

Angle-changeable Immersive Projection Display

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Abstract

We propose a new room-sized immersive projection display. The display consists of a cylindrical screen that can be moved horizontally and vertically, allowing the user to easily change his/her field of view by moving the screen to any angle. The angle of the screen is measured by a motion sensor, and the projected stereo images are changed in response to the measured angle. With this cylindrical screen system, it is necessary to project a distorted image onto the screen to produce a correct image. We make the distorted image using a multi-pass rendering method. In addition, a magnetic sensor measures the position and angle of the user and the screen images are changed if the user moves.

1. Introduction

To comprehend complex phenomena or data, we sometimes use three-dimensional (3D) stereo displays. However, if we use a small 3D representation system, such as a cathode ray tube (CRT) or a liquid crystal display (LCD) 3D system, we cannot see the entire area and details of a complex 3D object simultaneously. To overcome these problems, it is necessary to fill one's field of view with the 3D image. An immersive projection display is a powerful tool for evaluating 3D data. The CAVE system [1] is a pioneering immersive projection display that is widely used for viewing complex 3D images. However, a typical CAVE system does not have a screen on the ceiling, so it is impossible to view complex data from below. To compensate for this shortcoming, the CABIN system [2] was proposed, which has five screens, including a screen on the ceiling, allowing the user to see the bottom and top of complex objects.

However, these systems require a large amount of space and are expensive, so they cannot be installed easily. One solution to this problem may be head-mounted displays, but the

angle of the field of view is too narrow for users to become deeply immersed in a virtual environment.

To resolve the problems of cost and small size, immersive projection displays have proposed [3, 4, 5], but these systems also lack a screen on the ceiling. We constructed an immersive projection display that can represent the top and bottom of 3D objects, has a wide field of view, allows several people to observe a 3D object simultaneously, does not need a big space for installation, and is relatively inexpensive.

2. Angle-changeable Immersive Projection Display

To solve the above-mentioned problems, we constructed an angle-changeable immersive projection display. It is not necessary to represent the top and bottom views of a 3D image simultaneously, as in most situations the user sees a 3D image only from the top or the bottom at any one time. For example, when we see a visualized numerical simulation result, we usually see the model from the top or front, since such material is usually observed from the outside. By contrast, when we experience a walk-through content, we usually pay attention to the upper part and sides of the image. Most users are less interested in the bottom view because this is often only a road. Therefore, we constructed a general cylindrical screen system in which the angle of the screen can change in any direction. Using this screen, the user can easily set his/her field of view to the top, bottom, or side view depending on the 3D contents. If the user wants to change his/her view, this can be done easily by changing the screen angle.

2.1. System Configuration

Figure 1,2 shows the configuration of our proposed system. This system is designed to be installed in a room measuring $4.1 \times 4.8 \times 2.9$ m (length $\times$ width $\times$ height) and the system measures about $3.6 \times 4.1 \times 2.8$ m (maximum).

The cylindrical screen is made of polycarbonate. The radius of the cylindrical screen is 1591 mm and the center angle is about 90 degrees. This screen is set in a steel frame in front of the user. A stereo projector (Christie Mirage S+3K SXGA+ 3000 ANSI Lumen stereoscopic projector) is connected to this cylindrical screen by a steel pipe. The user wears liquid crystal shutter glasses (Stereo Graphics, Crystal Eyes 3) and sees the projected 3D objects. The screen and projector are not connected to the ground or ceiling and can be moved freely by the user as one united body, provided that neither the screen nor the projector touches the walls, ceiling, or floor.

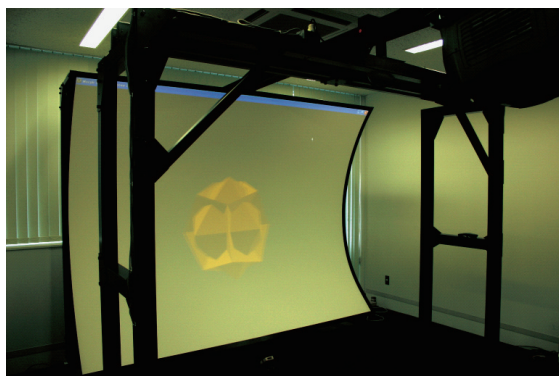


Figure 1. Angle-changeable Immersive Projection Display.

For providing a correct image to the user, it is necessary to measure the angle of the screen. For example, if the screen is moved toward the left, the position of the represented object relatively moves towards the right from the position of the user. To do this, we install the magnetic sensor (Polhemus Patriot) in the screen to measure the position and the angle. This sensor is attached on the back of the screen and the transmitter of this sensor is attached on the connecting pipe. By this sensor, if we move the screen, the image of the screen is also changed at once. The user usually sits under the center arch that supports the steel pipe between the screen and projector, although the user can move around because a magnetic sensor measures the position and angle of his/her head. By measuring them, the user can see correct image.

2.2. Data flow

A single personal computer (PC; CPU Intel Core2Duo E6850, GPU NVIDIA Quadro FX 4500 3.0 GHz, 2 GB Main Memory, Windows XP Professional) is used to control this system. To make stereo images, the PC obtains the user's position and angle data and the screen's angle from the magnetic sensors. Using these, the model-view matrix of the scene is changed to project correct 3D images. Figure 3 shows this procedure.

