Anylogic Simulation Research on Passenger Evacuation System of Urban Transportation Hub

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Abstract: In recent years, the rapid development of rail transit has led to a sharp increase in the number of people, and there are certain security risks in many important urban transport hubs. This article selects AnyLogic simulation software that can reflect the characteristics of pedestrian behavior to study how to evacuate the crowd emergency in the subway station hall. Taking a certain tier city as an example, establish a station model, simulate it through field survey data, and finally use the pedestrian density in the results to analyze the problems in crowd evacuation, and optimize the facility layout to propose improvements.

1 INTRODUCTION

People's daily life is inseparable from transportation, so the safety of traffic has become an increasingly concerned issue. In recent years, due to the impact of some major events such as the Olympic Games and the World Expo, pedestrian simulation has become a hot field in simulation, which has attracted much attention at home and abroad. In different scenarios, the assessment of the accommodation and capacity of the area improves the planning plan, which plays an important role in solving the problem of crowd evacuation in key areas.

At present, many scholars have conducted research on such issues to varying degrees. Reference (Zhao Jinlong, et.al, 2020) in order to ensure the safety of travellers taking the subway, Pathfinder software is used to model a special subway station in Beijing to improve the efficiency of response to emergency events. Reference (Pan Ke, Xiu Shunyan, 2017) simulates the time of crowd evacuation in different subway stations under different scenarios, and analyzes the distribution rules of its personnel. Reference (Deng Yuanyuan, et.al, 2020) proposed an emergency evacuation scenario, and conducted simulation experiments on people with different familiarity and different numbers. Reference (Liu Zhen, 2019) improves the crowd simulation model through monitoring analysis and user surveys, and combines physical technology to describe emergency evacuation scenarios. Reference (Haibo Lin, et.al, 2020) added new modes in user-defined form by analyzing and improving the existing simulation framework, which is important for comparing different evacuation models. Rreference (Li F, Chen S, Wang X, et al, 2014) improves there are many ways to study the problem of crowd evacuation. Reference (Lei Hou, et.al, 2014) added an influence model with leadership effect to solve the current evacuation problem. Reference (Weiliang Zeng, et.al, 2014) introduces how to apply social force model in pedestrian behavior analysis of pedestrian crossing.

Therefore, this article will use the interaction of crowd organization, a complex dynamic system, and a transportation hub as a carrier, consider the particularity of the existence of a large urban transportation hub, and take a large crowded subway station in a city as an example to build a dynamic model in the subway station. To provide a theoretical basis and analytical means for solving the problem of crowd evacuation in crowded places.

2 ANALYSIS OF THE COMPLEXITY OF CROWD BEHAVIOR IN URBAN TRANSPORTATION HUB

In densely populated cities, there are a wide range of transportation options. However, due to the advantages of time guarantee, low price and good

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environment, such as subway transportation, more and more people will choose this way to travel.

1) Because of the difference and particularity of individual behavior, the behavior of passengers will be limited in the subway platform, which forms a kind of restriction for the behavior of passengers.

2) Due to the different destinations, there are particularity and complexity in the routes of passengers. The routes will be restricted by the facilities and space in the subway station, and there are individual differences caused by factors such as travel speed and walking speed among individuals.

3) Due to the complexity of the subway station environment, passengers have different behaviors and different time points, which lead to obvious differences in the flow of people in the subway station. It is necessary to consider the density of the subway station hall.

Because of the particularity and complexity of subway station and passengers, a clear dynamic model is needed to analyze the subway station hall, which is conducive to further solve how to evacuate people in special circumstances.

2.1 Simulation Implementation Method

2.1.1 Simulation Method Selection

Because crowd evacuation is a problem that needs to be considered from both macro and onlookers, it is necessary to use the model to dynamically display the evacuation process. There are characteristics such as pedestrian path differences and complicated flow lines in the subway station. The micro simulation model is used to simulate the situation in the subway station. Therefore, the social force model is selected as the analysis tool.

