4F-7

An IllusionHole with 3DTV for Seated Multiple Users

Kasım Özacar Kazuki Takashima Yoshifumi Kitamura

Research Institute of Electrical Communication
Tohoku University

Abstract
IllusionHole is an interactive tabletop display that allows multiple users to simultaneously observe individual stereoscopic images from their own viewpoints. According to this idea, we newly design a thin and compact system using 65 inch 3D plasma TV and a set of 3D trackers in order to allow seating users around the table to interactively observe the higher quality stereoscopic images.

Introduction
Interactive stereoscopic display is becoming a standard to share 3-dimensional visualization by multiple people such fields such as industrial designing, and medical imaging. Such display is often designed as tabletop style for creating face-to-face workspace and high accessibility of the displayed contents from any positions around the display. The workspace must be designed in such a way that users would use the opportunity of sharing understanding by direct indication of content [1]. However, traditional interactive 3D tabletop displays have significant limitations about directly pointing to displayed 3D objects [2] and exactly sharing the interactions among users.

To overcome these limitations we have been exploring the tabletop 3D display, IllusionHole (IH) [3], which allows multiple users to directly indicate a specific point of a displayed 3D content with their fingers, and easily share the content and aware information from their own viewpoints with distortion-free views. The principle of IHs places a mask with a hole on the stereoscopic tabletop display, and uses optical tracking system for detecting the positions of users around the table. This principle allows the users to see and access their own individual stereoscopic image pairs through the hole (one image is for left eye, another is for right eye to produce 3D content). IH was investigated in how the stereographic image is affected by errors arisen from measurements of the users' eyes' distances and positions [4].

In this study, we design a novel and compact IH using 3D TV that can be used in a typical collaborative work space where users sit around the table. It is achieved by not only introducing a new hardware configuration, but also re-implementing the software. With this configuration, the system can produce a rich and easy medium to build and render 3D contents on a higher quality image display compared to the previous version of IH. In addition, the new IH is designed to be used in such contexts where users can stand or sit during collaborative tasks.

The previous IllusionHole
IllusionHole is a 3D stereoscopic display system which dynamically supports multiple moving users. The position of the image displaying area (Figure 1) for each user is computed using optical tracking sensors according to his/her viewpoint.

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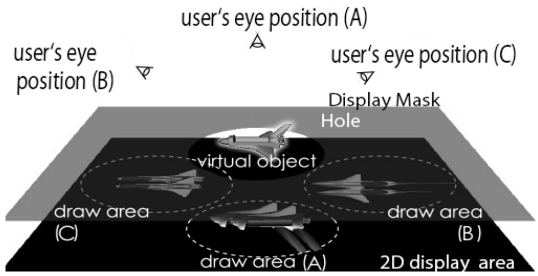

Figure 1: Configuration of draw area

Consequently, using shutter glasses or polarization filters, each user can observe the stereoscopic image pairs (A, B, C) shown in an individual area. These image pairs are at the same position on the display (the virtual object in Figure 1). Moreover, because the display mask occludes the other users' image display areas, no user are able to see the other's drawing area (Figure 1).The display's enclosure is large because it uses a rear projection system. This system either uses a high brightness, 120Hz, and 3D projector, or two projectors with a mirror as a reflector (as described in [2]), allowing only standing users to use.

Compact IllusionHole using 3DTV
Hardware
We use a 65 inch 3D Panasonic VIERA Plasma TV as basic display system to make a more compact enclosure compare to the previous IH. Plasma TV is favored over LCD TVs as a tabletop 3D display with glasses because LCD TVs use polarization so that users lose contrast when they tilt the shutter glasses while watching the TV. On the other hand, a plasma TV has no polarizer on the display surface Hence there is no conflict with the directions of the polarizers on shutter glasses. Another reason is because it needs to have a wide angle from any viewing direction in order to let users see the displayed object continuously while moving. A display mask with a hole at the center is located over the display (Figure 2, top). The display resolution was set at 960 x 1080. Because the 3D TV has widescreen, the mask hole is designed to be in an elliptic shape (360 mm major axis and 210 mm minor axis lengths). The maximum height of each user's viewpoint is 750 mm and the distance between mask and the TV display is 320 mm, the table's size is 1620mm x 1006mm. Configuration of the new IH including all dimensions is shown in Figure 2. The position of the display area for each user is calculated dynamically according to the users' eyes' positions. Each user's eyes position is computed using Optical tracking system (Natural Point, Inc.). Users wear active shutter 3D glasses to observe stereoscopically displayed content. The graphical contents are created by a Windows 8 PC (CPU: Intel Xeon E5520 2.27GHz, memory: 8 GB, graphics card: NVidia Quadro FX 4800). The IH's software creates side-by-side signals that are supported by the 3DTV. When the TV receives these side-by-side 3D signals, it splits left and right frames to extract the frame for each eye. The TV then rescales these individual frames to a 960 x 1080

