Forest Environment Virtual Reality Navigation System: Implement of the Spread of Fire in Typical Terrain*

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Abstract

Virtual reality technology is human representation of the outside world, which is revolutionary change not only guarantee a high external validity, but also has high experimental control. fire drills virtual reality technology integrate fluid dynamics, social psychology, multidisciplinary scientific research field which is important in fire safety prevention and relief support, the technical core is to realize the simulation of fire development, an accurate analysis of fire personnel during the injury, gives the best fighting program. The simulation of the fire spreading process is different from totally dependent on computer programs to simulate fire spread. Principal innovation is the combination of 3ds max, Photoshop and VR-platform virtual reality platform to simulate the fire spread, alternative programming of complex computer simulations. This paper studies the basic theory of virtual reality technology knowledge, based on the establishment of three-dimensional model 3ds max full use of VR-platform to create friendly man-machine interaction interface and the ability to write simple code functions, simulate the characteristics of four typical terrain fire spreading process, detailing exploring the process of fire spread simulation methods.

1. Introduction

Virtual Reality a kind of advanced computer of human-machine interface, which is special for its immersion, interaction, and vision. It combines computer graphics, simulation technology, multimedia technology, artificial intelligence technology, computer network technology, parallel processing and multi-sensor technology to simulate human vision, hearing, pselaphesia and other sensory functions. Thus, People can make real-time interaction with each other through language, gestures and other natural way in the computer-generated virtual state to create a humanoid multi-dimensional information space. In summary, virtual reality is a kind of vision technology about how people interact with computer [1-3].

Chinese People's Armed Police Force Academy Science and Technology Institute, pioneered the development of computer simulation of tank fire command training system, which is able to do fire scenarios designing, and simulation, fire command program and process simulation, and to carry out fire efficiency experts evaluate, realize training process playback and play in the training simulation with good results. National Fire forces gradually use virtual reality computer technology to all areas of fire prevention such as fire safety supervision and management, business training reform and actual decision-making assistance. If we use virtual reality technology to the assessment of fireworks, we can have a better understanding of the relationship between design parameters and design data, found the potential design flaws and problems and explore problem-solving ways to make the whole designing even perfect. In assisting the elimination of fire hazards with the application of virtual reality technology, it will enable the process of fire rescue to become more scientific, all of the hidden, potential fire hazards will be exposed to our eyes .In the implementation process of the fire rescue, through a virtual reality system to combine the experience and keen of the commander with the speed, precision, intuitive visibility of computer virtual simulation, to rule out useless information as far as possible, provided a feasible approach to address this issue [4-5].

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With the development of network technology, Rego Granlund, Erik Berglund, Hen rikEfik sson from the Department of Computer Information Science, Linköping University, Sweden proposed a Web- based C3 Fire micro-world system, C3 (command, control, communication) [6].The system is written with JAVA programming language, though which you can use different methods to train the collaboration and situation awareness of users. The simulated training environment is forest fires, in which the users can simulate members at any level such as the investigators, firefighters, fire department commander, on a commanders and staff officer. C3 Fire micro-world simulates emergency situations to help users make decision at the end of the grid end. There are three ways can be used for trainees on the network to exchange information, that is GIS, e-mail and logs. In a task, simulation training system continuously updates the unit commander team's location, and staff officers get the information of the situation from logs and e-mail access to on-site commanders and investigators. Playback system also provides training for follow-up evaluation [7-9].

2. The realization of the spread of fire in typical terrain

It is difficult to achieve the fire spreading in the VRP, because the single particle animation can not achieve part movement, only the overall change, so we use the method of overall change in the process of fire spread simulation after repeatedly trying. To do the following: creat a plane in 3ds Max called "the fire change", which then be imported into VRP to bind together with the particle system. Then import another plane named "on fire" and without binding to any particle system. Create a path along the uphill direction, which is named “uphill path". Add the anchor to reach action to “uphill path", as shown in Table 2.1. In the mountain path, select a number of anchors with appropriate distance, and add the trigger action command for each anchor. Mainly by the animation of carrier in the path of "on fire", each get an anchor to trigger a corresponding script command to achieve to control the size of the vector "changes on the fire",then control the size of the fire particle system. Prior to place most of the carrier "on the fire change" near the mountain, only at Z-axis direction to make the particle system large, then can create the visually effection of upward fire spread.