Some traditional modeling software use a specific modeling method, and AnyLogic is a tool which can simulate from many aspects, angles and methods. Other pedestrian simulation software is in a closed architecture scenario, while AnyLogic provides a social force model as a basis for pedestrian simulation, while providing a high degree of freedom for the development environment, which can be highly customized.

2.2 Simulation Principle

2.2.1 Principle of Social Force Model

Solving the crowd evacuation problem generally uses a social force model, which is based on Newton 's mechanical formulas and pedestrians 'escape behavior, simplifying each pedestrian to be described as a particle, which is attracted by the destination to generate its own drive At the same time, the particle is subjected to repulsive and frictional forces with obstacles and other particles. Under the action of these forces, the particle generates acceleration in a two-dimensional space, driving the particle to move continuously. The dynamic formula is as follows:

$$\mathrm{m}_i \frac{dv_i}{dt} = \frac{m_i (v_i^0(t) e_i^0(t) - v_i(t))}{\tau_i} + \sum_{j(\neq i)} f_{ij} + \sum_w f_{iw} \quad (1)$$

Among the dynamic formula, $m_i(v_i^0(t)e_i^0(t) - v_i(t)) / \tau_i$ is the driving force for pedestrians to point to the destinations, f_{ij} is the force of the pedestrian, f_{iw} is the interaction between pedestrians and obstacles, m_i is pedestrian quality, v_i^0 and $v_i(t)$ is pedestrian expected speed and actual speed, $e_i^0(t)$ is Desired direction of movement, τ_i is Adaptation time.

The acting force between pedestrians and obstacles is composed of repulsive force and friction force, and its calculation formula is as follows:

$$f_{iw} = (A_i \exp[\frac{r_i - d_{iw}}{B_i}] + kg(r_i - d_{iw}))n_{iw} + \kappa g(r_i - d_{iw})(v_i \cdot t_{iw})t_{iw} \quad (2)$$

Among the calculation formula, d_{iw} indicates the distance between the pedestrian and the edge of the obstacle, n_{iw} represents a standardized vector from the edge of the obstacle to the pedestrian, v_i represents the actual speed of pedestrians, t_{iw} represents the tangent direction of pedestrian and obstacle edges, Ai, Bi, k, κ is constant quantity.

2.2.2 Pedestrian Library Application Principle

This article will mainly apply the pedestrian library in AnyLogic. The pedestrian library is a high-level pedestrian library used to simulate the performance of pedestrian flow in the actual traffic environment. Pedestrian library includes environment modeling and behavior modeling:

1)Environmental modeling includes building walls, columns, platforms, service facilities, queuing, etc.

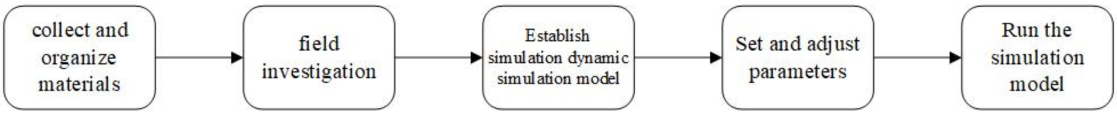

Figure 1: Step chart for building crowd evacuation model.

2) Behavior modeling needs to be achieved through flow charts. Determine pedestrian routes and behaviors, and establish a flow chart of the entire process from pedestrian generation to pedestrian departure.

When multiple locations in the model need to reuse the same function, a function can be defined. These functions are implemented in the Java language. AnyLogic can check the syntax of types, parameters and graphics. For each error, its location and description are displayed in the problem view.

2.3 Create the Simulation Model

This article uses AnyLogic simulation software as a modeling tool. The construction process is shown in Fig.1, and the specific steps are shown in 1) to 5).

1) Collect and organize materials. According to the specific information of the transportation hub metro station hall to be investigated, the preliminary information collection work needs to be carried out, and the important information such as facilities, environment, and people flow in the metro station needs to be collected.

2) Site investigation. Due to the lag of the relevant data on the Internet, and the actual situation needs to be analyzed and calculated on site, so check the relevant preliminary data in the subway station and collect the on-site information.

