Shooting Recognition and Simulation in VR Shooting Theaters

Shuo Feng[1], Wei Gai[1], Yanning Xu[1,2](✉), Tingting Cui[1], Pu Qin[1], Huiyu Li[1], Dongdong Guan[1], Chenglei Yang[1,2](✉), and Xiangxu Meng[1,2]

[1] School of Computer Science and Technology, Shandong University, Jinan, China
{xyn,chl_yang}@sdu.edu.cn
[2] Engineering Research Center of Digital Media Technology, Ministry of Education of PRC, Jinan, China

Abstract. VR shooting theaters are very popular now, and shooting recognition system is one of the important components. In this paper, we will introduce a new simulation gun and a novel shooting recognition system used in VR shooting theaters in which multi-players can moving freely, and describe how to improve the realistic experience of shooting actions in virtual worlds. We will also show one of its application in two-view VR shooting theaters in which players can see the different pictures rendered from different viewpoints.

Keywords: Shooting game · VR theater · Simulation gun

1 Introduction

The traditional first-person shooter video game exists mainly in the consoles, and users play games with keyboard, mouse, or joystick in an unnatural way. Currently, more and more virtual reality (VR) theaters come forth in cultural theme parks, exhibition museums and so on, with the development of VR, human-computer interaction, computer animation, computer game and projector technology. The existing VR theaters [1] usually involve a large screen, 3D glasses, surround-stereo sound systems and dynamic seats. They allow the interaction of a large number of audiences. Generally, all the players share one same scene image. As one kind of the VR theaters, the shooting theater systems provide shooting game with cooperative mode, usually limiting players in the seats, so the players cannot move freely to shoot the hiding targets [2]. To enhance the immersive experience, simulation guns based on infrared and laser technology are made-up of complex and expensive apparatus [3]. The guns are connected to the seats by cables in most scenarios. However, the use of simulation guns becomes the biggest drawback of this form of the game, mainly embodying as follows: First, the simulation guns correction process is very complex, affected deeply by subjective ideas of the correcting people. Second, simulation guns on each seat needs to be corrected, which are large correction tasks. Third, the use of wired simulation guns, limits user interaction and impacts on the user's immersive experience.

We implemented a two-view VR shooting theater system in which multi-players can move freely and interact with the movies, and briefly introduced a shooting

H. Zha et al. (Eds.): CCCV 2015, Part II, CCIS 547, pp. 286–292, 2015.
DOI: 10.1007/978-3-662-48570-5_28

recognition system [4]. In this paper, we focus on introducing an improved shooting recognition system. The simulation guns only have laser transmitters and have no cameras in them. The system only uses an infrared camera to capture screen images, and we complete interactive shooting task by analyzing the position of front sight and users' shooting information. Without the limitation of power cable, each user can move freely. We also discuss how to improve the realistic experience of shooting actions in virtual worlds in this paper, and show one of its application in two-view VR shooting theaters in which players can see the different pictures rendered from different viewpoints.

2 System Architecture of the Shooting Recognition System

Figure 1 shows the system architecture of the shooting recognition system. The camera is placed where lens is on the centerline of the curtain, and install it on the roof or other high at 2.5 to 3 meters away from the curtain. Adjust the position by monitoring software that comes with the camera. Then the projector is also placed where lens is on the centerline of the curtain. We install it on the roof or other high (It can be placed at the bottom of the camera). Adjust the position of the projector imaging. Make sure the camera and projector are set up a good network connection to the computer. We complete the front sight positioning and determine the case of the simulation guns by infrared emitters on the guns. The simulation gun has two laser emitters. One is on all the time and utilized to locate front sight, another is on while player is shooting, and is utilized to determine whether player is shooting.

