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Research Article

Study on Evacuation Evaluation in Subway Fire Based on Pedestrian Simulation Technology

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In order to improve the ability to evacuate from subway fire in subway's planning, design, operation, and maintenance stages, a simulation model of pedestrians' evacuation process in subway fire was established based on Legion and FDS software. It can truly reflect the dynamic effects of the fire environment on subway station evacuation. Then dynamic evaluation indicators systems were established from the point of survival index, security risk index, effectiveness index, and orderliness index. In order to help decision makers to identify the most appropriate plan, matter-element analysis (MEA) was used to rate different plans. At last a case study of Songjiazhuang (SJZ) station was provided to test the effectiveness and practicability of the evaluation method.

1. Introduction

The subway, as one of urban public transportation means, due to the large capacity, land saving, and so forth, is becoming an effective tool to alleviate urban traffic congestion. But subway is a place where the disasters and accidents happened easily owing to its characteristics of being complex, close, agglomerate, and so on. Of all these disasters, fire is the most serious. Therefore, it is necessary to evaluate different pedestrians' evacuation plans facing with different fire conditions in subway's planning, design, operation, and maintenance stages. Because of the particularity of fire accident, the drilling method has many shortcomings such as big-cost, time-consuming, and more participants. And in the planning and design stages, it is difficult to evaluate and optimize the fire evacuation facility and pedestrians' evacuation plan.

With the development of computer technology, simulation technology of subway fire has become a way of high-feasibility, low-cost, and good-effect. Based on the reasonable parameter calibration, the simulation model can truly reflect the status of subway fire and record the data of pedestrians' speed, acceleration, density, coordinate, and other traffic behavior. It provides a strong support for the quantitative evaluation of fire evacuation situation and has been widely used in all areas [1–5].

There have been many researches [6–8] about evaluation of fire evacuation in subway station at home and abroad. However, the evaluation systems have a lot of shortages in different degrees. Firstly, there are still some qualitative indicators in exiting evaluation system. Setting value of these indicators needs to be finished by experts. Thus, qualitative indicators are limited to the experience of the experts or decision makers and the values might be not objective and convictive. Secondly, quantitative indicators are not reasonable enough to be selected and quantified. And they cannot reflect pedestrians' behavior dynamically in the evacuation process. Thus, the evacuation situation cannot be reflected accurately. At present, qualitative description or basic comparison of simulation results is still the main application method of pedestrian simulation tools. The simulation evaluation method is not versatile because of lacking of standard dynamic evaluation indicators system and procedure.

In this paper, a model of pedestrians' evacuation process in subway fire is established based on Legion and FDS simulation software, and a dynamic evaluation indicators system

Table 1: Details of parameters.

Parameters	Details
Facility layout	Stairs, escalators, ramps, brake machine, etc.
Pedestrian characteristics	Age ratio, culture degree, sex ratio, etc.
Demand	The number of pedestrians, distribution
Pedestrian behavior	Along the wall, clustering behavior, panic behavior
Regions	Walking region, waiting region, isolation region, danger zone
Environment calibration	Speed reduction, path choice, life characteristics

Table 2: Output parameters of Legion.

Output format	Output parameters
Map Chart Table	Ingress and egress Occupancy Flow Speed Entity and space density Journey time Social cost Inconvenience and frustration discomfort and dissatisfaction

is also established. A case is used to verify its effectiveness and practicability.

2. The Evacuation Evaluation in Subway Fire

2.1. Pedestrian Simulation Technology: Legion and FDS. The multiagent pedestrian model is the heart of the Legion simulation tool which uses the "minimum cost" [9] as the basic principles. Field investigation and data preparation are the basic work for pedestrian simulation modeling. Therefore, the parameters in Table 1 should be calibrated in building a simulation model.

Legion can record detailed track of each individual pedestrian and can accurately calculate the individual traffic behavior parameters and macroscopic traffic flow characteristics of pedestrian. The status of pedestrian traffic system can be reflected by maps, charts, and tables. Detailed output parameters can be found in Table 2.

Fire dynamics simulator (FDS) is the computational fluid dynamics simulation software in the fire, which was developed by the US national institute of standards technology. FDS can solve continuity equation, momentum equation, energy equation, and stress convergence equation with large eddy simulation (LES) model. Then the spatial distribution of temperature, pressure, gas composition, visibility, and so forth can be got [10]. FDS was validated by a lot of engineering experiments, and it is recognized by the international fire engineering.

2.2. The Process of Simulation Evaluation. The simulation is a method to simulate the complicated traffic phenomenon by computer technology and to display the real-time traffic situation based on the forecasting. Then the work of analysis, evaluation, and optimization can be started. The process of pedestrians' evacuation evaluation in subway fire based on the simulation technology is shown in Figure 1.

3. Pedestrian Evacuation Evaluation Indicators System in Subway Fire

3.1. Indicators System and Quantification of Indexes. It is vital to ensure that pedestrians' evacuation in subway fire is effective and safe. The evaluation of subway fire evacuation is used to investigate the merits degree of survival index, security risk index, effectiveness index, and orderliness index under different conditions such as facility layout and evacuation plan. The dynamic pedestrians' evacuation evaluation indicators system in subway fire based on the output parameters of Legion is shown in Figure 2.

