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A Chessboard Model for Urban Anti-terrorism Based on Unity3D

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Abstract. In view of the complexity in large-scale urban anti-terrorism exercises and the difficulty for intelligent terrorist NPC, this paper put forward a chessboard model for urban anti-terrorism based on Unity3D, and designed a reliable terrorist siege training system. Besides, the paper also use genetic algorithm to program the escaping route of terrorist NPC. The whole paper contains three parts, gridding of the city, the operating system designed for trainers and the AI of terrorists. Finally, the paper apply the chessboard model to a CBD of a city. The results show that the simulation system is more flexible, the exercise scheme has reference significance, and the training effect is better.

Introduction

Documents [1-2] suggest that the aim of terrorism is to provoke fear and anxiety through terrorist activities. Therefore, terrorist attacks tend to be carried out in prosperous areas with large crowds. In the process of escaping, terrorists often attack innocent people to create chaos to cover themselves, such as the 9/11 attacks, Russian apartment explosion. These incidents show that it's meaningful to analyse how to arrest terrorists as soon as possible after terrorist attacks.

In view of the outstanding advantages of Unity3D in 3D scene virtual simulation, this paper will be based on Unity3D and related modeling tools. By constructing a three-dimensional urban chessboard, this paper launch the research of capturing terrorist simulation system.

The General Design of Chessboard Model for Urban Anti-terrorist

The design framework is shown in Fig. 1.

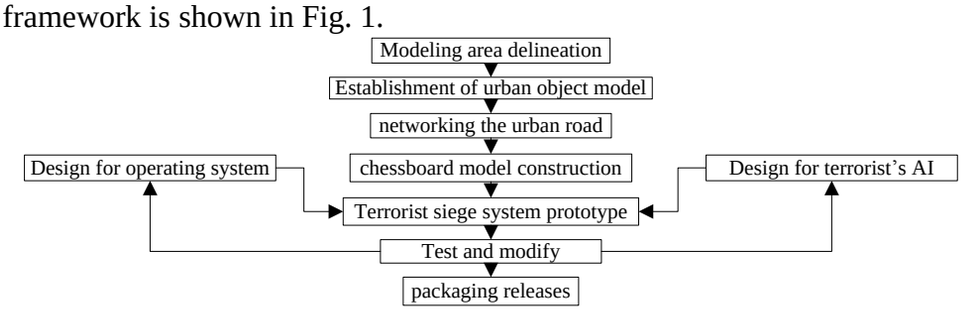

Figure 1. Design framework of anti-terrorism system.

The main contents are as follows:

(1) Modeling, including urban model construction and grid thinking.

(2) The construction of operating system for trainers, which mainly includes the design of operation mode of police chess and the design of system interaction interface.

(3) Terrorist AI design, which mainly includes the design of escape terminal selection scheme and escape route.

Simulation Chessboard Design

3D City Model Construction

On the process of Modeling, many papers, cover but are not limited to literature [3-4], have described it in detail. Therefore, this paper would not focus on modeling. Because the object of the study is how to round up terrorists quickly, there is little demand for the internal structure of housing and other models. On this basis, the models built in this paper just keep the shape of the house. All the model is optimized by LOD technology, so that the model in the distance becomes the cube with texture, and the details show up in the near. To some degree, using LOD technology can greatly reduce the computation of rendering, improve the utilization of memory, and greatly improve the fluency of the system[5].

The Idea of Chessboard Thinking

In this paper, indeed, the length of the road should be consider. However, the angle between the two roads has little effect on the simulation. In order to reduce the workload of modeling, urban layout and road shape can be simplified. By referring to literature [6], the number of roads connected to the road intersections is small due to the traffic light's limitation. Therefore, this paper has put forward the idea of chessboard which means the angles between the roads are set to 90°and the length of all roads would be set to the same length. The original model and simplified model for a block are shown in Fig. 2 (a) and Fig. 2 (b).

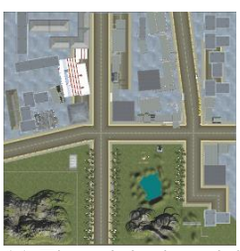

Figure 2. (a) The original model of a block.

Figure 2. (b) A grid model of a block.

This simplification can greatly reduce the workload of modeling and is beneficial to both the operating system and the design of terrorist AI, which will be elaborated in the following chapters.

Problems and Solutions of Chessboard Ideology

After gridding the model of the simulated urban area, the length of the road will be changed, which will affect the result of simulation. Therefore, the Correction scheme is greatly in need.

In this paper, a number of data are saved to record the transformation of road length changes. These data are used to correct the speed of car in a certain road, so that the time of vehicles passing through a road keep the same after gridding.

Design of Anti-terrorism Simulation System

The General Design Scheme of Simulation System

Fig. 3 shows the general design of the operating system.

The design flow shows that what the operating system need is the deployment of the direction of operation of the police units. Therefore, the operating system should include the initial deployment of each police force at the beginning of the simulation and the further deployment of the police units at the intersection. In addition, the system also allows the police unit to turn halfway.

