Air-filled type Immersive Projection Display

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Abstract. This paper proposes an immersive projection display using air-filled tubes that allow the user to touch the large screen directly. In general immersive system, the user is restricted to use a small device to interact with the displayed image. To realize direct and intuitive interaction, we utilize air pressure to maintain the shape of screen. Several accelerometers are attached outside the tubes in order to detect the user's touch on the screen. We examined position detection accuracy of our prototype to compare these sensors.

Keywords: Immersive Projection Display, Inflatable, Touch Sensitive Display

1 Introduction

Immersive projection display is one of the most powerful systems to enhance spatial presence and experienced realism. Cave-like immersive display systems are rapidly used for the immersive VR applications.

In Cave-like systems, human-computer interaction is restricted to use a small interface such as wand joystick due to physical space and configural limitation. Non-portable or cable connected devices are not appropriate for the immersive projection display because such devices interfere with the user's concentration on the screen and decrease his/her presence in VR environment. Although full-size large objects are projected on screens, human-scale interaction is not considered completely.

At the point of these requirements, various interfaces have been developed and implemented by VR researchers. For instance, PHANToM or other haptic interfaces are applied to use inside immersive VR environments [1][2]. Moreover, portable or wire-stringed mechanism interfaces have been developed in order not to occlude virtual objects visually[3][4][5].

In this work, we considered that such mechanisms would not be equipped with the user but would be fixed on the display. We apply air-filled tubes to the immersive projection display in order to allow the user to touch the large screen directly. The advantage of utilizing air-pressure is that the screen can present elasticity as a reaction force to the user. Needless to mention that air pressure is adequate to form the shapes of screen.

2 Design Criteria for Immersive Touch Display

In order to develop an immersive display that the user can touch without limitation, we determined the following three criteria.

(1) Size and shape of the screen
The most important condition is that the user can reach the screen easily when he/she intends to touch virtual objects. The screen would be placed in the reach zone of upper limbs so as not for the user to walk around inside the display. The reach zone of the user is considered to be dome-shaped of 60-70[cm] in the radius that centers on the shoulder. Therefore, the proper size and shape of the screen are determined as above mentioned.

(2) Casting shadow problem
When a user's hand approaches the screen for touch, the shadow will appear on its surface. The simplest solution to avoid casting shadows is to apply a rear projection technique like typical CAVE systems. In this case, however, rear projection is undesirable because the touch display needs to equip touch sensors on the screen and these mechanisms may interfere with the projected image. Therefore we must apply the front projection method and consider the layout of projector for reducing the appearance of shadow. We have decided to place the light source near the user's viewpoint because the casted shadows are consequently occluded by the user's hand.

(3) Detection method of touch
In general touch sensitive screen, mechanisms of detecting contacts are distributed over the whole surface. However it is not reasonable to apply the same mechanism to the large-scale screen. For instance, external cameras enable the system to detect the user's motion by capturing the shadows. This method cannot measure the contact force exactly. In this study, we applied several accelerometers attached outside the tubes to determine the position of the user's touch on the screen.

3 Implementation

Air pressure is suitable to maintain the shapes of screen. We utilized several commercialized inflatable swimming pools as air-filled tubes to support the cylindrical shape around the user. Fig.1 shows the basic design of inflatable touch display based on above mentioned criteria. The cylindrical shapes are composed of stacked air chambers that are a part of swimming pool toys. The inside diameter of the cylinder is approximately 1100mm (Criteria 1). The cylindrical shape is covered by a flexible white cloth material as the surface of the screen. Once the projecter's lights are reflected on a convex mirror in order to spread in wide angle, the lights are projected on inside the cylindrical screen. To minimize the casting shadow, the position of right source is arranged near the user's viewpoint (Criteria 2). Several sensors are attached outside the tubes in order to detect the user's touch on the screen (Criteria 3).

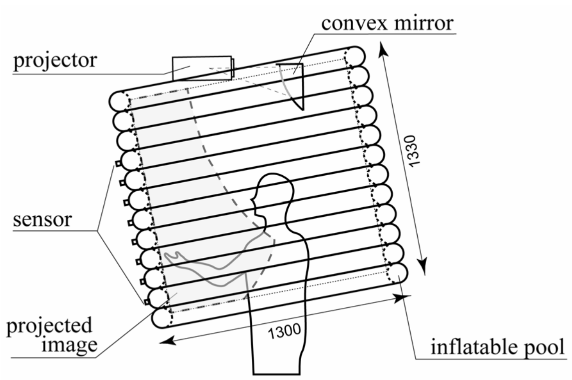

Fig. 1. Basic design of inflatable touch display: The user can immerse into the cylindrical shaped screen. The image is provided by a single projector. In order to actualize a wide angle view, we applied convex mirror to spread the projection area [6].