3.1.1. Survival Index. Survival index reflects the survival probability directly in the evacuation process. It can be described as two aspects: one is survival ratio and the other one is survival reliability.

(1) Survival Ratio u_{11}. The index reflects pedestrians' survival situation in the evacuation process:

$$u_{11} = \frac{q}{Q} \times 100\%. \tag{1}$$

In the type, q stands for the amount of evacuation pedestrians; Q is the total amount of pedestrians.

(2) Survival Reliability u_{12}. Due to the randomness of pedestrians' evacuation process, there will exist distance between deterministic methods to describe the evacuation process and actual situation. So this paper uses survival reliability index to describe pedestrians' evacuation process.

In the process, if available safe evacuation time (ASET) is longer than required safe evacuation time (RSET), pedestrians will be safe. That is,

$$\text{ASET} - \text{RSET} > 0. \tag{2}$$

According to the above criterion, the limit state equation for pedestrians' safe evacuation can be constructed:

$$Z = T_A - T_R > 0. \tag{3}$$

T_A stands for ASET and T_R stands for RSET. The unit is "s." T_A is mainly affected by the fire situation; it can be got by FDS in all regions. T_R can be got by Legion and obeys the normal distribution according to existing research [11].

Obviously, Z obeys the normal distribution, and its mean μ_z and standard deviation σ_z are as follows:

$$\mu_Z = T_A - \mu_{T_R}, \quad \sigma_Z = \sigma_{T_R}. \tag{4}$$

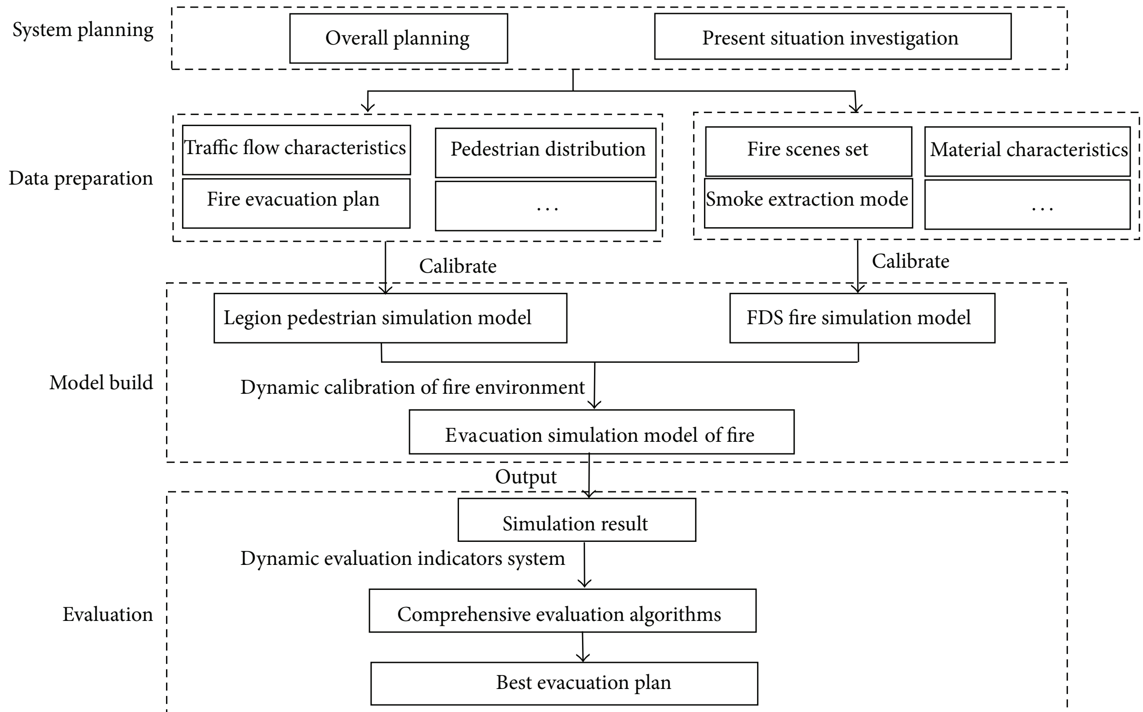


Figure 1: The process of pedestrians' evacuation evaluation based on the simulation technology.