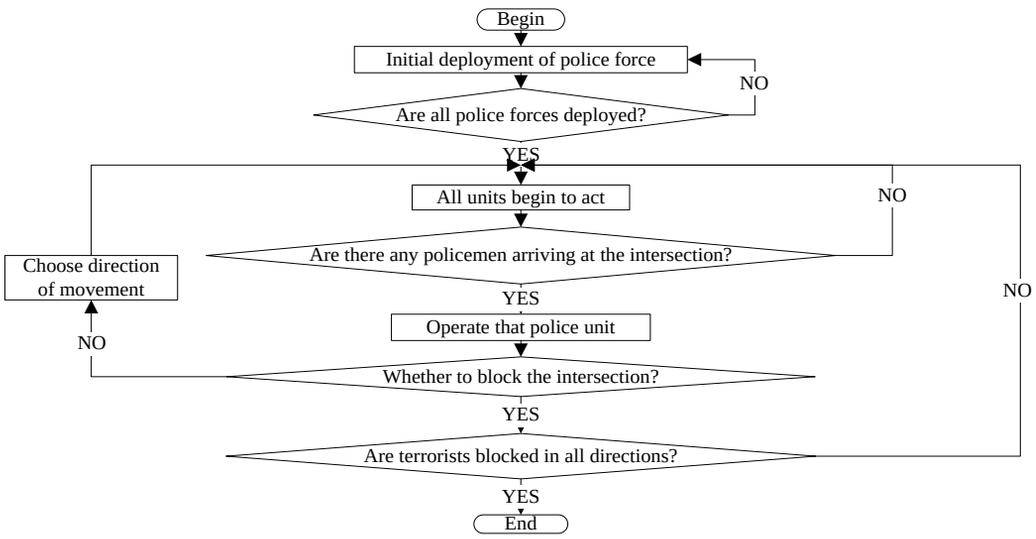

Figure 3. Design flow chart of operating system.

The Design of Interactive System

Since the chessboard model for urban anti-terrorism has been put forward in this paper, the road in the urban scene is simplified in four directions, east, south, west, and north. Apparently, this model greatly simplifies the design of the interactive system.

With the help of GUI components in Unity3D, this paper build the interaction interface shown in Fig. 4 (a) and Fig. 4 (b). By using the GUI button in Unity3D, the trainer can choose the direction of police unit and whether to block an intersection.

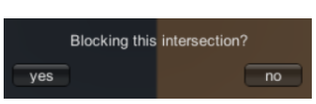

Figure 4. (a) Action mode selection.

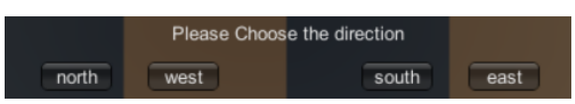

Figure 4. (b) Maneuvering direction selection.

Indeed, when the police unit is waiting for the command, all the units' movement should be paused. This paper uses the global int variable A to meet demand. When the police unit is waiting for the command, set A = 0. Iterative relations can be expressed in Eq.1.

$$p(x,\ y,\ z) = p(x,\ y,\ z) + A \cdot v(x,\ y,\ z) \tag{1}$$

Where, $p(x, y, z)$ is the current location of each unit, and $v(x, y, z)$ is the velocity.

After obtaining the command, set A=1 so that the simulation can restore.

Optimization of Interaction System

Due to the large urban area, it is difficult to observe the specific simulation process if the global situation is directly displayed. The following two solutions are adopted. One is to add status lamp to each intersection to indicate whether any unit arrives. Fig. 5 shows the operation effect.

Figure 5. State lights.

Figure 6. Small map model Fig.

Figure 7. Small map renderings.

The other is to narrow the main Camera's field of view, and to use another camera to create a small map. By clicking on the small map, the main camera can move to the corresponding location of the urban area. As shown in Fig. 6, by using the RawImage GUI component in Unity3D, a panorama of the city scene is displayed in the upper right corner of the screen to capture the above material. The specific operation effect are shown in Fig. 7. Besides, when a police unit arrives at the station, the corresponding position on the map flickers.

Intelligent Terrorist Design

Terrorist AI Design Process

In order to improve the authenticity and feasibility of the simulation system, the design of terrorists AI is very important. The design framework of terrorist AI is shown in Fig. 8.

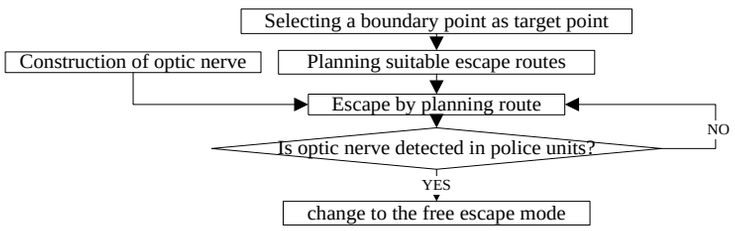

Figure 8. Design framework of terrorist AI.

