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ARTICLE

Exploratory Study on the Simulated Police Force Allocation of Shopping Mall Emergency Based on AnyLogic Platform

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ABSTRACT

Due to the rapid development of society, public places, especially large shopping malls, are relatively frequent places for emergencies. Such emergencies not only seriously affect public security and property, but also bring great psychological pressure to citizens. Therefore, this study is of great significance for the exploration and study of public place emergencies.The research object of this study is the public shopping mall. Based on the AnyLogic simulation platform and guided by the relevant principles of social force model, this study utilize the pedestrian storehouse in the platform as the core module to build the simulation environment, and attempts to simulate the police force restraining effect on the overall event and the perpetrators after the occur of emergent incident under different police force allocations. In order to ensure the accuracy of the experimental data, the research team conducted field survey to estimate the average flow of people and the general data of the security personnel in shopping malls, also estimated the rest rain and capture time after repeated experiments.The results indicate that increasing additional police force outside the shopping malls and pre-organizing reasonable patrol routes can obviously facilitate police officers to restrain perpetrators. Meanwhile, it is also clear that the AnyLogic platform can effectively simulate pedestrian movement and interaction behaviour in emergencies.

1. Introduction

In recent years, with the rapid development of computer technology, various modeling methods and simulation theory are progressing increasingly. Simulation gradually contributes to the social development in a more convenient manner, affecting our lifestyle in various aspects. As a complete simulation software supporting multiple joint modeling methods, AnyLogic platform attracts an increasing number of researchers with its powerful performance and well-designed modeling tools [1], AnyLogic not only has an intuitive and friendly graphical interface, but also is fully compatible with Java. In addition, AnyLogic is competent for simulation work in most cases with an open and easy-to-use programming method.AnyLogic simulation modeling has produced a great number of successful cases in many fields. Dan Zheng and others utilized AnyLogic to simulate the complex evacuation behavior effectively [1]. Shengtao Ma et al conducted simulation research on traffic congestion based on AnyLogic [2].Zhenwu Zhao and his team studied the simulation and optimization of airport passenger

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security inspection process based on the AnyLogic platform [3]. Wenke Zhou and others utilized AnyLogic software to illustrate the speed changing process and the route selection results of crowd under the fire development [4].With the emergence of new modeling methods and technologies, as well as the rapid growth of computer performance, it is reasonable to predict that simulation modeling technology based on AnyLogic will be applied to more extensive fields.

To sum up, it can be seen that there are limited number of police simulation studies based on AnyLogic platform. This study aims to apply this method to police work though AnyLogic simulation software. In specific, utilize simple simulation model construction, set up a certain level of police force and the best patrol route, then conduct experiment with different police force allocations as the comparison scheme, observe how the time required to restrain perpetrators changes with the number of police forces after the incident, so as to explore the issue of police force allocation.It is hoped that this study will facilitate police officers to deal with similar emergencies and formulate prevention and control plans.

2. Principle of Social Force Model

Human simulation mainly relies on pedestrian storehouse and agent, and reflects the change process of pedestrian by building flow chart and logic. The main focus of this study is not the crowd evacuation behavior, therefore the logic diagram of shopping mall customer agent will be briefly illustrated as follow:

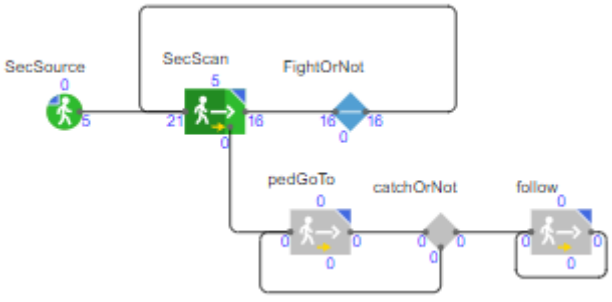

Figure 1. Pedestrian flow

The core of pedestrian storehouse is the social force model proposed by Helbing and Molna [5-8], which can reflect the force between pedestrians and between pedestrians and the outside world, and can also simulate the phenomenon of pedestrian self-organization and escape behavior [9]. Its dynamic equation is:

$$m_a \frac{d\vec{\omega}_a}{dt} = \vec{F}_a(t) + \xi \qquad (1)$$

$$\vec{F}_a(t) = \vec{F}_a^0\left(\vec{v}_a, v_a^0\vec{e}_a\right) + \sum_\beta \vec{F}_{a\beta}\left(\vec{e}_a, \vec{r}_a - \vec{r}_\beta\right) + \sum_B \vec{F}_{aB}\left(\vec{e}_a, \vec{r}_a - \vec{r}_B\right) + \sum_i \vec{F}_{ai}\left(\vec{e}_a, \vec{r}_a - \vec{r}_i, t\right) \qquad (2)$$

