ORIGINAL RESEARCH PAPER

Computer Science

RESERCH ON THE KEY TECHNIQUES OF VIRTUAL DRILL SYSTEM FOR FIRE ESCAPE

KEY WORDS: UE 4, Particle System, Pathfinding, Virtual Simulation

Dong Han College of Computer Science and Software Engineering, Tianjin Polytechnic University, Tianjin 300387, China.

ABSTRACT

In order to make the primary and secondary school students and ordinary people rescue and escape by themselves when the fire occurs, and to protect people's lives and property safety, it is necessary to simulate the fire process of escape drill effectively and truly. This paper researches the key technologies of virtual simulation system of fire escape drill base on the Virtual Reality Technology. A virtual simulation system of fire escape drill is realized by using the advanced Unreal Engine 4(UE 4); the fire, the explosion and the change of the flame's color effects are realized by taking advantage of the particle system, to get JPEG images from external directly as textures for the flame particle system by C++ programming with VS2015; the routing algorithm in traditional fire scene is improved to make the escape route more secure. The running results show that the simulate system developed with UE 4 has strong immersion by vivid pictures, and the system provides a basic platform for further research on virtual simulate of fire escape drill.

0 INTRODUCTION

Virtual reality technology is a computer simulation system which can establish and experience virtual world. It creates a simulation environment with computer and users can immerse themselves into the environment [1]. The simulation system of virtual reality technology has unique sense of immersion, interaction and imagination [2]. In modern technology, virtual reality technology has significant prospect [3-4] and application value which is applied to computer software, computer application and so on [5-8]. The article simulates a virtual fire escape practice system (hereafter called system) based on UE4 (Unreal Engine 4,) and researches the key technologies for the system.

Many people hurt or even dead finally because of dense smoke, flame, etc. in the fire. Although the effect of fire drill is good, it is difficult to popularize because of its complexity [9]. The establishment of the virtual drilling system capability for fire escape can provide learners with intuitive learning methods and improve the experience of self-help in fire [10].Meanwhile, systematic practice can increase the experience of firefighters. They can make decision quickly when the fire happened for firefighting is hard and physical strength demanding and there is a little time for people to extinguish fire [11-14].

UE4 engine is characterized by fast rendering speed, life-like physical property. It can not only develop large games, but also research and development simulation system [15]. In addition, UE4 provides many useful tool for simulation [16]. The article is about two important parts in UE4 simulation system: fire scene simulation and safe escape route system.

1 RESEARCH ON THE KEY TECHNIQUES

Traditional fire scene simulation is deficient in simulating fire. Its defects mainly lies in: it lacks interaction between fire particle system and other software platform. For example, the supervision software for real fire can provide real-time image of fire and we can save it in computer files. However, because of different protocols of different software, UE4 can't acquire images outside computer as texture mapping in the system.

Without considering the randomness of explosion in the fire which may cause the ignition of other combustible materials, for example, the explosion caused by ignition of chemical medicine, the sparks will result in the ignition of other combustible materials. However, randomness is highly related to the distance between fire spot and combustible materials.

The article improves the defect of traditional fire simulation. It presents the idea that obtaining images outside computer and make it into maps format as the maps in particle system and proposing the idea of fire possibility to simulate the randomness of other combustible materials ignition caused by explosion in real fire.

1.1 GET EXTERNAL TEXTURES

The system can acquire image of JPEG format (or PNG format) from local according to C++ code in VS2015 platform. These images are used in material attribute of required module in fire particle system to acquire outside image and apply them to texture maps of fire particle system. This is to avoid the conflict between different protocols in different platforms and to realize interaction between images of different platform, setting foundation for texture drive simulation based on outside images with C++ program and blueprint program. The introduction is as follow. The path of the external picture is indicated by _FilePath, _outTex indicates a texture in UTexture2D format. The function named GetlocalTexture () indicates to get a picture with a local address of _ FilePath and convert its data to an array of type uint8, and Unit8ToFColor () function indicates converts an array of unit8 format to a FColor array, TextureFromImage() indicates that the FColor array is assigned to the Texture.

Algorithm Get External Textures ___

1 : **Input:** _outTex = NULL, _FilePath

2 : TArray<unit8> origin GetlocalTexture(const FString _FilePath)

3 : TArray<FColor> SrcData Unit8ToFColor(TArray <unit8> origin)

4 : _outTex TextureFromImage(SrcData)

5 : **Output:** _outTex

This method can be improved as acquiring real-time images of other software platform in UE4 as texture maps in UE4 fire particle system, which will make the fire simulation more real with more real-time quality.