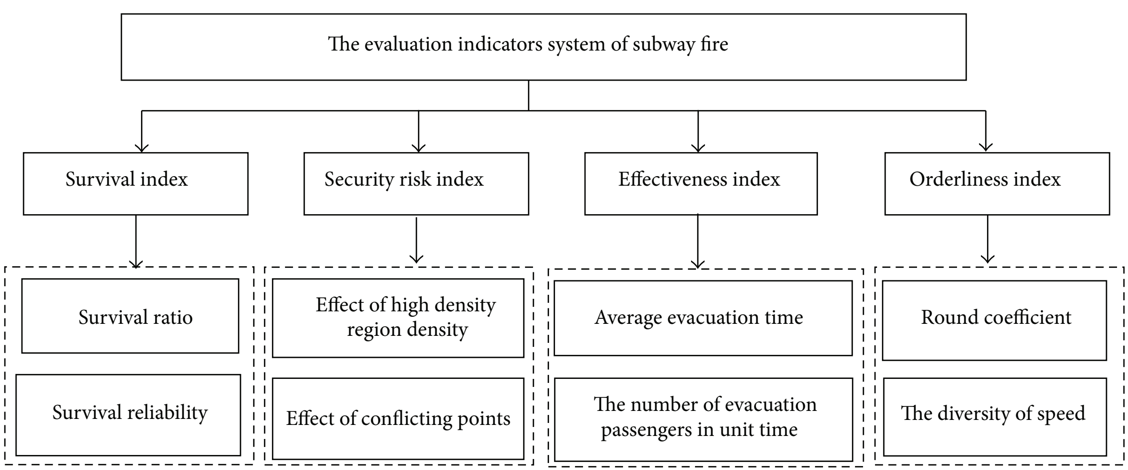


Figure 2: Pedestrians' evacuation evaluation indicators system in subway fire.

μ_{T_R} and σ_{T_R} are T_R's mean and standard deviation. The reliability index of safe evacuation (β) can be indicated as follows:

$$\beta = \frac{\mu_Z}{\sigma_Z}. \quad (5)$$

Then, u_{12} can be described as follows:

$$\mu_{12} = P(Z > 0) = \phi(\beta). \quad (6)$$

In the type, $\phi(\cdot)$ is standard normal distribution function.

3.1.2. Security Risk Index. In pedestrians' evacuation process, some high density and serious conflicting regions are often high probability of accidents. There is security risk that should be avoided.

(1) Effect of High Density Region u_{21}. This index reflects the effect of high density. It can be considered that regions under "D" service level are high density [12]. The formula takes time of duration and affected passenger flow into account:

$$u_{21} = \frac{\sum_{i=1}^{e} \sum_{j=1}^{m_i} l_{ij} \cdot v_{ij}}{T_t \cdot q_t}. \quad (7)$$

In the type, e is the number of high density regions, m_i is the number of high density time periods in region i, l_{ij} is the length of time period j in region i and the unit is "s," v_{ij} is the number of passengers during time period j in region i, T_t is total simulation time and the unit is "s," and q_t is the total passengers in all simulation regions.

(2) Effect of Conflicting Points u_{22}. This index represents the proportion of passengers who go through the conflicting points:

$$u_{22} = \frac{\sum_{i=1}^{n} q_i}{q_t}. \tag{8}$$

In the type, q_i stands for the number of affected passengers in conflicting point i, q_t stands for the total passengers during the simulation time, and n is the number of conflicting points.

3.1.3. Effectiveness Index. Effectiveness refers to the execution efficiency in pedestrians' evacuation process.

(1) Average Evacuation Time u_{31}. For passengers, evacuation time can reflect evacuation efficiency intuitively:

$$u_{31} = \frac{\sum_{i=1}^{q_t} t_i}{q_t}. \tag{9}$$

In the type, t_i stands for the evacuation time of passenger i and the unit is "s" and q_t stands for the total passengers during the simulation time.

(2) The Number of Evacuation Passengers in Unit Time u_{32}. According to "Design Specifications for Subway," the longest evacuation time is not more than 6 minutes in subway station. The number of evacuation passengers in unit time can also reflect evacuation efficiency. The formula is as follows:

$$u_{32} = \begin{cases} \dfrac{Q}{T} & T \leq 6 \\ \dfrac{Q}{6} & T > 6. \end{cases} \tag{10}$$

In the type, Q stands for the number of evacuation passengers in 6 minutes; T stands for the whole evacuation time.

3.1.4. Orderliness Index. Orderliness mainly reflects the order of pedestrians' evacuation process. Good order can ensure safety and comfort.

(1) Round Coefficient u_{41}. This index reflects the convenience of pedestrians' evacuation in integrated transport hub:

$$u_{41} = \sum_{i=1}^{r}\sum_{j=1}^{s} w_{ij} \frac{\sum_{k=1}^{O_{ij}} l_{ijk}}{O_{ij} \cdot S_{ij}}. \tag{11}$$

In the type, r is the total number of starting points, s is the total number of terminal points, O_{ij} is the number of passengers from starting point i to terminal point j, S_{ij} stands for the shortest distance from i to j and the unit is "m," and l_{ijk} stands for the actual working distance of passenger k from origin i to destination j. w_{ij} is weight of i to j. Considering the passenger flow of each OD pair, w_{ij} can be calculated based on entropy weight coefficient method. Based on information theory [13], the entropy of OD pair ij is

$$\begin{aligned} H_{ij} &= -\frac{1}{\ln n}\sum_{l=1}^{n} h_{ijl} \ln h_{ijl}, \\ h_{ijl} &= \frac{o_{ijl}}{\sum_{l=1}^{n} o_{ijl}}, \end{aligned} \tag{12}$$

where n is the number of fire evacuation plans.