In the first formula, m_α is the pedestrian mass; ω_α is the expected speed of pedestrians in the current environment; in the second formula, $\vec{F}_a$ (t) is the resultant force exerted on the personnel in the model. The small term in the second formula represents the driving force, the interaction between pedestrians, the interaction between pedestrians as well as the surrounding barrier boundary, and the resultant force of attraction; and ξ is a random variable.As a comparatively accurate pedestrian dynamic model, social force model can effectively reflect pedestrian flow and pedestrian interaction behaviors, and has been applied to many pedestrian simulation studies.

3. Model Parameter Setting

Due to the software design and technical reasons, the complex large-scale shopping mall is abstracted into a simple structure model to simulate the shopping mall emergent incident, and simple variables will be utilized for analysis and research. The simulation interface of the shopping mall is shown below, among which the blue individual is the police. It is clear from the graph that police force is set up in the shopping mall, both the number of police and the patrol route can be adjusted dynamically.When the emergent incident happened, the alarm of shopping mall will sound and the crowd will begin to escape and evacuate. The nearby police and the security personnel of the shopping mall will quickly rush to the incident spot, hold and arrest the perpetrator.

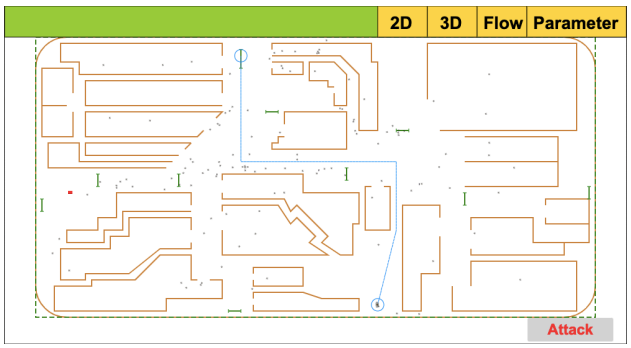

Figure 2. Simulation animation display

This study sets up three agents,including pedestrian, perpetrator and police, and the corresponding functions compiled in the software are applied to define the agents' delayed behaviors in shopping malls, such as dining and

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shopping. The behavior state of the agents is defined by the state diagram in the pedestrian module and given with correlation functions.

The status of pedestrians is shown in Figure 3, which includes three states: In the shop, Out of the shop and dead. The Ped Wait module is used to describe the pedestrian behavior in the mall, and Uniform (10,20) indicates that the agent's residence time in the area is about 10-20 minutes; send ("inshop", ped) and send ("outshop", ped) are used to describe the behavior of agents entering and leaving the area, and the initial speed is set as 2m / s.

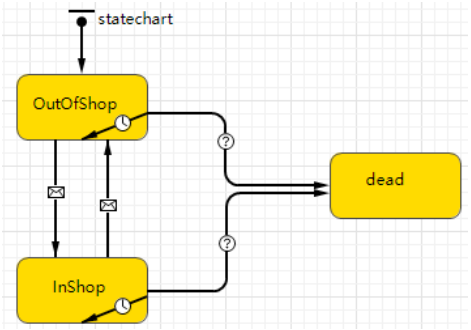

Figure 3. Pedestrian Status

The status of the perpetrator is shown in Figure 4, which includes five states: waiting, scanning, chasing, killing and caught. In terms of perpetrators, it is necessary to set detailed state commands in the agent state to define their specific behavior states. The command to find the target state (scanning) is as follows:

```
this.setSpeed(normalSpeed);
Main.X_killer = this.getX();
Main.Y_killer = this.getY();
```

The order of chasing a target state (chasing) is as follows:

```
this.setSpeed(chasingSpeed);
Main.X_killer = this.getX();
Main.Y_killer = this.getY();
```

The command to kill the target status (killing) is as follows:

```
stop();
victim.statechart.receiveMessage("killed");
victim.killOrNot = 1;
Main.X_killer = this.getX();
Main.Y_killer = this.getY();
```