1.2 PROBABILITY OF THE TRIGGER OF FIRE

After the happening of fire, a fire spot can cause the explosion of combustible material in other places. Sparks generated from explosion causes the fire in nearby fire spot is random, which is closely related to the distance between explosion spot and combustible materials. To make simulation system become more real, we include the idea of ignition possibility into pathfinding system.

When the explosion spot ignites, a possibility value PR_i which set in (0,1) for each combustible material F_i according to uniform distribution, and then calculate the distance L_i between combustible material F_i and the fire spot. The fire possibility of combustible material F_i can be according to scene scale and unit distance D.

$$P_i = [\frac{1}{\frac{L_i}{D}} \times W_L + PR_i \times W_{PR}] \quad (1)$$

In formula (1), WL, WPR are distance weigh and random possibility weigh respectively. In addition, every Fi combustible material has its own PR_i value which can simulate the randomness of ignition of

other places caused by real explosion more exactly. Because the closer distance has bigger possibility in causing ignition, thus in this article W_L is 0.6 and W_P is 0.4

2 VIRTUAL DRILL SYSTEM FOR FIRE ESCAPE

2.1 FIRE SCENE SIMULATION

The fire happened in the teaching experiment building when the students make chemical experiment of industrial alcohol distillation. After lighting alcohol lamp, zeolite is forgot when the liquid is boiling. Taking thermo well to add zeolite immediately is incorrect, which results in the squirt of alcohol and then cause fire. The explosion occurs quickly and ignite other combustible materials, causing the fire gets bigger.

Vertical fire simulation module design is key to the system. It concerns the practical effect of the whole system. The part combines real fire to design logic firstly and then construct better scene model to achieve more vivid effect with the sense of immersion.

Irregular objects simulation is important in simulating real world [17]. In 1983, Reeves proposes the concept of particle system at first time [18]. Fire scene in this system simulates fire combustion, explosion, and dust and so on with particle system. The texture of fire is retrieved from the outside using the method mentioned in 1.1.

2.2 INTRODUCTION OF PATHFINDING ALGORRITHM

Once the fire is uncontrollable, all the people in experiment building should escape to survive immediately. Choosing the shortest and most safe escape route to safe places outside experiment building.

Traditional navigation grid searching algorithm concerns about shortest time for searching safe spot without considering explosion which may influence the safe of escape personnel, thus it isn't suitable for real situation. Safety escaping algorithm n this article explores the randomness of explosion which may cause nearby combustible materials ignition and judges whether the route near combustible materials are closed by means of fire possibility P. It also makes simulation experiment to traditional navigation searching algorithm and safety escaping algorithm and contrasts their results.

This paper chooses to simulate the safe escape algorithm on the UE4 engine. There are two important links in the virtual simulation system of fire escape, the realization of the fire scene and the search of the role safety escape route.

The realization of the flame based on UE4 particle system, the realization of the role safe escape based on the safe escape pathfinding algorithm in this paper, the roles can avoid obstacles in safe areas to choose the shortest safe route to escape. In the simulation experiment, the fire point, the Explosion point, fire danger point, safe area, danger area and escape route of the escape personnel are recorded. The simulation scene is shown in Figure 1.

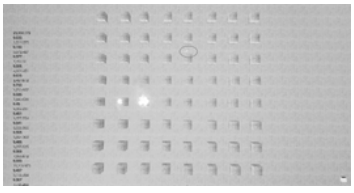


Figure 1: Simulation experiment scene of fire escape

In terms of the effectiveness of safety escaping algorithm, programmer makes it into reality. The following are introduction of the algorithm and simulation experiment.

First of all, create a fire escape simulation environment, and set the role. As an escape personnel, the evacuation personnel follows the algorithm to find a way to escape after the fire, and the safe escape pathfinding algorithm is introduced below. The information of combustible material fi is indicated by the value of flag(f_i), flag(f_i) = 0 indicates f_i is the dangerous point prone to fire, flag(f_i) = 1 indicates fi is the ignition point, flag(f_i)) = 2 indicates fi is the safe point with little possibility of fire, and dis(a, b) indicates the distance between a and b.

