

The Application Research of Virtual Reality Technology in Emergency Evacuation Simulation of Sports Stadium

Xiao Yi

Sport Events Research Center of Shanghai University of Sport,
Shanghai 200438, China
E-mail: cutexxx@163.com

Abstract—With the activities of major sports events have become increasingly active and the social influence of sports events is gradually increasing, people have more and more opportunities to watch matches in sports stadiums. Sports stadium, as a place of relatively large occupant density, has high demands for its safe operation except that it is necessary to meet the needs of competitions. Under the unexpected situations, how to ensure the public safety has become the focus of social concern. This paper takes the emergent evacuation simulation of sports stadium as a main research object. It concerns the main problems that how to use virtual reality technology to build a three-dimensional simulated scene of sports stadium; how to truly simulated the whole evacuation process of many people under unexpected situations. The scene modeling of sports stadium, The construction of evacuation model, The visualization of evacuation process, Dynamic Roaming and Interaction design, Evaluation system and other issues are discussed in this article.

Keywords— *Sports Stadium; emergent evacuation simulation; Virtual Reality Technology*

I INTRODUCTION

With the activities of major sports events have become increasingly active and the social influence of sports events is gradually increasing, people have more and more opportunities to watch matches in sports stadiums. Sports stadium, as a place of relatively large occupant density, has high demands for its safe operation except that it is necessary to meet the needs of competitions. Under the unexpected situations, how to ensure the public safety has become the focus of social concern.

If the unexpected event occurred, how to better design treatment programs so as to effectively reduce losses has become one of the important issues. However, when emergent accidents occur, the sources of information to deal with are complex; the data to deal with is very large. The correlation dealing process

and results can not be showed very well only by a simple numerical display.

Virtual reality technology (referred to as VR) is a computer-generated and high-level human-machine interaction system that can constitute not only a visual three-dimensional environment, but also such senses as hearing, smelling and touching, etc. It integrates the latest achievements of computer graphics, multimedia, AI, sensor, the Internet and parallel processing techniques. In the virtual three-dimensional environment, the vision, hearing and tactile sense seem to be in the real world. Virtual reality technology is now widely used in military, medical, automotive and other areas such as disaster mitigation, preparedness and simulation modeling.

So if we can make use of virtual reality technology to realize the evacuation simulation process and results visualized, the real scene evacuation simulation process can be displayed in a more comprehensive and intuitive way. Furthermore, the interaction and evaluation system can be established so as to assist the environment design and safety plan development, and provide a safe training environment.

A. Meaning

When people concentrate in a stadium to do activities, once an emergency happens, if the evacuation can not be carried out in time, significant casualties are often caused, so the dynamic evacuation should be studied in depth. The study of human behaviors in emergency evacuation is a complex and multi-disciplinary research topic. Traditional research methods include on-site inquiry, investigation and exercise etc. These methods have many shortcomings. However, a lot of survey data can be easily gotten by using virtual reality technology. So, the evacuation process of evacuees under unexpected situations can be simulated by using the virtual reality technology and computer simulation technology to establish a appropriate evacuation model, which provides the user

with a reasonable and safe evacuation plan. In addition, according to different situations, different evacuation plans and be made, and reasonable assessments and recommendations corresponding to each plan can also be given to the user, which is of great practical significance and practical value.

B. Methods

The research methods include literature, program design, system analysis, system modeling and system simulation method etc.

II RESEARCH STATUS

In view of the importance of public safety, the research on the evacuation simulation started early at home and abroad. A large number of simulation methods have been used in the related researches. These studies are mainly focus on the time , then behavior and then dynamics of evacuating. For example, Zhang peng, who studied the vertical high-rise building evacuation simulation, focusing on the evacuation status of elevators and stairs, analyzed the key problems and solution ideas of vertical evacuation, but the scope of its application is relatively narrow, it can only be used for some high-rise buildings; Hughes developed the evacuation simulation instance used in coalmines; Minesh etc. analyzed the modeling method of evacuation simulation on the aircraft ; Tan guitian and others studied the evacuation simulation of people in fire.

There has many research fields of simulation evacuation. EVACNET4, developed by the University of Florida, is widely used network simulation software for evacuation. The software describes the building structure in form of a network, which simulates the personnel's movements in the network, until all the people eventually reach a safe place. Through a series of predefined graphic symbols, the software establishes a network model to simulate the evacuation, which can accurately reflect the layout of the internal structure of the building .However, because the software is based on the network model, it has some shortcomings in three-dimensional process exhibition and simulation training.