3) Establish simulation dynamic simulation model. Based on the data collected and sorted out in the early stage, the plan of the subway station is drawn with CAD software to determine the layout of the facilities in the subway station, and the plan layout of the subway station is established with AnyLogic software.

4) Set and adjust parameters. Organize and analyze the data recorded during the on-site survey, calculate the pedestrian flow and path in the subway station at different times, and further count other data (pace, pedestrian type, number, etc.) generated during pedestrian walking. Record the sorted parameters in the created simulation system, and check the difference with the actual situation.

5) Run the simulation model. Run the established dynamic model and analyze the output indicators, such as the density of people in the subway station at different times and the specific action time of pedestrians.

2.4 Empirical Research

2.4.1 Scene Construction of Related Subway Stations in a Railway Station

Because of the particularity of the subway station, part of its underground area is public area, and because the subway station is underground in the railway station, there are many entrances and exits, its environment has certain complexity. And the walking path of pedestrians is different from that of other subway stations in that pedestrians enter and exit from different railway stations, so the path has certain complexity. Therefore, it can help to solve the problem of evacuation in the later stage.

1) Drawing of plane model in subway station hall.

The plan of metro transfer part is shown in Fig.2, and the shaded part is the main modeling part.

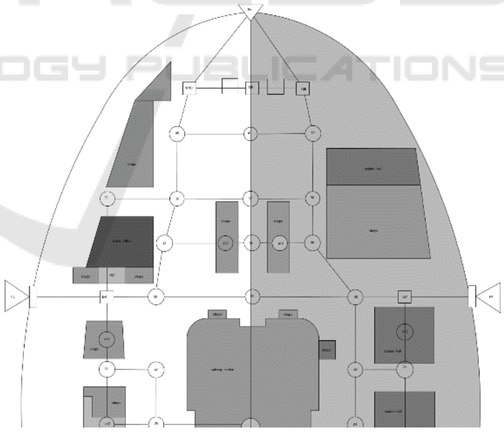

Figure 2: Environment modeling in subway station hall.

2) Statistics on the flow of people in different subway entrances and exits during the evening peak hours. Taking person/hour as the statistical unit, the station north exit 1 is 720, the train station arrival exit 4 is 791, the subway north exit 2 is 2705, and the subway east entrance is 1550. The specific survey data is shown in Fig.3.

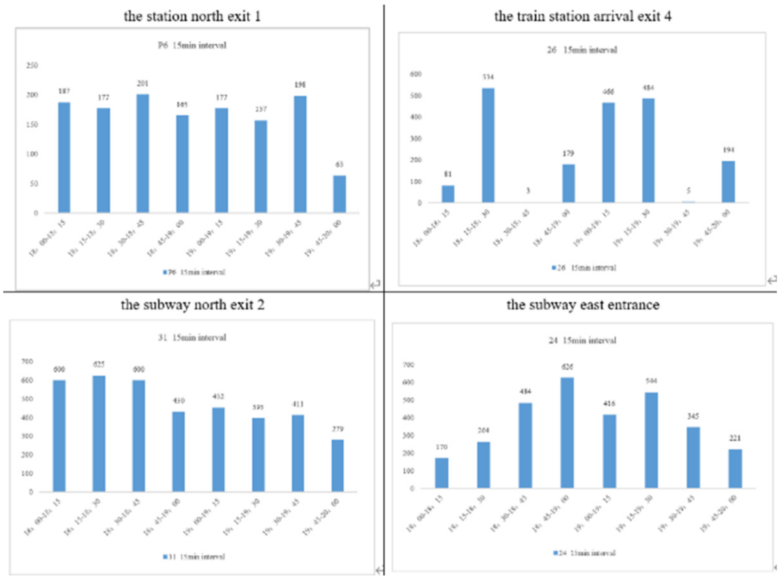

Figure 3:.Survey data at each exit of the station hall.

