Entertainment Applications of Human-Scale Virtual Reality Systems

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Entertainment applications of human-scale virtual reality systems

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Abstract. This paper describes three applications of human-scale virtual reality in demonstrative systems. The first application is a demonstrative system, the "Tangible Playroom". It was designed as a computer entertainment system for children. It provides virtual reality entertainment with a room-scale force-feedback display, an immersive floor image, and real-time physics simulator. Children can play using their whole bodies to interact with a virtual world controlled by software using rigid body dynamics and the penalty method. The second application,"the labyrinth walker," was designed as a virtual exploration system for children's museum. Its step-in-place capability can provide a 'walkable' walk-through virtual reality environment with no worn interfaces. The third application regards photo-realistic virtual TV sets for high-definition television (HDTV) production. It can provide a real-time high-quality 3D synthesis environment using high dynamic range images (HDRI), global illumination, a HDTV depth-measuring camera called "Axi-Vision" and wire based motion control camera for real-time synthesis. In this paper, we report on these applications' possibilities and give abstracts on their technology.

1 Computer entertainment system using human-scale VR

1.1 Tangible Playroom

The "Tangible Playroom" was designed as a future demonstrative computer entertainment system for children. By "Tangible" we mean "graspable" or "perceptible by touch". It is an important experience for children. By "Haptics", or "touchable virtual reality", we mean that render stimuli touch into a virtual world. However, there are no good VR application systems for children that use haptic hardware, as far as we know. This project is thus focused on providing interesting haptic experiences for children. Figure 1 is a picture of the Tangible Playroom. The idea is that children can play with it in their rooms at home. They can interact with it by using their bodies. The game scenes are projected on the floor and walls. Its image is very large, and the children can walk directly on the screen while they play with it. The wires are links to the haptic devices internal structures. These human-scale VR systems can be turned off to discourage unlimited play.

Fig. 1. "Tangible Playroom", a sketch (left) and a prototype (right)

System configuration The system incorporates a human-scale haptic device and a large display. The large "walkable" floor screen enables the players' to move about freely. The 3D position from the tangible grip is calculated on a server PC using input from four lengths of encoder motors. The lengths are fed into the real-time rigid-body dynamics engine, which stores all the location, velocity, inertia, and behavior information for the virtual world. When it detects a collision with the floor or other characters, it uses the penalty method to generates a reaction force for force feedback via the tangible grip. All the characters in this world are driven by rigid body dynamics. Any virtual characters can move themselves autonomously based on a force vector generated by an A.I. engine. A game judge enforces rules such as scoring and time outs. Sound effects are generated according to the real-time rigid body dynamics engine based on the output of the penalty method. A multi-projection function accommodates larger displays and extra displays using networked PCs. The projected image is generated in real-time using OpenGL or DirectX. The number of projectors is variable. This software is based on a cluster real-time rendering system for CAVE-style immersive displays.

SPIDAR and haptic rendering The Tangible Playroom is a room-scale haptic display system. To realize its force-feedback via tangible grip, the haptic system is based on "SPIDAR" (SPace Interface of Artificial Reality) [1]. SPIDAR usually uses a ring to indicate the force to users. In our system, we had to focus on the safety and convenience of children so we decided to use a cork ball as the Tangible grip.

Demonstration Content "Penguin Hockey" is a simple 3D hockey game content for the Tangible Playroom. It has an ice rink, four pucks, three penguins and two goals. The puck is shaped like a snowman. The children's team (right side in Fig.1) has one autonomous penguin, whereas their opponents, the enemy team, has two autonomos penguin players. The children thus are to help the underdog penguin in this game situation. All the objects behave according to the rigid body dynamics using the penalty method, each with a weight and a center of gravity. When a player interacts with the computer-generated characters, he or she feels the impact of the puck and the force of body checks. When penguins block the player, they check using full body movements. If a player checks one of them, they make the exclamations depending on the check's force. The pucks and penguins have the same shape in the collision model, and the pucks have a higher center of gravity and a lighter weight compared with the penguins. This game is similar to interactive bricks, each with their own will. Playing with the penguins, passing the puck skillfully, and experiencing physical contact should be of interest to the players.