The weight of OD pair ij is

$$w_{ij} = \frac{\left(1 - H_{ij}\right)}{\left(r \times s - \sum_{i=1}^{r}\sum_{j=1}^{s} H_{ij}\right)}. \tag{13}$$

(2) The Diversity of Speed u_{42}. The index reflects orderliness of evacuation process directly. The formula is as follows:

$$u_{42} = \sqrt{\frac{\sum_{i=1}^{n} \left(v_i - \overline{v}\right)^2}{n}}. \tag{14}$$

In the type, v_i is evacuation speed of period i, n is the number of simulation time periods, and $\overline{v}$ is the average speed during the whole simulation.

3.2. Matter-Element Evaluation Algorithm. Many algorithms can be used to sort the best plan such as cosine function, linear assignment, fuzzy logic, and matter-element algorithm [14–16]. This paper uses matter-element analysis to calculate the value of decision-making of each plan. The main theories of this algorithm are the definition of matter-element, extension mathematics, and the matter-element transformation theory [17–20]. It has been widely used in evaluation fields. In this paper, a specific matter-element algorithm is established based on the dynamic evaluation indicators system.

3.2.1. Normalization of Decision-Making Matrix. It is assumed that there are n fire evacuation plans in subway station noted to $S = \{S_1, S_2, \ldots, S_n\}$. The index set of second grade is $P = \{P_1, P_2, \ldots, P_n\}$. Then the decision-making matrix of plan S_i with matter-element algorithm can be written as follows:

$$Y_i = \begin{bmatrix} A_i & P_1 & y_{i1} \\ & P_2 & y_{i2} \\ & \vdots & \vdots \\ & P_m & y_{im} \end{bmatrix} \begin{matrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_m \end{matrix}, \quad i = 1, 2, \ldots, n. \tag{15}$$

Each index has different units and needed to be normalized. To define index set $P^+ = \{\text{indexes of bigger better}\}$ and to define P^- = {indexes of smaller better}, then normalization process can be represented as follows:

$$r_{ij} = \frac{\left(y_{ij} - \min_{1\le i\le n} y_{ij}\right)}{\left(\max_{1\le i\le n} y_{ij} - \min_{1\le i\le n} y_{ij}\right)}, \quad i = 1, 2, \dots, n, \ j \in P^+,$$
$$r_{ij} = \frac{\left(\max_{1\le i\le n} y_{ij} - y_{ij}\right)}{\left(\max_{1\le i\le n} y_{ij} - \min_{1\le i\le n} y_{ij}\right)}, \quad i = 1, 2, \dots, n, \ j \in P^-. \tag{16}$$

The normalized matter-element algorithm matrix of plan S_i can be represented as follows:

$$R_i = \begin{bmatrix} A_i & P_1 & r_{i1} \\ & P_2 & r_{i2} \\ & \vdots & \vdots \\ & P_m & r_{im} \end{bmatrix} \begin{matrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_m \end{matrix}, \quad i = 1, 2, \dots, n. \tag{17}$$

3.2.2. The Best and Worst Matrix. To define

$$r_j^+ = \begin{cases} \max\limits_{1\le i\le n} r_{ij}, & j \in P^+ \\ \min\limits_{1\le i\le n} r_{ij}, & j \in P^-, \end{cases}$$
$$r_j^- = \begin{cases} \min\limits_{1\le i\le n} r_{ij}, & j \in P^- \\ \max\limits_{1\le i\le n} r_{ij}, & j \in P^+, \end{cases} \tag{18}$$

then the best and worst matrix can be represented as follows:

$$R^+ = \begin{bmatrix} A_i & P_1 & r_1^+ \\ & P_2 & r_2^+ \\ & \vdots & \vdots \\ & P_m & r_m^+ \end{bmatrix} \begin{matrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_m \end{matrix},$$
$$R^- = \begin{bmatrix} A_i & P_1 & r_1^- \\ & P_2 & r_2^- \\ & \vdots & \vdots \\ & P_m & r_m^- \end{bmatrix} \begin{matrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_m \end{matrix}. \tag{19}$$

3.2.3. Weights Calculation. In this paper, APN method is used to calculate the weight of each index [21, 22].

3.2.4. The Distance and Relative Closeness. To define S_i^+ as the distance from plan S_i $(i = 1, 2, \dots, n)$ to the best plan and S_i^- as the distance to the worst plan

$$S_i^+ = \sqrt{\sum_{j=1}^{m} \omega_j^2 \left(r_{ij} - R^+\right)^2},$$
$$S_i^- = \sqrt{\sum_{j=1}^{m} \omega_j^2 \left(r_{ij} - R^-\right)^2}, \tag{20}$$

Table 3: The number of passengers for evacuation.