There are three key points in AI design. The first one is how to select a better point as the escape target. The second one is how to plan a better escape path. And the last one is how to detect police units, which help the terrorist unit to judge whether change to the free escape mode.

Selection of Escape Target Points

After committing a crime, terrorist units will choose a route to escape, in which they are difficult to be caught by the police units. Therefore, in this paper, the average distance of the police to a certain point will be chosen as the basis for selecting the escape target point. Apparently, how to get the distribution of the police units in the simulation area is the key point. This paper has pretreated the police units by adding the label as shown in Fig. 9.On the basis of finding all the police units, the optimal escape target point on the boundary of the simulation map can be easily calculated.

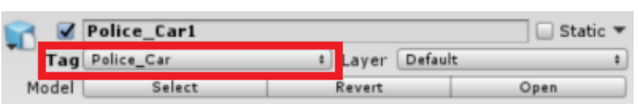

Figure 9. Schematic diagram of the property of a police car.

Flight Path Planning Based on Genetic Algorithm

While terrorist units are escaping, they should avoid to choose detours. Based on the Urban chessboard model, this paper can define the intersection coordinates with (x,y). Assuming that the terrorist's crime point is (2,3) and its escape destination is northeast (6,8), the terrorist needs to move 9 times.

Therefore, the genetic coding, whose length is 9, can be expressed as Eq.2.

$$L=(l_1,l_2,...,l_9) \tag{2}$$

Where, l_i means the direction of a crossing, when l_i=0, the terrorists chose the north-south direction to escape; then l_i=1, the terrorists chose the east-west direction to escape.

The coordinates of the ith intersections($i > 2$) can be given by Eq.3 and Eq.4.

$$x_i = x_{i-1}+L_i \tag{3}$$

$$y_i = y_{i-1}+(1-L_i) \tag{4}$$

Finally, by constructing a suitable fitness function S_j(x,y), this paper consider Eq.5 as objective function and regard Eq.6 as constraint condition.

$$\text{Max } S = L_i[G_1(x_i,y_i)+I_1(x_i,y_i)]+(1-L_i)[G_4(x_i,y_i)+I_4(x_i,y_i)] \tag{5}$$

$$s.t. \quad \Sigma L_i = \Delta y \tag{6}$$

Among them, (x_i,y_i) is the coordinates of the ith intersection that terrorist units pass through.

Therefore, how to construct the fitness function is a key point. In this paper, the most two influential factors, police units' distance and the number of pedestrians, are taken into account.

For the dimensions of different data are different. It is necessary to standardize the original data. Dimensionless processing is used to solve the problem. Eq.7 shows the specific process.

$$g_i = (n_i - n_{\min})/(n_{\max} - n_{\min}) \quad (7)$$

$$i_i = (d_i - d_{\min})/(d_{\max} - d_{\min}) \quad (8)$$

Where, n_i represents the original data, n_{min} represents the minimum value, and n_{max} represents the maximum value. After processing, each data will be located in [0,1].

As shown in Eq.8, the average distance from the police is treated by the same way.

In addition, terrorists are less likely to be surrounded by the police in the early stages of escape. Therefore the impact of bunkers and pedestrians on the direction of escape is relatively low. However, in the later stages, in order to be able to easily escape and take hostages, selection depends more on the number of pedestrians and pedestrians. And this dependence increases with time. Therefore, this paper correct the two value through Eq.9 and Eq.10.

$$G_i(x,y) = k_1 g_i(x,y) \quad (9)$$

$$I_i(x,y) = k_2 i_i(x,y) \quad (10)$$

Where, k_1 =exp[-i/(L-i)], k_2 =1-exp[-i/(L-i)].

Therefore, the overall fitness can be given by accumulating the individual fitness.

Based on the analysis in this section, the number of 0 and 1 of genetic code is fixed. Therefore, in this paper, GA proceeds to initialize a population of solutions and then to improve it through repetitive application of the crossover and selection operators[7].

Visual Nerve Design for Terrorists

Visual nerve is an important way for terrorist NPC, which is used to observe the distribution of surrounding police units. For this reason, By using Unity 3D's built-in function OnTriggerStay, the trigger for the terrorists is shown in Fig. 10.

Figure 10. Visual trigger for terrorists.

When the police unit is detected, the terrorists abandon the established route and quickly approach any boundary point in the direction of no police units.

Actual Case Analysis

This paper takes a CBD in a city as an example to set up the chessboard as shown in Fig. 11.

Figure 11. The chessboard model.

Figure 12. (a) The route for escaping.

Figure 12. (b) Operation of police.

The escaping route of terrorist is shown in Fig. 12(a). Besides, the deployment of the police force is shown in Fig. 12(b).Finally, the simulation succeeded in capturing terrorists.

Summary

Based on Unity3D, this paper designs a reliable training system for terrorist rounding-up by proposing the idea of chessboard thinking planning the escape path of terrorist NPC through genetic algorithm. It solves the problems of diversity of schemes in large-scale urban anti-terrorism exercises and difficulty in considering the whole situation by intelligent terrorist NPC. The results show that the simulation system's exercise scheme has reference significance.

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