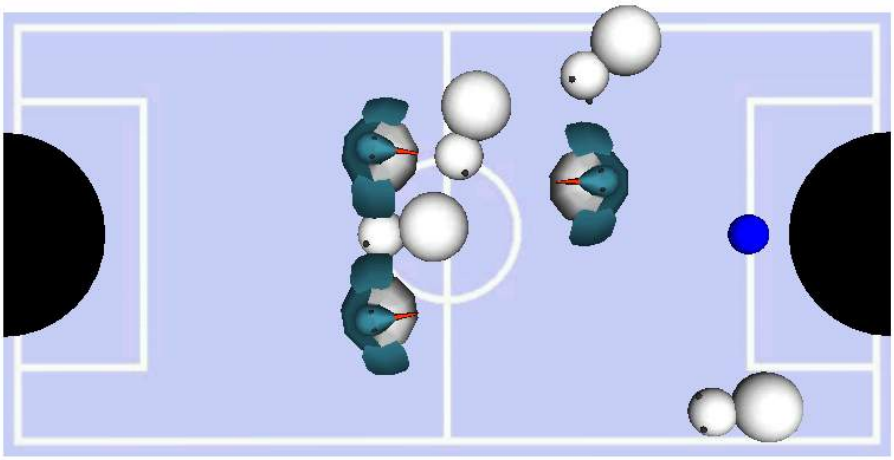

Fig. 2. "Penguin Hockey" , a demonstration content for Tangible Playroom

1.2 Labyrinth walker

Locomotion interface with a floor screen "The labyrinth walker" was designed as a virtual exploration system for children's museums. It can provide a walk-through virtual reality environment with no interfaces that have to be worn. Photo-realistic interactive images of virtual worlds are projected onto the floor screen. Under the screen, there is an embedded locomotion interface using a linear motor-driven turntable and four pressure sensors between the turntable and the floor. When the player steps-in-place on the image, the sensors detect his or her movement and orientation. The player's turning actions are then canceled by the turntable's to keep the player facing the front of screen.

The virtual scenes are written in VRML. All of behaviors involving collision and falling were developed with "Springhead", the C++ software development environment for virtual reality. The original locomotion interface system provides continuous visual feedback despite the limitations of the screen. The use of smart-turntable walking platform lets users perform life-like walking motions in a seamless manner and without wearing an interface. The interface can be easily integrated into most large-screen virtual environments. Even if the screen size is limited, the system delivers a continuous surround display. A number of children's museums have expressed their interest in purchasing this system.

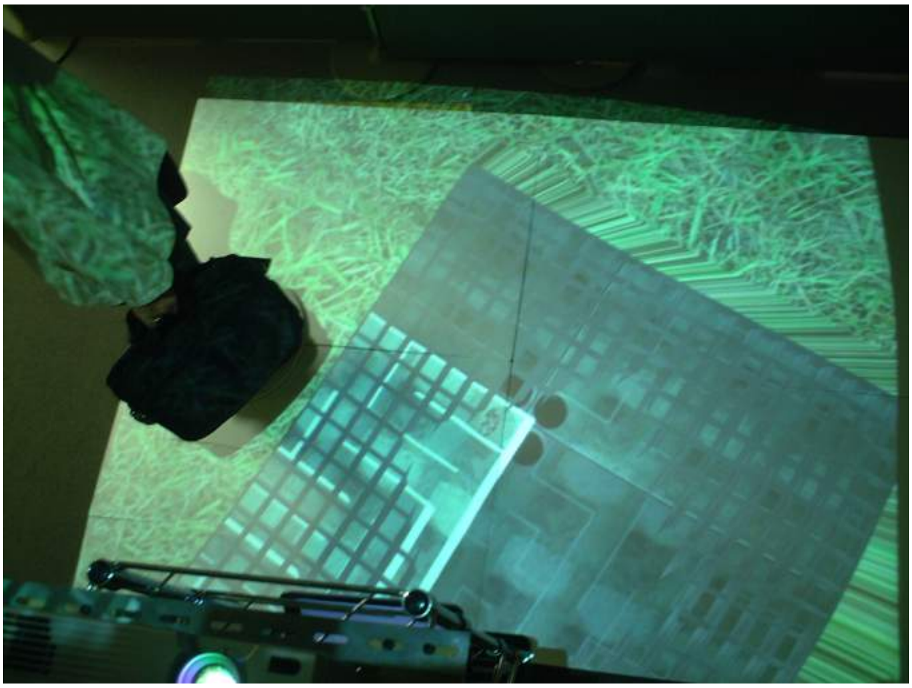

Fig. 3. The Labyrinth Walker

2 Photo-realistic virtual TV sets systems

Photo-realistic computer graphics are difficult to achieve in a real-time graphics environment. Moreover, high-performance computers are needed to make human-scale virtual worlds sufficiently interactive. Consequently, most of VR systems are rendered by abstracted graphics images. The NHK Science and Technical Research Laboratory has studied the basic technologies for a next-generation TV production environment for making high-quality visual content. In the stance of our research group, human-scale virtual reality systems mean to new methods of video production using real-time high-quality computer graphics with interactive techniques in TV studio sets.