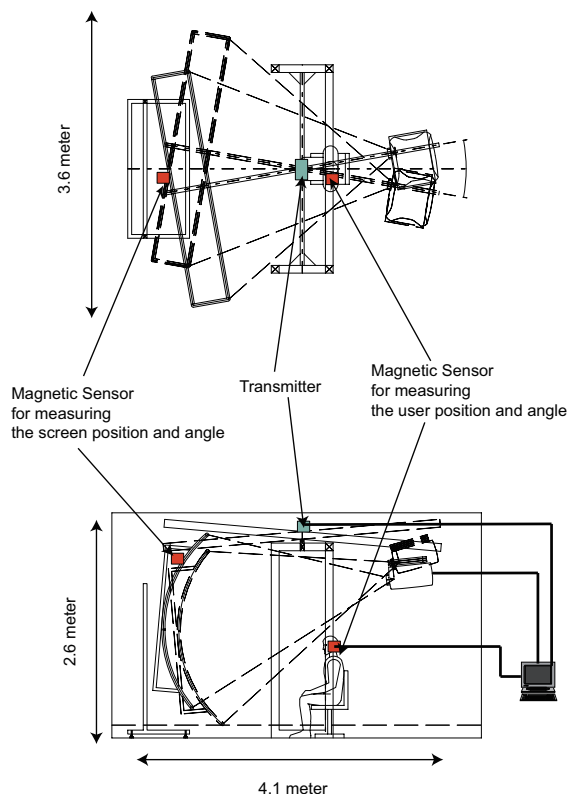


Figure 2. Configuration of the angle-changeable immersive projection display.

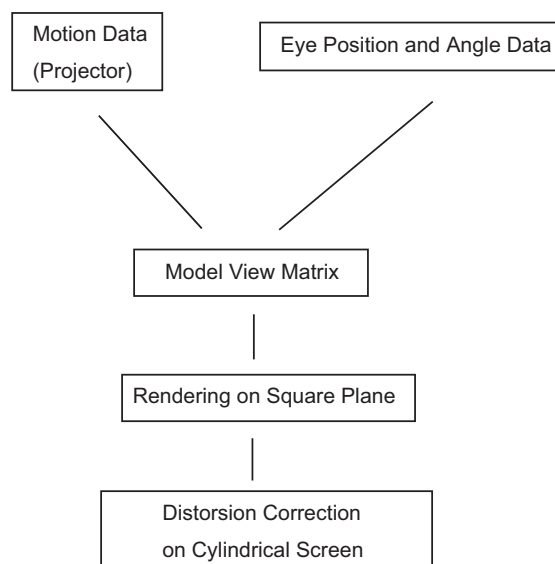
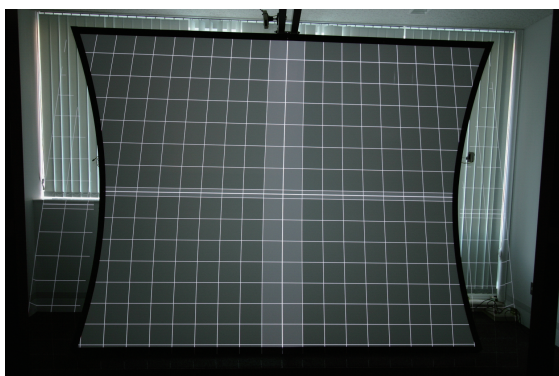


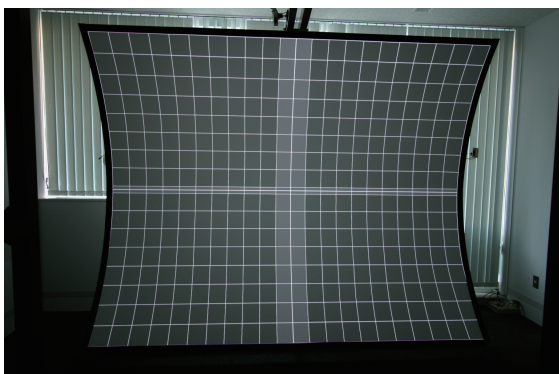
Figure 3. Data flow used to produce stereo images on the cylindrical screen.

2.3. Distortion Correction

For projection onto a cylindrical screen, it is necessary to distort the images, because normal (square) images would appear distorted on this screen. To provide the correctly adapted image, we use CHRISTIE TWIST [6]. Figure 4 shows the images before distortion correction and after distortion correction.



Before distortion correction



After distortion correction

Figure 4. Distortion correction.

3. Conclusion

In this study, we proposed a angle-movable immersive projection display. This system has a single cylindrical screen with two sensors that can detect when the user moves the screen and change the field of view automatically. This system enables the user to see the top, bottom, or side view of 3D objects. A further advantage of this system is its low cost and small size (compared with a CAVE-like system). This system uses one PC and one projector and can be installed in a 4-m-square room. Since the screen measures about 3.0×2.25 m, the user can become deeply immersed in 3D objects.

4. Acknowledgements

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3