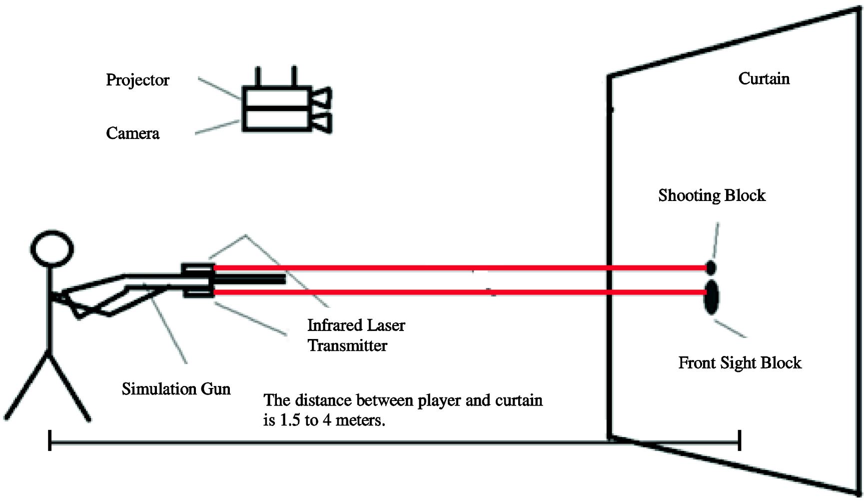


Fig. 1. Multiplayer free shooting recognition system and device

3 The Method of Shooting Recognition

We briefly introduced a shooting recognition system in reference [4]. The simulation gun was equipped with three infrared lasers on the head. Two of them on the side are turned on to locate the front sight, and the last one in the middle is controlled by the trigger as the signal of shoot. When the trigger was pulled, the infrared camera will catch the light of middle laser, and the shooting event will be triggered. The infrared lasers can compose different patterns with the parameters such as different angles, distance etc., and it's convenient to be recognized using pattern recognition technology. As the example in Figure 2, gun A shows a line shape and gun B shows a triangle shape, so the infrared camera can distinguish them through capturing and detecting the pattern of laser points. But it is difficult to recognize the guns when several patterns are overlap.

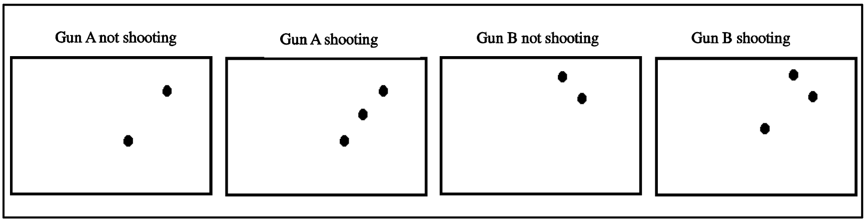


Fig. 2. Different patterns of simulation guns

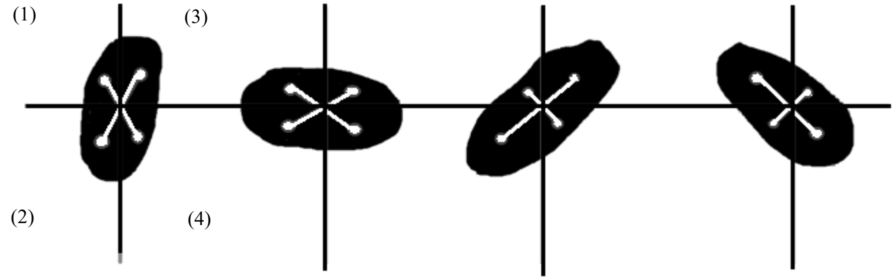
In this paper, a new simulation gun recognition method is presented, which enables users to play a shooting game with wireless simulation guns in a more natural way. The simulation gun is equipped with two infrared lasers. One for target locating is always on during the game (Figure 3.a), and the other one for trigger status will be turned on only if the user pulled the trigger (Figure 3.b). An infrared camera is adopted to capture the infrared laser spots from the curtain. Because a filter is covered in front of the camera to filter out contents from the projector, we can easily capture laser spots generated by the infrared laser transmitter and record them with black color blocks. Our method is supposed to recognize the front sight position and the triggers status.