Fig. 4. High dynamic range images in different light environments

2.1 High dynamic range image based archiving and rendering

The cinema industry uses high dynamic range images (HDRI) for image based lighting and rendering. HDRI describes a wide range of intensity by using multi-graded exposed photographs. Its images can archive the information about the light environment of TV studio sets. Figure 4 shows HDRI images of different lighting environments. We have developed a global illumination rendering system, "OptGI" for HDRI light sources. Figure 5 compares artificial images rendered with HDRI (right) and the original scene (left) by OptGI.

Fig. 5. Original scene (left) and artificial furnitures (right) using HDRI and global illumination rendering

2.2 Virtual shadow casting using depth camera

"Axi-Vision" is a special HDTV camera invented by Masahiro Kawakita. It can simultaneously take depth grayscale images of objects in the frame and match them to RGB pixels while operating at the full rate for HDTV movies (30 fps). This camera system has two HDTV cameras and infrared LED arrays. A dichroic prism separates these coaxial optical systems. The main system is for taking normal RGB images. The other is composed of high-definition CCD camera and a specially developed image intensifier (I.I.). The I.I. acts as an ultrahigh-speed (1 nanosecond) shuttering device with high resolution. The image including reflected light intensity by modulated LED illumination contains the depth-to-surface, orientations and reflection conditions. The ratio of the two images describes the distance from the camera to any surface in the field of view. Figure 6 contains the original background image and an artificial rabbit with her shadow. There are eleven paper plates on which the shadow should be stepped. Depth information recorded by Axi-Vision was used to make the survey model of the background.

2.3 Wire based motion control camera

Photo-realistic virtual TV sets needs real-time rendering system with least 6 DOF (degree of freedom) that contains 3 transitions (x, y, z) and 3 rotations (pitch, yaw, roll) input interface for fact camera information in three dimensional space to synthesis final images. In current technology, the rotation information can detect by tripod with mechanical encoders but transition is difficult to detect without huge mechanism such as a crane or hanger. These camera-tracking technologies are called as motion control or capture camera.

Figure 7 are concept pictures of wire based motion control camera. A motion sensor or mechanical encoder detect its rotation and transition tells absolute

Fig. 6. Virtual shadow cast on depth image

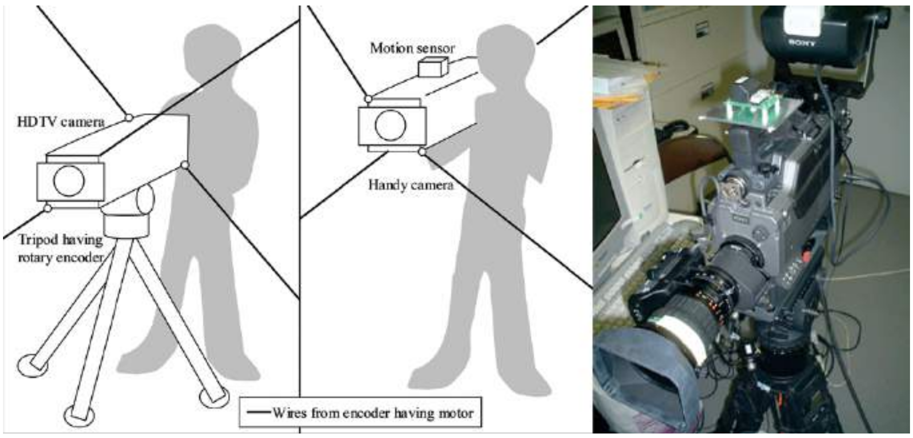

Fig. 7. Prototypes of wire based motion control camera

location. When the camera operator collides to an invisible virtual set in fact world, these wires tell to him/her via force feedback. Wires are not interference in TV studio rather than laboratory and lighter mechanical position detection has an advantage for using specialized camera such as Axi-Vision, infrared PSD, sensors or computer vision.

3 Conclusion

So far, our work has demon strated the practicality of human-scale VR systems in computer entertainment and TV production. This technology shouldn't be limited only CAVE style displays or visual environment. In this paper, we've just shown some suitable demonstrative application to both of fields. However each applications use some common important VR technologies such as physics engines, rendering and haptics. We expect the basic VR technologies like real-time physics engines, displays, motion tracking, haptic and photo-realistic CG rendering will be used to make new environments that are advances upon the current industrial.

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