The final status of the arrest order(caught) is:

```
getEngine().finish();
```

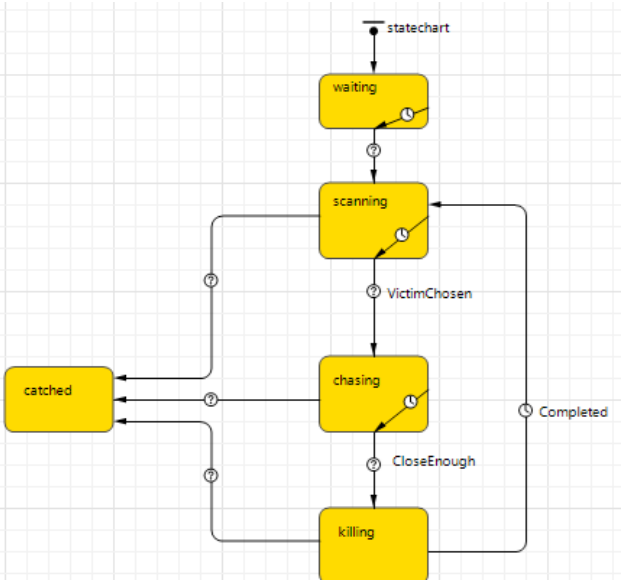

Figure 4. Perpetrator Status

As shown in Figure 5, the police officers are in three states: scan, find and fight. In the process modeling library, Select Output module makes conditional judgment on the behavior of the police officer and define the agent through the command! agent.inState (Security.fight). If the condition is true, the police officer will confront and arrest the perpetrator. The initial speed is set at 1m / s. The behavior state of the police is set through the state diagram, the behavior of restraining perpetrator is defined by the command sendToAll ("fight") .

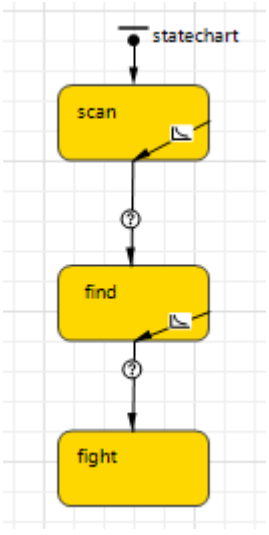

Figure 5. Police Status

4. Analysis of Experimental Results

The simulation experiment in this study is on the basis of the principle of social force model, using the pedestrian

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library module in AnyLogic platform. When the simulation starts, there are three security personnel on the first floor of the shopping mall by default, and the police officers on duty are transferred in the venue. In order to acquire the comparison results intuitively, the number of police officers is set to 1, 2 and 5 respectively as three different schemes.When the number of people inside the shopping mall is relatively stable, the researcher clicks the button of perpetrator to start the incident, and the crowd starts to escape, then the police and security personnel handle it. Each scheme is tested repeatedly for several times to obtain different data, and the number of police and the time required to arrest the perpetrator are analyzed.

The experimental results show that when there are three security personnel on the first floor of the shopping mall by default, additional police officers are deployed to patrol the venue, and the patrol route is always around the center of the shopping mall. When the emergent incident occurs, the nearby security personnel and the police on duty rush to the scene to deal with the perpetrator. When the number of police officers increases gradually, it is intuitive that the time needed to arrest the perpetrator will decrease accordingly. By conducting statistical analysis of the obtained data, the results are illustrated as follows:

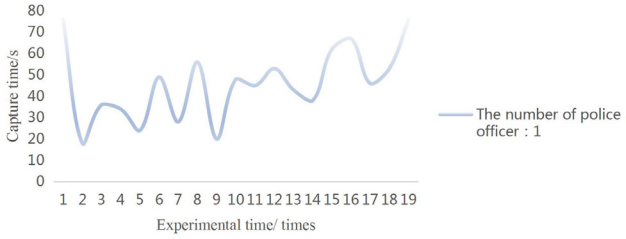

Figure 6. Statistics of capture time when the number of police officer is 1

It can be seen from Figure 6 that when a police officer is added to the shopping mall, the time taken to arrest the perpetrator is between 18s and 76s after the happening moment of incident,omitting the minimum value and the maximum value, the average restraining time is approximately 43.9s.