Figure 3 shows us different patterns might be produced by our infrared simulation guns. Figure 3(a) describes the four predefined status that users do not pull the trigger; figure 3(b) describes status when users pull the trigger, and we can notice that an extra dot block for firing status is captured; and patterns in figure 3(c) is generated when an overlap is happened during the shooting process.

Before shooting patterns recognition, we define the feature value of shooting patterns as

$$v = (v_1, v_2)$$

and $v_1 = ((x_1 - x_4), (y_1 - y_4)), v_2 = ((x_3 - x_2), (y_3 - y_2))$. We calculate the center point of the front sight block, and build a frame with the center point



(a)

(b)

(c)

Fig. 3. Patterns of infrared simulation guns

as the original point. Then we find a center for each block area in on phase. $(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)$ are coordinate of center points in phases 1, 2, 3, 4 respectively(Figure 3(a)).

The basic idea is to calculate the feature value of the captured image and compare it with the predefined patterns to decide the status of the simulation gun. The main steps can be described as:

Step 1: Calculate the area of each shooting pattern.

Step 2: Decide the status of each shooting pattern. Set up three predefined ascending value C_1, C_2 and C_3. If the area of block is lower than C_1, we consider it as noise. If between C_1 and C_2, it is a shooting block and goes to step 3. If between C_2 and C_3, it is a front sight block and goes to step 4. If bigger than C_3, it is an overlap block and goes to step 5.

Step 3: Enumerate each front sight block, and calculate distances between the front sight block and the shooting block. Find the nearest pairs that meet the distance requirements and mark the front sight block as firing status.

Step 4: Calculate the feature value, compare it with the shooting patterns, and find the best match pattern with minimum sum of square difference method.

Step 5: Decide the pattern of the overlap front sight blocks. Calculate the missing front sight block of current frame from the previous frame. Find a nearest overlap block for each missing block. If the distance between the missing block and its nearest overlap block is less than a predefined value, the missing block exists and we assign the overlap block coordinate as its new coordinate. Otherwise, the missing block will be skipped.

4 Shooting Effects Simulation

Three types of particle systems are used to simulate the visual effects of firing flare, firing smoke, and hitting smash correspondingly. Transparent billboard pictures are used to represent particles. Particles to simulate the firing flare and the firing smoke are both emitted along the virtual gun direction. The former particle is emitted with high speed and short life cycle. The latter one has long life cycle and low spread speed. Particles for hitting smash simulation are relatively complex to design. The difficulty is that different visual effects are supposed to be displayed when the bullet hits different objects. We have categorized objects into three kinds and designed smoke, splat, and explosion effects to simulate the hitting effects for hard objects, fragile objects, and explosive objects perceptively.

Gunkick and viewkick are introduced to enhance the player experience for firing. A quick backward gunkick movement or a predefined reload animation for virtual gun is displayed and produces the shooting delay. We change the view position slightly after each shot for two reasons. The swift and slight shake of view position can produce the viewkick effects. And players are expected to adjust targets after each shooting action due to the fact that their positions are changed slightly when shooting.

5 Application in Two-View VR Shooting Theater Systems

In conventional projection-based display systems, stereoscopic images are projected onto a single large screen to allow groups of people to view the virtual environment. These systems provide only one stereoscopic image pair in a shared virtual environment, and also all viewers observe stereoscopic images from a single viewing position, this case lacks realistic experience. The multi-view projection display system which presents multiple viewpoints of the same screen concurrently has become the focus in recent years[5][6]. Using this kind of technology, we developed a shooting theater system, equipped with two-view projecting system, 3D shutter glasses, individual surround-stereo earphone and user-customized simulation guns [4]. To provide a more friendly interaction for the players, we use Kinect networks to capture the movement of players.

