation. It can be seen from Fig .15. that the area with high personnel density is significantly reduced compared with SchemeNo.1. At the same time, the thickness of personnel in some areas of the station hall and the corridors and equipment of B and D entrances and exits is relatively uniform, and congestion is not easy to occur.

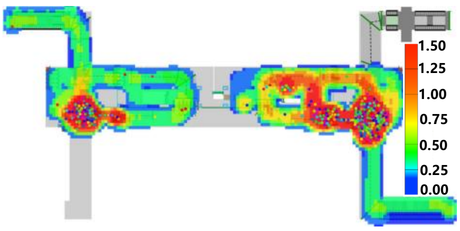

Fig. 15. Personnel density map of scheme No.5

The simulation result of scheme No.6 is shown in Fig.16. It can be seen that there are still crossing conflicts of walking paths in the whole station hall layer during personnel evacuation, especially between the entrance and exit verification gates. However, the change of escalator running direction is conducive to the rapid departure of unsecured personnel from the station after they reach the entrance and exit, thereby improving the evacuation efficiency.

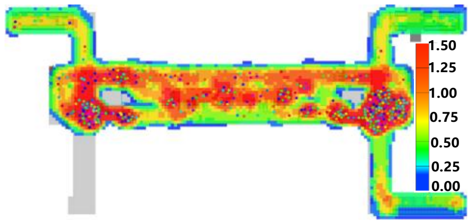

Fig. 16. Personnel density map of scheme No.6

The cause of congestion in scheme No.7 is still similar to that in scheme No.3. Still, the optimized result is as shown in Fig .17. It can be seen that the area of dark high-density area is effectively reduced compared with scheme No.3 and No.4. Although the evacuation area of personnel is not specified during an evacuation, most personnel can follow the entrances and exits after entering the set path, and the escalator can evacuate the arrived personnel out of the station.

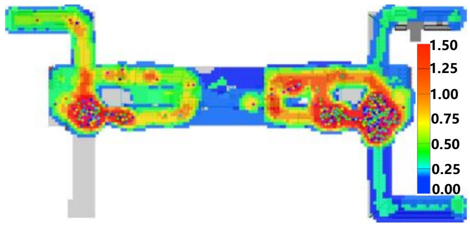

Fig. 17. Personnel density map of scheme No.7

Scheme No.8 comprehensively uses the above optimization measures. In the Fig. 18, it is observed that the personnel density in the scheme is evenly distributed within the specified path; that is, the probability of personnel congestion is small, and the practical organization makes the personnel exit streamline smooth, and the efficiency of the entire station emergency evacuation system is effectively improved.

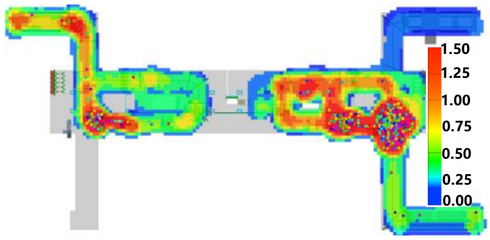

Fig. 18. Personnel density map of scheme No.8

C. *Comparative analysis of evacuation schemes*

The simulation results of all evacuation schemes are summarized and compared. The statistical results of each data are shown in Fig.19.- Fig.20. In Fig. 19, schemes that use a single optimization measure, the number of people evacuated from the station in scheme No.2 within 6 minutes increased by 16.1% compared with scheme No.1, and the total evacuation time decreased by 14.4%. When only one optimization measure is used, the effect is significant to small. The order is designated evacuation area > specified walking path > change of escalator direction. The results show that whether the evacuation area is designated according to the location of the personnel has an essential impact on the evacuation results.

The optimized lifting rate in Fig. 20. is obtained by comparing scheme No.2 to No.8 with scheme No.1. In the scheme using combined optimization measures, the evacuation ratio of scheme 8 is 6.4 % higher than that of scheme No.7, and the evacuation efficiency is 5.73 % higher. The comparison shows that the optimization effect of scheme No.7 is the worst; that is, the evacuation area is designated according to the location of the personnel, and the evacuation efficiency can be further improved by combining other measures. On the contrary, it is difficult to achieve the optimization effect.

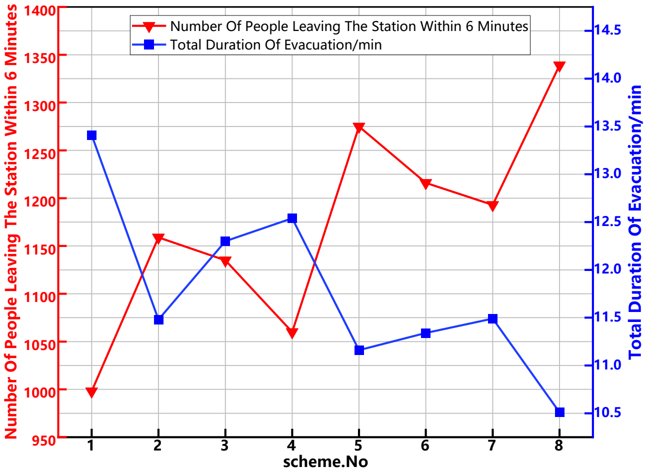

Fig. 19. Comparison of evacuation time of each scheme

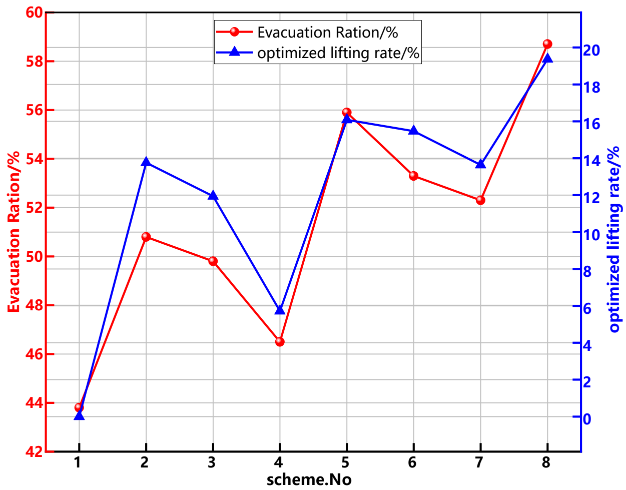

Fig. 20. Comparison of evacuation ratio of each scheme

VI. Conclusion

1) In this paper, an intelligent evacuation system for an URT station was established using AnyLogic, considering the significant impact of sudden heavy passenger flow on the operation and organization of URT system, and the simulation of the evacuation process of the people in the URT station after they were hit by the sudden heavy passenger flow was realized by adjusting the parameters of the relevant attributes of the intelligences.
2) Determining the bottleneck area in the evacuation process is an important work in this article, in order to make the results more scientific and persuasive, the factors constraining the efficiency of evacuation in the station are analyzed using uncertainty theory, and based on the results of the analysis, an optimization measure based on the location of the personnel and designating evacuation areas is designed.
3) Combined with other evacuation optimization measures mentioned in the established literature, multiple evacuation schemes were designed in this article. The number of personnel that can be evacuated within a determined time, the percentage of evacuees, the time for all people to evacuate and leave the station, and the density of pedestrians are used as the evaluation indexes for each evacuation scheme. Through comparative analysis, it is found that the evacuation measure designed in this paper based on the location of the personnel are effective, and the proposed evacuation schemes can provide decision-making references for the evacuation of personnel in the URT station.

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