Places		Arriving person	Waiting person
Subway platform	Line 10 up	1200	300
	Line 10 down	1200	300
	Line 5	700	300
	Line Yizhuang	700	300
Subway hall		—	450

then the relative closeness of plan S_i $(i = 1, 2, \dots, n)$ to the best plan is e_i:

$$e_i = \frac{S_i^-}{S_i^+ + S_i^-}. \tag{21}$$

In the type, e_i is the value of decision-making of plan S_i and $0 < e_i < 1$. When e_i is bigger, S_i^+ is closer to 0 and the evacuation plan is better.

4. Test Results

4.1. Simulation Model. In order to test the practicability of evacuation evaluation system in subway fire, the paper chooses Songjiazhuang (SJZ) station as an example. SJZ is a transfer station of line 10, line 5, and line Yizhuang. It is predicted that the peak hour traffic of SJZ will reach 66800 in 2016. There is no doubt that it will be one of the most large-scale subway stations in Asia. Therefore it is particularly important to evaluate the fire evacuation plans of SJZ.

4.1.1. Data Preparation. Data preparation is the basic work for pedestrian simulation modeling. The number of passengers in subway platform and subway hall is shown in Table 3 through field investigation.

4.1.2. Fire Environment. In order to reflect the evacuation conditions of different fire scenes in subway, in this paper, two different scenarios are simulated. Exhaust mode settings are shown in Table 4 and the distribution of fire product in platform is shown in Figure 3.

4.1.3. Speed Calibration of Fire Environment. Equivalent velocity is the movement speed in fire environment. The paper considered the impact of mainly fire products on personnel evacuation separately:

$$v = v_0 \cdot f\left(K_s, \rho, T\right) = v_0 \cdot f_1\left(K_s\right) f_1\left(\rho\right) f_1\left(T\right), \tag{22}$$

where v is equivalent velocity, v_0 is pedestrian normal velocity, $f_1(K_s)$ is visibility influence coefficient, $f_1(\rho)$ is toxic gas concentration influence coefficient, and $f_1(T)$ is temperature influence coefficient.

(1) The Effect of Visibility on Pedestrian Speed. The relationship between people' walking speed and smoke obscuration coefficient when people were exposed to the irritating and nonirritating smoke is shown in Figure 4 by experiment [23].

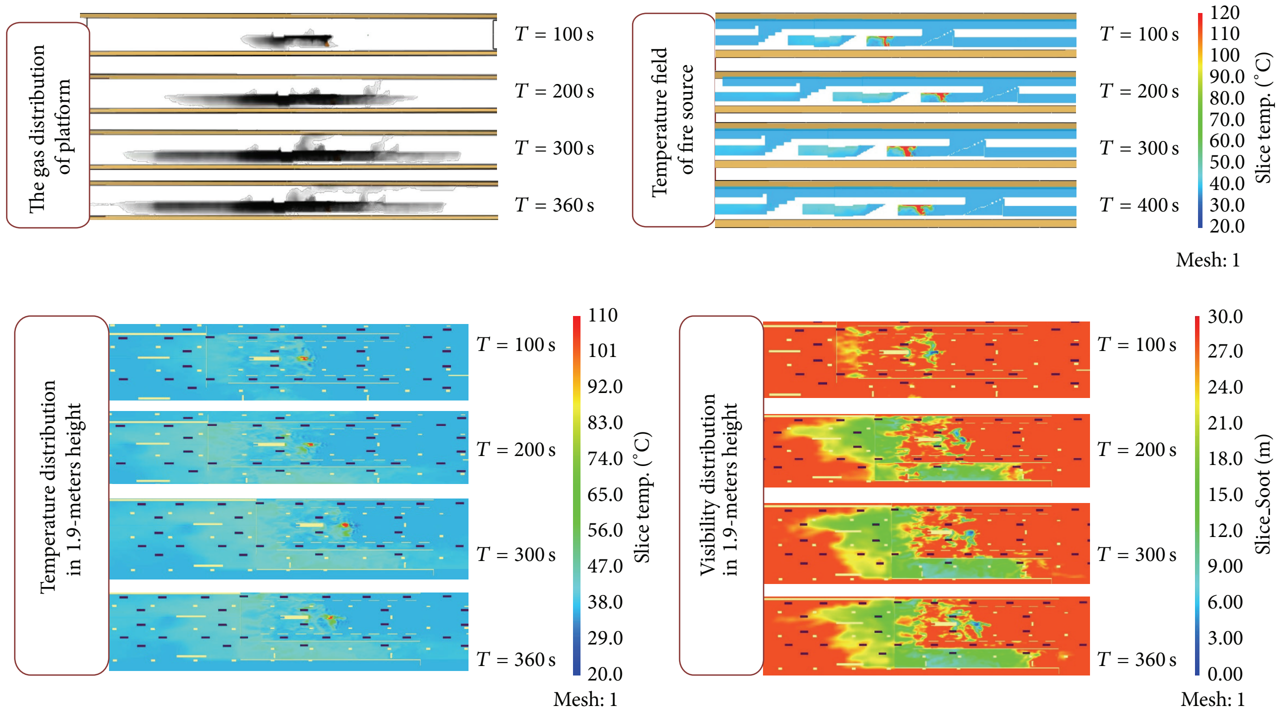


Figure 3: Fire product distributed in platform.