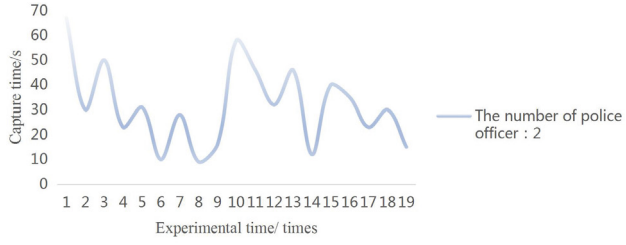

Figure 7. Statistics of arrest time when the number of police officers is 2

It can be seen from Figure 7 that when two police officers are added to the shopping mall for patrol, the time required to arrest the perpetrator is reduced after the happening moment of incident, and the time required is between 9s and 67s. The average calculation time is about 30.9s without the minimum value and the maximum value. Compared with the time when there is only one police officer, the time required to control the scene is reduced.

In order to make the results more intuitive and obvious, the number of police officers was set to 5 before the experiment, and the following results were obtained after repeated experiments:

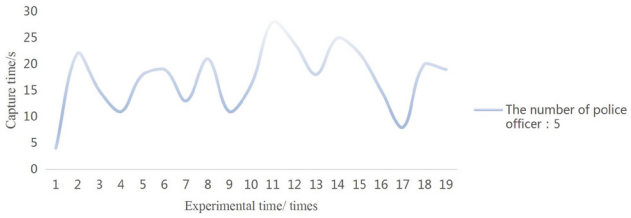

Figure 8. Statistics of arrest time when the number of police officers is 5

When the number of police on duty in the shopping mall is 5, the average time required to arrest perpetrator is merely 17.5 seconds omitting the maximum value and minimum value, and the time required to arrest perpetrator is much less than that of 1 or 2 involved police officer(s), which indicates that the increase of police officers can reduce the time taken to arrest the perpetrator.

In addition, the experimental results indicate that the use of AnyLogic platform can effectively simulate shopping mall emergencies and crowd interaction behavior, which can provide valuable reference for police force allocation and patrol route design.

5. Conclusion

This study utilizes AnyLogic platform to build a simulation model to simulate emergencies in shopping malls. The study collects the change of the time required to arrest the perpetrator under different numbers of police officers based on the experimental data from repeated experiments.The results proves the effectiveness of deploying certain police forces in large shopping malls for patrol under relatively ideal circumstances. In addition, it is also proved that AnyLogic can effectively simulate pedestrian interaction behavior and can be applied to the field of public security and police, so as to make great contribution to the data society and the intelligent policing.

As an exploratory study, there are still some deficiencies,

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such as the lack of experimental error analysis, and the limited exploration of whether the force value of police force and the perpetrator would affect the perpetrator restraining or not. In the future research, the above problems, including the experimental process as well as the parameter settings will be further refined and improved. In addition, the future research will attempt to introduce specific cases to further explore the crowd evacuation behavior in emergencies, and whether the police force or security personnel deployed in the shopping mall would affect the evacuation behavior of the crowd in the emergency or not.

References

[1] Shuo Yin. Study on safety evaluation and computer simulation of urban central heating system[J]. Beijing University of Civil Engineering and Architecture, 2014.

[2] DaN Zheng, Peng Xue. Study on evacuation of public buildings based on AnyLogic[J].Computer application and software, 2018(06).

[3] Shengtao Ma, Lei Yu, Jie Yang, Yuan Kang. Study on evacuation of public buildings based on AnyLogic[J]. Computer application and software, 2017(12).

[4] Zhenwu Zhao, Xinyuan Li. Simulation and optimization of airport passenger security process based on AnyLogic[J]. Journal of Civil Aviation University of China, 2018(05).

[5] Wenke Zhou, Huan Zhao, Huijuan Zhou. Study on fire evacuation of college dormitory based on AnyLogic simulation[J].Fire science and technology, 2014(12).

[6] Helbing D,Farkas I,Vicsek T. Simulating Dynamical-Features of Escape Panic[J]. Nature, 2000.

[7] Helbing D, Molnar P. Social Force Model forPedestrian Dynamics[J]. Phys Rev E Stat PhysPlasmas Fluids.

[8] Qingchao Shan, Xiuyuan Zhang, Chaofeng Zhang. Application of social force model in pedestrian movement modeling[J]. Urban transportation, 2011.

[9] Lingxiao Yang. Pedestrian flow characteristics analysis and guidance strategy research in open environment[J]. Beijing Jiaotong University, 2011.

 DOI: https://doi.org/10.30564/jeisr.v2i2.2417