The system mainly has four modules: output module, interactive input module, real-time parallel rendering module, and integrated processing module. Kinects and simulation guns are utilized as interactive tools to trace information such as shooting position, shooting action, player's dynamic position and ID of simulation gun. Images are rendered by the rendering server based on the information, and then projected on the large screen. Players can see their individual view of 3D scene through the customized shutter glasses and hear sound with stereo sound earphone. At the same time, the integrated processing server also drives the devices to produce special effects of smog, rain, bubbles in line with the story to form a unique experience.

As there could be multiple players in the game, cooperative strategy needs to be made. The system supports two kinds of game mode: collaborative mode in which players will cooperate with each other and adversarial mode in which players in different team will shoot each other. Both modes follow the same rules: when there are two players, they can move freely to drive the virtual avatar and each of them will see his own scene image with different shutter glasses. When there are more than two players, they will be divided into two teams. Players can only see the scene of their own team. Each team should assign a leader who commands the team, control the story plot and change the scene. Each member in one team wears the same kind of shutter glasses.

The multi-view projection display system which presents multiple viewpoints of the same screen concurrently has become the focus in recent years[5][6]. Using this kind of technology, we can also develop a six-view shooting theater system. The method of shooting recognition and simulation in this paper also can be adapted to the six-view shooting theater system.

Different from the traditional single view system, it is necessary to render the scene from different viewpoints simultaneously for multi-view systems. In our system, we maintain different worldview transformation matrix for different players. Although, the positions and shooting information of two players are recognized with the same Kinect network and camera, positions and directions of different group of players are transformed to different places in the scene after the worldview transformation.

6 Conclusion

This paper introduces a kind of multiplayer free shooting recognition system and device for 7D shooting theater. This system can rapidly identify the ID of each player, locate front sight and obtain shooting information. No need to pre-correction, easy to use, more freedom because of wireless. In addition, it is easy to transport and set up, low cost, suitable for family.

For future work, we would like to evaluate the two-view free shooting recognition system by a user study. We will design a shooting task and ask volunteers to fulfill the task in different systems including our two-view system. Objective indicators such as task completion time and subjective indicators such as user satisfactory will be used to evaluate the system.

Acknowledgements. This work was supported by the China National Natural Science Foundation (61272243, 61202146, 61472225), the China National Science and Technology Support Program (2013BAH39F00), Shandong Province Natural Science Foundation (BS2009DX003).

References

1. Ahn, S.C., Kim, I.-J., Kim, H.-G., Kwon, Y.-M., Ko, H.: Audience interaction for virtual reality theater and its implementation. In: Proceedings of the ACM Symposium on Virtual Reality Software and Technology-VRST 2001, pp. 41–45 (2001)
2. Virtual Reality 7D Movie Theater With Infrared Control Gun Shooting Games - quality 7D Movie Theater for sale. http://www.5dmovietheater.com/china-virtual_reality_7d_movie_theater_with_infrared_control_gun_shooting_games-2201558.html (accessed on April 23, 2015)
3. Professional PC Light Guns for Arcade Games. http://www.arcadeguns.com/index.php?main_page=index (accessed on April 23, 2015)
4. Yu, H.-D., Zeng, W., Li, H.-Y., Sun, W.-S., Gai, W., Cui, T.-T., Wang, C.-T., Guan, D.-D., Yang, Y.-J., Yang, C.-L.: A two-view VR shooting theater system. In: Proceedings of the 13th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and its Applications in Industry-VRCAI 2014, pp. 223–226 (2014)
5. Bolas, M., McDowall, I., Corr, D.: New research and explorations into multiuser immersive display systems. IEEE Comput. Graph. Appl. **24**(1), 18–21 (2004)
6. Kulik, A., Kunert, A., Beck, S., Reichel, R., Blach, R., Zink, A., Froehlich, B.: C1x6:a stereoscopic six-user display for co-located collaboration in shared virtual environments. In: Proceedings of the 2011 SIGGRAPH Asia Conference on-SA 2011, vol. 30, no. 6, p. 1 (2011)