Algorithm Safe escape pathfinding

1: **input:** Combustibles set F = {F_1, F_2,…, F_3}, explosion point location E, W_L=0.6, W_{PR}=0.4, n=64, the unit of distance D= 2470
2: **for** 1 i, n **do**
3: P(F_i) PR_i
4: L_i dis(F_i, E)
5: $P_i \longleftarrow sum(\frac{D}{L_i} * W_L, P(f_i) * W_{PR})$
6: **if** P_i >=0.65 and P_i<= 0.80 **then**
7: flag(F_i) = 0
8: **else if** P_i >=0.80 **then**
9: flag(F_i) = 1
10: **else**
11: flag(F_i) = 2
12: **end if**
13: **end for**
14: **output:** security mark flag(F_i)

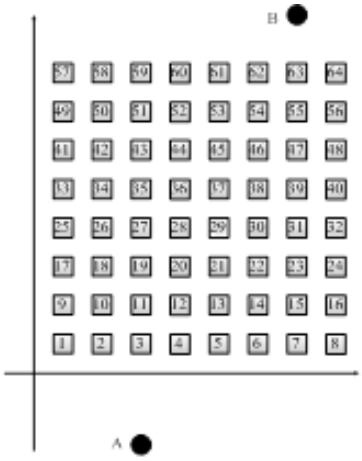
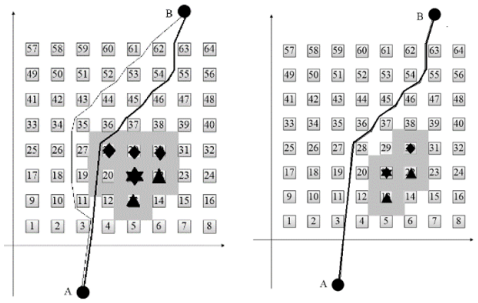


Figure 2: The simulation model of safety escape pathfinding



（a） （b）

Figure 3: Simulation Results of Safe Escape Path-finding Algorithm

In this paper, the fire simulation model takes the 8*8 matrix as the fire occurrence area, and set number 21st to the point of explosion, other location as the fuel. The starting point of escape personnel and the safety point B finally reaching is set in the matrix on both sides. According to the proportion of simulation model, set up the unit distance D for 2470, as shown in fig. 2.

The results of two simulation experiments in the simulation experiment are listed below, as shown in fig.3.

The thicker lines represent the escape paths of the traditional navigation path algorithm, and the finer lines represent the escape paths of the safe escape route algorithm. If the triangle is the ignition point with a trigger ignition probability of P value greater than 0.8, the combustible material will trigger the fire. The

diamond is the ignition danger point of the trigger ignition probability P value between 0.65 and 0.8, the 12 side shape is the set explosive point, the shadow area is the fire danger area, the blank area is the safe area, and only one black line indicates two pathfinding algorithms to get the path of the overlap. The shaded region in the experimental results diagram indicates the dangerous spot of the flammable and the dangerous area around the ignition point. As shown in fig. 3(a), the information of combustible materials in hazardous areas is shown in table 1. If the escape route passes through the shadow part, it is deemed that the evacuation process of the personnel is dangerous, and the escape route can avoid the shadow part as a safe escape route. From the simulation results can be intuitive to see in the figure, the point of ignition and fire danger point will change as each experiment with random probability changes, the danger zone will change too.

TABLE - 1. Figure 3(a) combustible materials information in hazardous areas

Figure	The labels of combus-tible materials	The probabili-ty of the trigger of fire	Set combustible materials information
(a)	13	0.816	Ignition point
	22	0.867	Ignition point
	28	0.763	Dangerous point prone to fire
	19	0.741	Dangerous point prone to fire
	30	0.735	Dangerous point prone to fire

When the starting point and the safe point of the role are determined, the escape path obtained by using the traditional navigation grid algorithm only considers the shortest path to avoid the obstacle search, regardless of the safety of the escape route, and the path obtained by using the safe escape algorithm is the shortest path to avoid the obstacle search in the safe area to avoid the fire danger area. The safe escape algorithm is safe and effective.

3 CONCLUSION

The virtual fire escape practice system based on UE4 simulates the flame in real fire vividly. The article obtains outside images as maps through programmer which can avoid the problem of different communication protocols in different software platform, setting foundation for the interaction between different software platforms. Aiming at the situation of the virtual simulation scene of fire escape, this paper makes further improvement based on the navigation grid algorithm, and puts forward a safe escape path-finding algorithm. Safe escape pathfinding algorithm considering the randomness of combustible fire and the influence of ignition effect about the safety of personnel escape, and the traditional navigation path finding algorithm and safe escape pathfinding algorithm in the application of the fire escape simulation. The simulation results show that the concept of trigger ignition probability improves the authenticity of fire escape simulation, and the safe escape path algorithm can avoid the dangerous area in fire scene accurately, which realizes the real-time pathfinding of fire safety in the scene.

Virtual simulation has important practical value and development prospect in real life. If the system is improved and combined with the current web App technology, it can realize the real fire scene after the rapid virtual simulation for the field personnel mobile phone simulation results, so that the disaster victims can observe the details of fire, such as the location information of fire danger zone etc., and quickly provide security escape routes for the affected personnel, etc., which can greatly improve the probability of fire safety escape, reducing the loss caused by fire on people's life and property.

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