Table 2.1 anchor command

anchor	Script command
2	Scale model, uphill fire change ,0,1/1/1.5
4	Scale model, uphill fire change,0,1/1/1.3
5	Scale model, uphill fire change,0,1/1/1
6	Scale model, uphill fire change,0,1/1/1
7	Suspended animation path, uphill, path,1

Plane was chosen as carrier, it is not only because when its Z-axis scales the Z-axis did not change significantly, with little variation. But also because when testing, it is not easy to influence the judgment of fire size and overall appearance. As the VRP does not support complex logic command, every scale is occurred at the current size status. So the value of each anchor should be scale in turn. Due to flames of anchor 5, 6 are large enough, so it needs not to scale up again. Setting a pause animation to anchor 7, then the "on fire" reached the point to trigger path suspended animation command, no animation will repeat, and then a continuous increase of the fire is caused. Effect diagram: as shown in Figure 2.17-2.18:

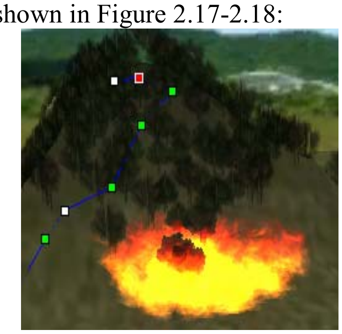

Fig 2.17-2.18: Initial state

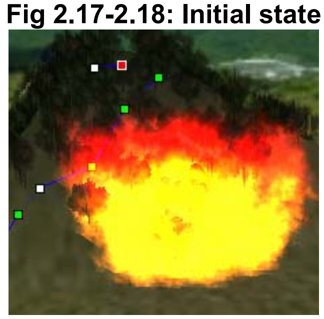

Fig 2.17-2.18: Final state

The "on fire" path animation triggers the anchor of the "uphill path" to reach the command, so as to control the size of the vector "changes on the fire" and spillover effects happen visually. But the disadvantages of this approach are: First: Although the visual effects have spread, but it is not easy to control the size between the anchor and the carrier "on the fire change". We need to select an appropriate anchor distance, proper scaling, and appropriate carrier location to get a more appropriate data, which is difficult to control. And if the control is slightly bad, the effect will vary a lot. Second: it is easy to control the proportions of the downhill fire and uphill fire at the steep mountain; however, because we use scaling to perform the spread, the whole fire particle system will be enlarged with the carrier plane, showing part of the Mountain burning visually. But in fact part of the body which is hidden in the mountains of amplification is enlarged. Once the hidden location is not appropriate, the spread and the combustion will be influenced greatly and it is difficult to control for the terrain difference, then it is not easy to add this method to the changes of the fire of other terrain. At the basis of the Approach in assessing above, through multiple explorations, we find a new way which can solve both the spread of the fire and adapt to the terrain change. Set the follow slope shape as an example, the choice of the vector is shown in Table 2.2:

Table 2.2 Comparison of the vector`s type

Vector	Problem	Conclusion
Plane	As the plane does not involve changes in Z axis, so we set plane as the carrier of the fire particle system.	After several tests, ultimately selected plane as the carrier particle system, and binding with it, to control the fire changes.
Sphere	1. While controlling the zoom, because the fire ball Z-particle system would affect the morphological changes, we should set the Z-axis remains the same in the process of the change, which is cumbersome and complex, and increasing quantities. 2. Sphere volume will change significantly after scaled which affect test results.	After several tries and error, it is not suitable to be carrier systems.
Pyramid	1. While controlling the zoom, because the fire Pyramid Z-particle system would affect the morphological changes, we should set the Z-axis remains the same in the process of the change, which is and increasing quantities. 2. Pyramid volume will change significantly after scaled which affect test results.	After several tries and error, it is not suitable to be carrier systems.
Box	1. While controlling the zoom, because the fire box Z-particle system would affect the morphological changes, we should set the Z-axis remains the same in the process of the change, which is cumbersome and complex, and increasing quantities. 2. Box volume will change significantly after scaled which affect test results.	After several tries and error, it is not suitable to be carrier systems.