Figs.2. show pictures of the appearance of this system. A usual room is acceptable to install the entire system. The screen can also be stored in a small space when chambers are not inflated. In order to display the correct image on the curved screen, multi-pass rendering technique is applied to generate pre-distorted images[7].

(a) (b)

Figs. 2. (a) External appearance of the display when the screen material is removed: The installation capacity is Width 1.5[m] Depth 1.5[m] Height 2.4[m]; (b) Internal appearance of the display: The user can intuitively interact with displayed objects.

4 Detection of the user's contact

Accelerometers are chosen here as a sensor for the detection of contact position on the screen. When the screen is struck, the vibration can be detected as its own motion by the accelerometer. Six sensors (KXM-52) are attached around the cylinder and their signals are connected to a personal computer via the amplifier and the AD converter. With six sensor signals the computer can estimate the touch position according to the interpolation based on the magnitude and phase of response. We examined the accuracy of the position detection when the screen was struck.

The experimental results are shown in Fig. 3. Based on this result, we can say that the detection error margin has been less than 10-15[cm] on an average. The detection error tends to be remarkable for vertical direction rather than sideways since inflatable chambers are horizontally aligned.

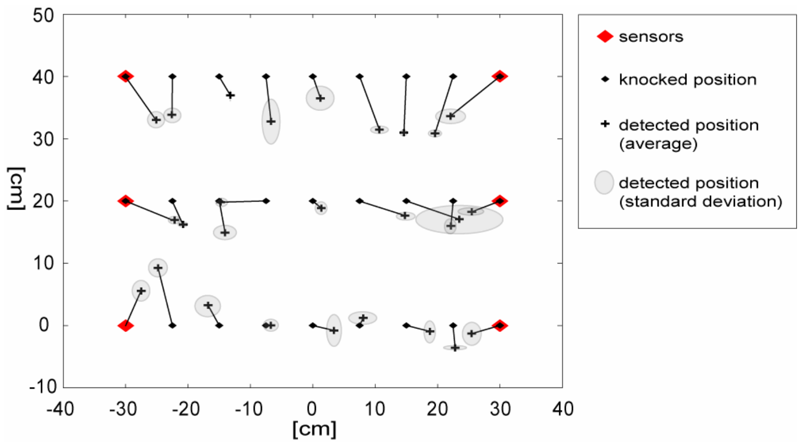

Fig. 3. Accuracy of the position detection using six accelerometers attached on the inflatable chamber: We struck on each position 10 times by a slingshot in order to keep its force constant.

5 Conclusions

In this study, we proposed an immersive projection display using inflatable chambers in order to allow the user to touch it directly. Advantages of utilizing air-pressure are the representation of elastic reaction to the user and the convenience (or flexiblity) for shape of the screen. Also the screen is not delicate compared with other display systems so that it is not easy to break even if the user treats it roughly. Air chambers play the role of cushion like an air-bag so that the system can secure the user's safety under the unexpected accident. As we focus on this advantage, we have been trying to improve the system that enables the user to encourage to do upper-limb exercise for supporting rehabilitation. In the future, we will apply the system to the cognitive rehabilitation of the elderly with dementia.

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References

1. Hashimoto, W. and Iwata, H.: Representation of volumetric data using immersive projection display and haptic display, Human-Computer Interaction INTERACT '01, (2001) 108-114

2. Fischer, A. and Vance, J. M.: PHANToM Haptic Device Implemented in a Projection Screen Virtual Environment, 7th Imternational Immersive Projection Technologies Workshop (2003) 225-229

3. Hirose, M., Hirota, K., Ogi, T., Yano, H., Kakehi,N., Saito, M. and Nakashige, M.: HapticGEAR: The Development of a Wearable Force Display System for Immersive Projection Displays, IEEE Virtual Reality Conference(2001), 123-129

4. Jeong, S., Hashimoto, N. and Sato, M.: Immersive Multi-Projector Display on Hybrid Screens with Human-Scale Haptic Interface, IEICE Trans Inf & Syst. (2005) E88-D, 888-893

5. Dorjgotov, E., Choi, S., Dunlop, S. R. and Bertoline, G. R.: Portable Haptic Display for Large Immersive Virtual Environments,", Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems (2006), 48

6. Iwata, H.: Full-Surround Image Display Technologies, International Journal of Computer Vision (2004) Vol.58, Issue.3, 227-235

7. Blimber, O. and Raskar, R.: Spatical Augmented Reality, A K Peters (2005)