Xu Gao and others developed a high evacuation simulation software Evac SA. The evacuation simulation can be done in a two-dimensional plane by doing some setting in the software. But because it is based on single PC, and only shows two-dimensional interface, the software relatively lacks of visual presence and immersion. Also in these studies, the human intelligence and accuracy during the evacuation

process are to be further strengthened, and the personnel actions and other physical characteristics in the evacuation process are still not considered enough. In view of the uncertainty of unexpected situations and the complexity of the sports stadium, the virtual reality software dedicated to the evacuation simulation of sports venues is still not developed at home and abroad of. At abroad, there are some fire safety calculation software, but their three-dimensional function is weak and the reality is not strong.

III THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY IN EMERGENCY EVACUATION SIMULATION OF SPORTS STADIUM

The complex problem that how to combine the virtual reality technology, three-dimensional modeling technology and computer simulation technology together to realize the evacuation simulation of sports stadium can be divided into the following sections:

A. The scene modeling of sports stadium

The evacuation simulation needs to build stadium models at first. We can build the three-dimensional models of buildings in several ways. The constitution of the three-dimensional model includes the layout of the outdoor environment, the indoor channels, the facilities, the fire signs and the indication the location of its exports. In the three-dimensional models, the width of evacuation channels and the layout of barriers can be regulated at will. The impact that the changes of the accident scene environment and the spatial structure produce on the reflection of evacuation behaviors can be observed in this way.

In order to improve program's efficiency, scene modeling can learn from the sub-regional generation method, that is to separate the scene into multiple parts and each part is modeled separately. Then all the separate parts are dynamically combined together through the program so as to achieve the purpose of speeding up the procedures.

B. The construction of evacuation simulation model

For personnel evacuation, currently the evacuation model can usually be divided into the following categories:

(1) The first one is the macro network flow model, which does not consider people's behavior characteristics. It looks people as individuals with no difference. People evacuate in crowd;

(2) The second one is the microscopic discrete grid model, which considers people's behavior characteristics. This kind of model divides the virtual

space into many small discrete grids. The evacuees are placed in the grids. The evacuation process is simulated by the occupied and vacant grids. The evacuation spaces are continuous, the evacuees can be distributed in any places, and the evacuation process considers the evacuees' behavioral characteristics. The behavioral characteristics mainly include: warning reaction time, personnel hazard-avoidance behavior and exports selection. Personnel as the main body of evacuation have a decisive influence on the evacuation process;

(3) The agent technology. Now there already are some researches using agent to build simulation model. The agent can perceive the environment and other users' coordination information, has its own knowledge base and rule library and has the ability to response. It can continuously evolve through learning this knowledge; can independently make decisions according to the perceived information and so on.

On the basis of fully analyzing the behavior details and its influence factors during the people's evacuation, by mapping the evacuees as Agents, mapping the individual characteristics of evacuees as the status properties of the Agents, mapping the evacuees' various actions spontaneous or invoked by the external events as the Agent rules, the evacuation model of sports stadium can be constructed. The evacuation model comprehensively considers the evacuees' competitiveness and the ability to judge, the herd behavior among evacuees, the guiding role and the impact from such external random events as fire, channel-blocking etc. on the of evacuees.

Because different evacuation model and its corresponding calculation software focus on different emphases, the modeling methods and the simplification for the evacuation process also vary. The appropriate modeling method should be selected according to the actual situation so that their simulated results can reflect the reality of the evacuation in the greatest degree.

C. *The visualization of evacuation process*

According to the selected evacuation model, a visual simulation of evacuation processes can be created. The simulation of evacuation processes mainly includes three parts: input module, function module and display module. Input module mainly completes the initialization of three kinds of information, that is the evacuation scene information, the location information of the personnel and emergent event; functional module is the core of visual evacuation simulation, including the simulation of emergency scenario (fire, poison, explosion, etc.) and the simulation of personnel decision-making behavior; display module mainly dynamically displays the entire

evacuation process driven by the functional module. The three-dimensional animation of evacuation simulation can demonstrate how the evacuees evacuate under an emergent situation and many kinds of parameters can easily be modified. This paper takes the sports stadium as an example; build a three-dimensional evacuation simulation of sports stadium to simulate the personnel evacuation under unexpected emergent situations and obtain some effective testing results.