Note: marked in red font on behalf of the selected plane

The choice of the vector size is shown in Table 2.3:

Table 2.3: The choice of the vector size:

Length	Width	Conclusion
10	10	There is big gap compared to the size of initial state of the fire particle system with which is not conducive to the test results show.
20	20	There is still difference compared to the size of initial state of the fire particle system with which is not conducive to the test results show.
30	30	It is almost the same size as the particle system, test, and we can see the changes of the carriers and fire particle system clearly.
40	40	Too large

Note：Marked in red font on behalf of the length and width of the carrier

First, rigid body animation of the spreading fire cannot be realized in the 3ds Max. We have mentioned in the first method that atmospheric device in the 3ds max is not supported in the VRP, so we do not add fire effect animations, only to make the plane carrier into rigid flat animation. As shown in Table 2.4-2.6:

Table 2.4 The choice of the Patches Scaling

Test Group	Status	Scaling(X\Y\Z）			Conclusion
1	beginning	100	100	100	no obvious changes in the fire and should continue to increase
	end	200	200	100	
2	beginning	100	100	100	Changes in the fire have occurred, but it is better to make sure the value of Y is less than X and should continue to increase
	end	350	350	100	
3	beginning	100	100	100	Obvious changes is occurred in the fire, but the Y value is too small and should continue to increase
	end	500	300	100	
4	beginning	100	100	100	XY value is

	end	550	450	100	slightly smaller and should continue to increase
5	beginning	100	100	100	Moderate XY size, can be used.
	end	650	550	100	
6	beginning	100	100	100	XY is too large, close to the size of the mountain, some too large and not conducive to control
	end	800	700	100	

Note: marked in red font on behalf of the chosen scaling

Table2.5. The length of the frame

Category	length	Conclusion
Normal fire	500	The fire animation spread too fast
	800	fire speed were not significant
	1500	Moderate speed to facilitate the completion of the fire bigger animation speed control
	2000	fire spread animation is too slow
Right side	800	fire spread animation is too fast
	1000	Moderate speed, able to complete directional control
	1500	the spread of Animation is slightly slow
left side	800	fire spread animation is too fast
	1000	Moderate speed, able to complete directional control
	1500	the spread of Animation is slightly slow

Note: marked in red font on behalf of the frame length

Table 2.6. Key frame

Category	Key points	Effect
Normal fire	0	The beginning of the normal fire spread animation
	1000	control the beginning speed of the fire in order to slow rate of spread, and start to accelerate more than 1000
	1500	The end of the normal fire spread animation
Right side	1510	The start frame of the right side fire animation
	2500	The end frame of the right side fire animation
left side	2510	The start frame of the left side fire animation
	3500	The end frame of the left side fire animation

Results shown in Figure 2.19-224:
Normal fire shown in Figure 2.19-2.20:

Fig2.19 The beginning

Figure 2.20. The end

Under the affection of the southeast winds, to the right deflection, the fire turns right. As shown in Figure 2.21-2.22:

Figure 2.21. The beginning

Figure 2.22. The end

Under the affection of the southeast winds, to the right deflection, the fire spreads left. As shown in Figure 2.21-2.22:

Figure 2.23. The beginning

Figure 2.24. The end

Advantages of this approach are: first: the ability to simulate all-terrain conditions of the spread of fire, with good adaptability. Second: focus on the production of rigid body animation in 3ds Max, scaling patches selection, the choice of frame length, key frame selection, and add animation to give a small facet angle of rotation, so that in the change process and match the shape of the mountain. Therefore, these key steps should be trial and error to find the best ratio and location. Too small patch selection is not match the mountains and the flame with floating state burned out of the mountains through the General Assembly body when it is too large. Since VRP own limitations, it cannot achieve real-time control functions. Such as the input wind direction, slope, temperature and fire-related factors, then we can control the fire changes.

3. Conclusion

Forest fire spread is a complex system, which is influenced by is the wind direction, slope, temperature, terrain and other characteristics of the combined effects. In this study, based on the establishment of three-dimensional model made in 3ds Max create friendly man-machine interaction interface ,write script commands to simulate the typical characteristics of the terrain hill fire spread process, with the full use of VR-platform. It made better simulation results, which is a new option for the understanding of the characteristics of different terrain conditions, the spread of fire behavior and the achievement of its visualization. The fire spread simulation of the next hill, the ridge zone, and saddle area is the next priority. At the same time, virtual reality simulates and actual fire spread modeling behavior should be combined. Beijing Forestry University Virtual Reality Laboratory simulation of fire behavior will be carried out, in addition to terrain factors to consider wind direction, slope, temperature and other factors should take into account, and to visualize the virtual, so as to China's forest fire prevention work, the process of risk of forest fire fighting armed terrain recognition, the spread of fire to provide intellectual support for the law of identification.

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