Table 4: Exhaust mode settings in different fire scenes.

Fire scenes	Exhaust smoke level	Exhaust smoke model	Remark
Fire of platform	180	Exhaust smoke of platform	All of the shield doors open for auxiliary exhausting smoke
Fire of hall	180	Exhaust smoke of hall	All of the shield doors open for auxiliary exhausting smoke

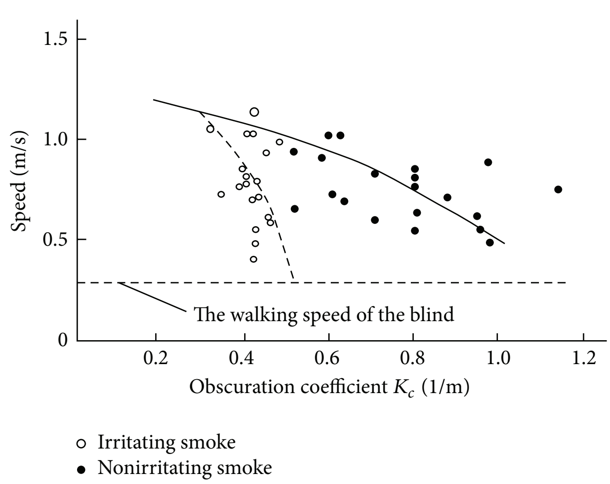


Figure 4: The walking speed in irritating and nonirritating smoke.

(2) The Effect of Toxic Gas on Pedestrian Speed. The effect of toxic gas on evacuation pedestrian is velocity-decrease. Milke had got the data by experiment about the effect of different concentrations of CO on pedestrian in fire [24] shown in Table 5.

(3) The Effect of Temperature on Pedestrian Speed. According to the predecessors' research data, the influence coefficient of flue gas temperature on personnel movement speed can be concluded as follows:

$$f_3(T) = \begin{cases} 1 \\ \quad (T_0 < T_s \leq T_{\sigma 1}) \\ \dfrac{(v_{\max} - 1.2)\left((T_s - T_{\sigma 1}) / (T_{\sigma 2} - T_{\sigma 1})\right)^2}{v_0} + 1 \\ \quad (T_{\sigma 1} < T_s \leq T_{\sigma 2}) \\ \dfrac{v_{\max}}{1.2}\left[1 - \left(\dfrac{T_s - T_{\sigma 2}}{T_{\text{deal}} - T_{\sigma 2}}\right)^2\right] \\ \quad (T_{\sigma 2} < T_s \leq T_{\text{deal}}), \end{cases} \tag{23}$$

where T_s is the temperature in the fire, v_0 is pedestrians normal velocity, $v_{\max}$ is maximum speed to escape, generally taking 5 m/s, $T_{\sigma 1}$ is the temperature when people feel uncomfortable, generally taking 30°C, $T_{\sigma 2}$ is the temperature that harm a person, generally taking 60°C, and $T_{\sigma 2}$ is the temperature that cause death, generally taking 120°C.

4.1.4. Pedestrian Survival Condition Calibration. All kinds of fire products occurring in the process of fire have

Table 5: Different concentrations of CO impact on pedestrian in fire.

Co (%)	Exposure time (min)	Cumulative dose (%min)	Personnel velocity decrease (m/s)
>0.1	1	>0.1	0.05
	2	>0.2	0.1
	n	$>0.1n$	$0.05n$
>0.15	1	>0.15	0.1
	2	>0.3	0.2
	n	$>0.15n$	$0.1n$
>0.2	1	>0.2	0.15
	2	>0.4	0.3
	n	$>0.2n$	$0.15n$
>0.25	Person faint or death, being unable to move		

Table 6: Human tolerance limits to fire products.

Content	Human tolerance limits
Radiation heat flux	2.5 kw/m^2
Gas temperature	When the smoke layer height >2 m, 180°C When <2 m for 30 min, 60°C
Visibility	When the smoke layer height <2 m, 0.1 m (10 cm)
Toxic gas	CO concentration achieves 0.25%

a great threat to pedestrians' life. The third edition of *Fire handbook in China* gives human tolerance limits to different fire products (Table 6).

4.1.5. Evacuation Routes Calibration

Plan 1. According to the layout of metro station and passenger flow forecast, the mode of passenger evacuation from the nearest exit is shown in Figure 5.

Plan 2. Because of the uneven distribution of passengers in the platform, it is suggested that part of passengers is guided to other exits which are not nearest to them. The specific measures are shown in Figure 6, guiding 300 passengers in line 10 platform to exits in line 5 and line Yizhuang platform.

4.2. Results of Evaluation. Based on the output data of simulation model, the value of the evaluation indexes of two evacuation plans in two scenes can be calculated, as shown in Table 7.

The value of decision-making of different plans can be calculated by the matter-element algorithms, as shown in Table 8.