2.5 Creating a Behavior Flow Chart in a Subway Station

In most cities, pedestrians can choose a mobile phone QR code or a transportation card to enter the subway station after entering the subway and choose the appropriate entrance security check. It can also choose a manual window ticket machine to buy tickets and enter the station. After purchasing the ticket and entering the station, the pedestrians choose the stairs or escalator to enter the second floor. Considering that the connection process between the train station and the subway is complicated, and pedestrians have a similar process after entering the station hall, so this article only selects four outbound entrances: north entrance 1 of a certain subway station, arrival gate 4, a certain subway's north entrance and the east entrance are simulated. According to the travel logic, the flow chart of the logic modeling of the behavior of the station hall on the negative first floor is shown in Fig.4.

2.6 Parameter Setting of Simulation Model

In AnyLogic software, each facility-related attribute has default values, but it is necessary to select objects according to actual conditions and combine actual survey data to change the default values in the simulation software to actual measured data. Specific parameter settings are shown in Table 1:

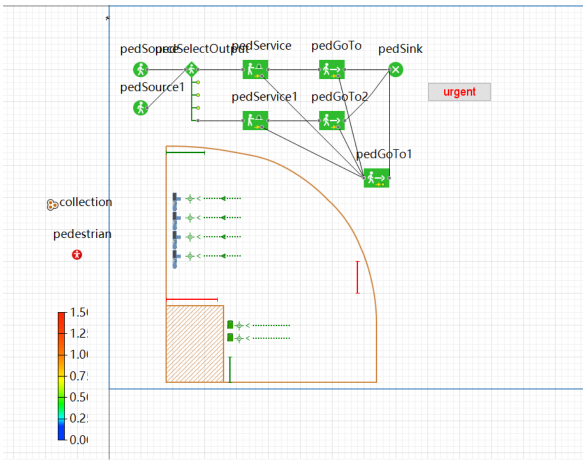

Figure 4: Survey data at each exit of the station hall.

Table 1: Comparison table of simulation model parameter settings.

Control type	Corresponding Environmental Elements	Parameter Name	Assignment Parameters
Pedsource	Reach the Goal	Moving Rate Moving Rate	2705(per hour) 791(per hour)
pedSelectOutput	Pedestrian Selection Probability	Usage Probability	0.2, 0, 0, 0, 0.44
Pedservice	Shortest Queue	Delay Time Delay Time	Uniform (2.0, 3.0) Uniform (2.0, 3.0)*8
Pedgoto	Reach the Target	Recent Exports	ped.getNearestGate()

This article additionally sets an emergency button in the model, which is used to simulate the simulation results when an emergency occurs, and for setting the function in the nearest exit. This can provide an effective basis for how to solve the crowd evacuation in emergency situations. In order to get a more accurate solution, three functions are set in the simulation, which are average residence time, area density and queue length.

1) Average residence time function

Average residence time function= timeMeasureEnd.disturbution.mean()

2) Regional density function

Regional density= pedAreaDescriptor.density()

3) Queue length function

Queuing number = pedService. queueSize (queueLine1)

2.7 Simulation Results and Optimization Analysis

2.7.1 Analysis of Simulation Results

As shown in Fig.5, setting the pedestrian density map in the simulation results can clearly show the degree of congestion in the station with the color depth. It can be observed from the results that there are relatively many people entering the subway station from the entrance of the train station, which is also The particularity of this type of subway station. Due to the large number of trains entering and leaving the train station every day, many passengers choose the nearest subway entrance to enter the station.