D. *Dynamic roaming and interaction design*

By using the virtual reality technology, the complex input data can be presented as a visual three-dimensional scene, and different emergent scenarios, different personnel density, distribution and behaviors can also be simulated according to different initial data. Thus, the scenery roaming of sports stadium can be realized; the evacuation process under unexpected situations can be simulated; the escape training and fire training can also be conducted. Through this testing and simulation, some of the evacuees' behavior reactions that can not be predicted under different accidents can also be found; some potential problems in the evacuation design can also be found so as to further perfect the evacuation plan, complete the search of optimal evacuation routes. All above helps to complete the risk evaluation of sports stadium.

E. *Evaluation system*

Through inputting various types of initial parameters, qualitative and quantitative analysis can be conducted to make the personnel's evacuation behaviors quantitative. By comparing the time that dangerous comes, whether the evacuees can be evacuated to safe locations before the dangerous condition comes can be determined, and the safety of personnel can also be predicted. The statistical analysis can be done by combining with the data obtained from practical exercises. The evacuation plan design can be made more rational by contrasting, evaluating different parameters, the effects of different evacuation plans.

IV CONCLUSION

Because the past researches on emergent evacuation simulation main focus on some special environment models, so their application domain is relatively narrow. In addition, the displaying of simulation results is mainly in two-dimensional interface, so there are some deficiencies in three-dimensional display and interaction of the evacuation process simulation, and

the intuitive and sense of immersion is also relatively weak. The dynamic displaying effect can be fully presented and the utility efficiency and performance of the virtual reality technology can be greatly improved if the modeling technology, computer simulation technology, three-dimensional animation and virtual technology are fully integrated, which can better play its unique role in the field of evacuation simulation of sports venues and further develop the application of virtual reality technology in sports field. On the other hand, by applying the visual reality technology in the sports stadium management and safety assessments, a new technological means is provided for the sports stadium management, which improves the accuracy and relevance of the programs-making of sports stadium training and emergent response.

REFERENCES

- [1] Chun Meng Xian, Zhou Shuqiu, Rao Min. Large-scale computer simulation of building evacuation Review. Computer Application Software, 2008, (03)
- [2] Wang Changbo, all Hongyan. Fire evacuation realistic physics-based simulation. Computer Aided Design and Computer Graphics, 2008, (08)
- [3] TRISH red, Li Qiang. Based on multi-agent technology in public places, evacuation model. System Simulation, 2008, (02)
- [4] Ji Qingge. Virtual Reality Simulation in the Physical Review. Computer Aided Design and Computer Graphics, 2003
- [5] Wang Jiao. Virtual reality technology in the fire evacuation Behavior. Geomatics, 2003.
- [6] Wang arrows, Niexiao Lin, Ji-hui. Virtual reality technology in the field of fire. Computer Simulation, 2002, 19 (2): 28 ~ 31.
- [7] Zhou Tingchong the United States, Xiao Wen, Ding-Fang Chen. Virtual Reality and interior design. Computer Engineering, 2002, 28 (9): 182 ~ 183.
- [8] Chang, Shao Chenxi. Personnel emergency evacuation system dynamics model and analysis. Computer Engineering and Applications, 2005.12.
- [9] Xiao Guoqing, Wen Limin, Chen Baozhi. Building Fire Evacuation Study of Human Behavior and Development Review. China Safety Science Journal, 2001.
- [10] Wang Qifan "Advanced System Dynamics," Tsinghua University Press, 1995.
- [11] Lo SMand Z Fangl A computer model for the evacuation for building. Journal of Fire Science, 2000, 9.
- [12] Helbing D, Farkas I, Vicsek T. Simulating dynamical features of escape panic. Nature, 2000; 407: 487-490.
- [13] Xu high, based on agent technology evacuation simulation model, Southwest Jiaotong University, 2003, 6.
- [14] Kebel A. Microscopic simulation of pedestrian crowd motion [A]. In: Schreckenberg M, Sharma SD (eds.), Pedestrian and Evacuation Dynamics (PED) . Berlin: Springer, 2002: 193-200.
- [15] Founder, Lu Zhaoming. Building evacuation evacuation grid model'. China Safety Science Journal, 2001; 11 (4): 10213.