From the results, when the platform is on fire, $e_2 > e_1$. It shows that $\mathbf{S}_2$ is better than $\mathbf{S}_1$. When the hall is on fire, $e_2 > e_1$. It also shows that $\mathbf{S}_2$ is better than $\mathbf{S}_1$. According to the value of decision-making in two scenes, it is known

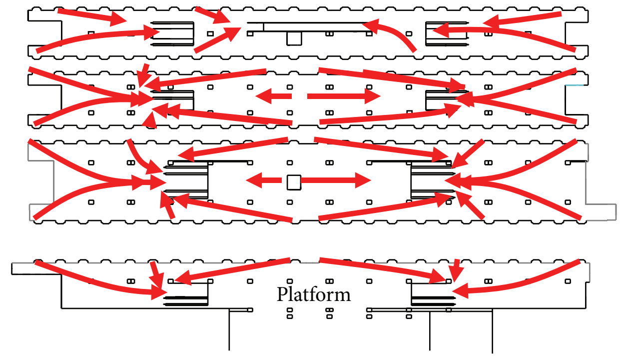


Figure 5: The evacuation route of plan 1.

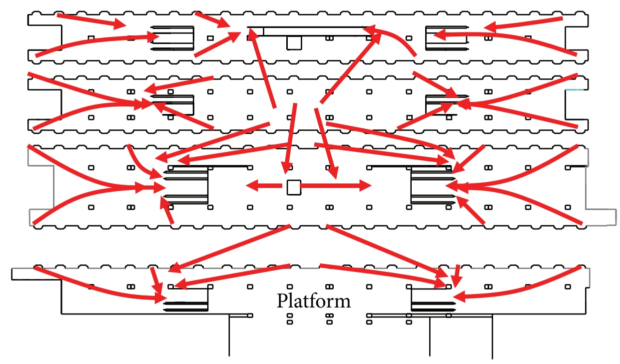


Figure 6: The evacuation route of plan 2.

Table 7: The value of evaluation indexes of two plans in two scenes.

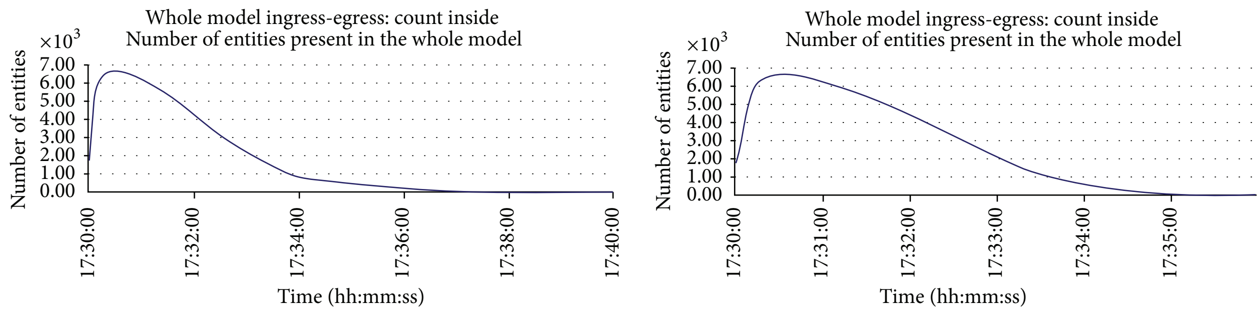
Evaluation indexes	Subway platform on fire		Subway hall on fire	
	Plan 1 ($\mathbf{S}_1$)	Plan 2 ($\mathbf{S}_2$)	Plan 1 ($\mathbf{S}_1$)	Plan 2 ($\mathbf{S}_2$)
u_{11}	99.35	99.57	99.82	99.88
u_{12}	0.943	0.942	0.969	0.966
u_{21}	0.763	0.783	0.782	0.773
u_{22}	0.639	0.623	0.659	0.624
u_{31}	278	221	271	216
u_{32}	678	741	691	761
u_{41}	1.36	1.32	1.33	1.21
u_{42}	0.18	0.14	0.16	0.13

that the fire evacuation effect in hall is better than in platform regardless of plans.

4.3. Analysis of Simulation Results. From the value of evaluation indexes of two plans shown in Table 7, we know the following.

(1) More people can escape in plan 2 and the others will die in line 10 platform from the simulation process. Figure 7 shows the relationship between the number of people present in the subway and the evaluation time of two plans. It is obvious that the escape speed of plan 2 is faster than plan 1.

(2) The comparison of security risk shows the effect of high density passenger and the number of conflicts



(a) Plan 1

(b) Plan 2

Figure 7: The relationship between the number of people present in the subway and the evaluation time.

Table 8: The value of decision-making of different scenes.

The value of decision-making	Subway platform on fire		Subway hall on fire	
	Plan 1 ($\mathbf{S}_1$)	Plan 2 ($\mathbf{S}_2$)	Plan 1 ($\mathbf{S}_1$)	Plan 2 ($\mathbf{S}_2$)
e_i	0.198	0.366	0.730	0.896

is less in plan 2. It is proved that the evacuation organization of plan 2 is more reasonable.