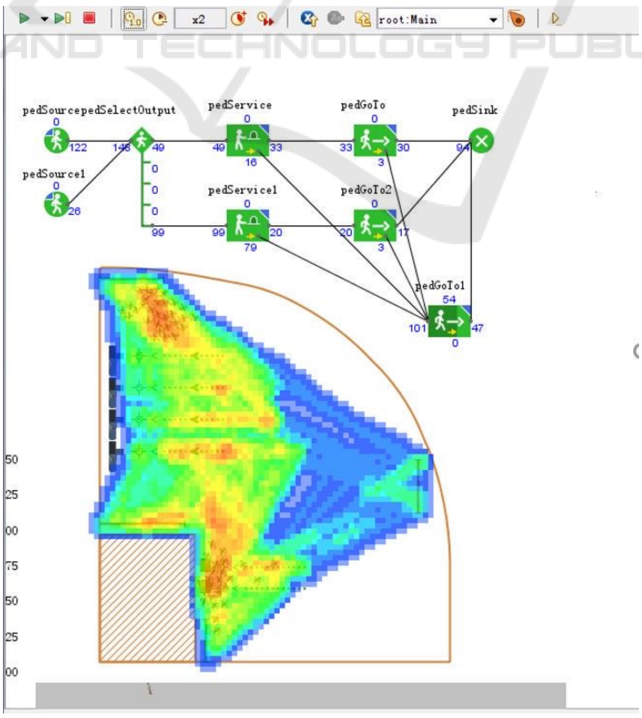

Figure 5: Pedestrian density simulation results show.

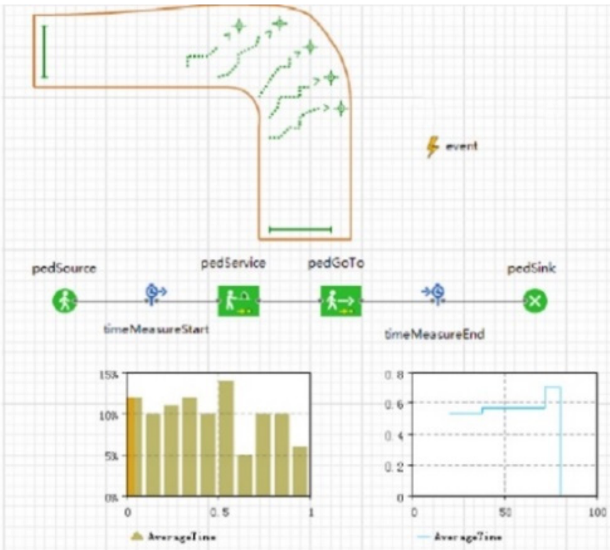

Figure 6: Model derived from running average residence time.

There will be different levels of crowding at different times in the subway station hall. Because the subway station selected in this article belongs to the station hall connected to the railway station, the personnel density will be higher than other subway stations, and it is more difficult to solve the problem of crowd evacuation. As shown in Fig. 6, running the simulation model yields the average stay time of passengers in the subway station hall.

2.8 Improve Proposals

Because the subway station is connected to the train station, what is different from other subway stations is that the station does not have the characteristics of only a large number of people in the morning and evening peaks, and the number of people in each time period of the station is different. If set too many evacuation exits, there will be resource redundancy. In response to the above problems, based on the operation results and the problems found, the following optimization and improvement schemes are proposed:

1) Due to the lack of gates for ticket checking, the inbound passenger flow is not smooth, leading to congestion in some areas of the station hall floor. Therefore, when the crowd is crowded, two outbound gates can be moved to the inbound gate. Taking into account operating costs, the number of ticket vending machines can be reduced by one.

2) When there are more passengers and the elevator load is insufficient, you can add indicator signs and manual guidance to transfer part of the concentrated passengers. Properly extend the passenger transfer route to increase the transfer time to avoid trampling accidents caused by crowded stairs.

3 CONCLUSION

In this paper, AnyLogic software is used to simulate the layout of the underground station hall of a subway station in the city, and four different entrances and exits are used for example simulation. By analyzing the simulation results and using the pedestrian density map to analyze the crowd density of the underground station hall of the station, to simulate how to evacuate the crowd when the crowd is crowded, it is found that the optimized simulation results are more reasonable and provide reasonable construction for the subway station hall. Reference. Therefore, from the perspective of modeling and simulation, the study found that AnyLogic simulation has certain application value for improving the operating conditions of subway stations and optimizing the layout of facilities, and can provide help for the construction of subway stations in cities.

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