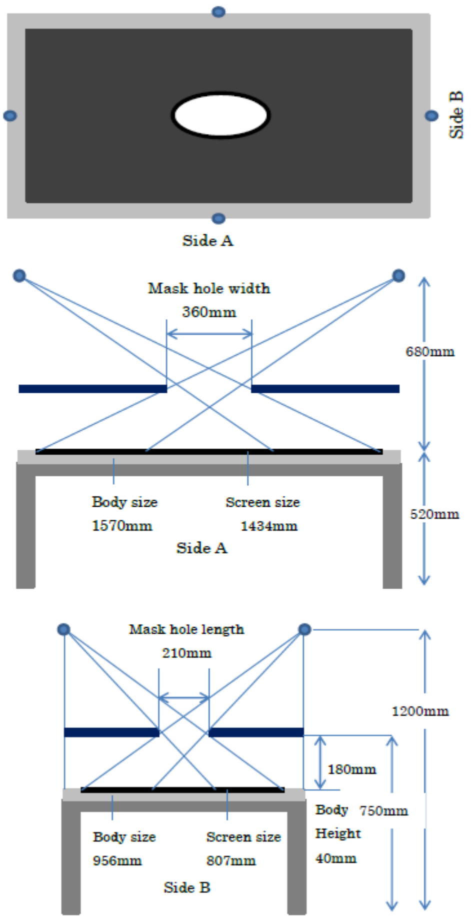

Figure 2: Table configuration

resolution. It then displays these frames alternately in a frame-sequential manner that is in synchronizes with users' liquid crystal shutter glasses works with integrated infrared emitter into the 3D TV on the display mask.

Software

The stereoscopic images are generated by software written in C# using Unity 3D IDE. Unity 3D is utilized to create high-resolution graphics and physics-based content visualization (such as collision, gravity etc.) The optical sensors were tracked at 120Hz using the standard OptiTrack system. The positional data of users are streamed in real time to the system in order to computes relative position between a user and the display area. Consequently, the users are able to observe intelligible 3D stereoscopic images from any direction without flickering and distortion while sitting around the table (Figure 3).

Result and Discussion

Using the new system, users can observe and share 3D content in a comfortable attitude, compared to the previous IH (Figure 4). There are many positive user feedbacks on this sitting scenario and clear images by the re-implemented software, which means we achieved to create better collaborative workspace. Due to the wide screen of the 3D TV, users at long sides (side A in Figure 2) have narrow display areas, and part of the content may remain out of the screen, depending the seating height of the users. However, it would be necessary to adjust the size of the mask to solve this limitation.

This system could stereoscopically visualize not only static 3D model but also animated object. The Figure 3 shows a space shuttle with an animation of jet fire. Therefore, this system is feasible to render complicated set of data such as scientific visualization and medical application.

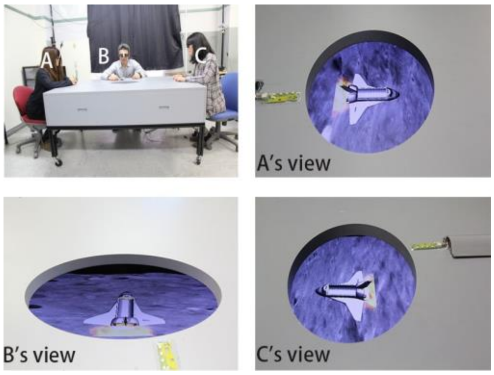

Figure 3: Users observe same content from their direction.

Figure 4: The previous (left) and current IH (right)

Conclusion

The newly designed IH system using 3D plasma TV which supports seated users is proposed. As a result, multiple users are able to simultaneously observe individual stereoscopic images at the same position from their own viewpoints using a tracking system while sitting. Adding 3D TV and new software support compared to the previous IH, the new prototype system became thinner, more compact, and much easier to change the displayed content. It supports to render higher resolution 3D image pairs and easy to implement 3D content including rich animations and physics based interactions. The new IH is suitable for multiple-users do cooperative work in a shared physical space. Future work includes arranging mask height and size to provide better observation according to the number of users and implementing direct mid-air interactions with displayed content.

Acknowledgment

This work was supported in part by Strategic Information and Communications R&D Promotion Programme (SCOPE) of the Ministry of Internal Affairs and Communications, Japan, and Kayamori Foundation of Informational Science Advancement.

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