(3) The comparison of effectiveness index shows the average evacuation time of plan 2 is less, although part of people did not evacuate from the nearest exits.

(4) The comparison of orderliness index shows the diversity of speed is smaller, so the evacuation flow is more uniform and orderly in plan 2.

4.4. Simulation Conclusion and Optimization

(1) Because of the uneven distribution of passengers in subway, the plan that all pedestrians evacuate from the nearest exits is not the best. Guiding a certain number of passengers to other exits may be more suitable.

(2) The evacuation time of pedestrians in line 10 platform is the longest from the simulation process; it is suggested that the new emergency stair or channel of line 10 platform should be added.

5. Conclusion

With the continuous improvement of urban subway system in China, the ability of subway stations to prevent the disasters and accidents will face a huge challenge. In the practical application, a model of pedestrians' evacuation process in subway fire and a dynamic evaluation indicators system are shown in this paper. The test results prove them to be applied and effective. The evaluation indicators system provides a new method to evaluate the facility layout and evacuation plan quantitatively. It also has a strong guiding significance for optimizing evacuation plan and improving the ability to prevent the disasters and accidents of subway stations.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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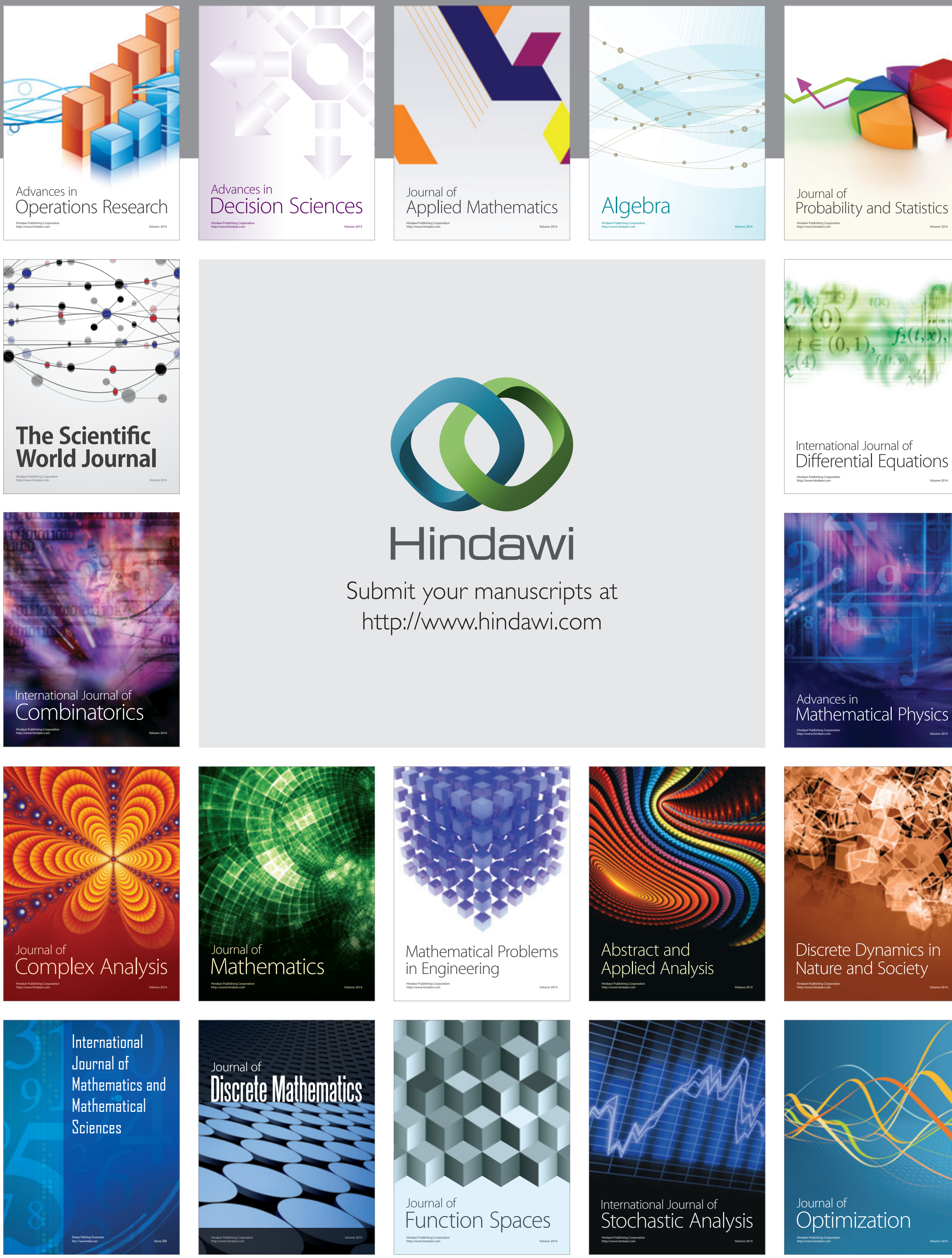
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