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i-ball: interactive information display like a crystal ball

http://www.hc.t.u-tokyo.ac.jp/i-ball

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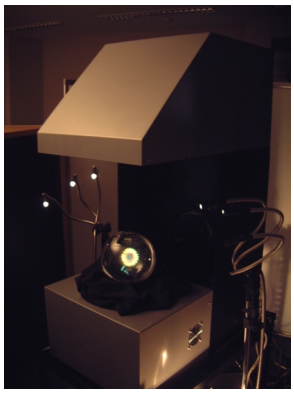
An object-oriented spatial display, which allows a user to observe 3D objects from any direction, is one of the emerging technologies in the field of visual interactive displays. The authors proposed and developed a new display of this type. Since the developed system is spherical and transparent, it looks like a crystal ball and is very attractive and expressive. Furthermore, the system is designed to be able to capture and process the images of user's behavior. This feature enables not only interactive displays, but also image communication through the transparent ball. We named the system "i-ball" which stands for interactive/information ball.


BACKGROUND:

We consider two types of 3D spatial display systems. One is the display surrounded by users. We can observe small objects inside the display from any direction. We call this type of display "Type A" for which an object-oriented display MEDIA^3 (Media Cube)[1] is one of the examples. Another is the display surrounding users. Within the display system, we

[1] M. Inami, N. Kawakami, T. Maeda and S. Tachi: "MEDIA^3: the Virtual Hologram", Conference Abstracts and Applications of SIGGRAPH '97, p. 107, 1997.

can stand and observe the surroundings. We call this type of display "Type B" for which Immersive Projection Technology (IPT) is one of the examples. Each type of display has its unique goals or characteristics, and we creatively use the appropriate type of display according to our purposes.

"i-ball" is a new method for the "Type A" display. In comparison with other display systems, i-ball is more conscious of interaction. It displays virtual objects within the transparent ball, and viewer can interact with it without particular wears, glasses, etc. The purpose of our system is not only for the presentation of virtual objects, but also for an interactive system, furthermore, a communication system.

INTERACTIVE EXPERIENCE:

Characteristics:

- ✓ The images, displayed within the transparent ball, are little bit distorted by the optical system. This distortion provides the illusion of depth sensation, though it is essentially a 2D display system.
- ✓ By capturing viewer's behavior, the system can display images interactively.
- ✓ By rotating the ball interactively, the system can display objects for any direction of observers.

Optical System Design:

- ✓ **Displaying images within the ball**

  Images are displayed on a monitor, and then transmitted to a mirror (Mirror1) in the ball by the combination of mirrors and lenses (Fig.1). The optical system is designed so that the transmitted images focus on Mirror1. A viewer observes images focused on Mirror1, and feels as if the monitor is virtually placed within the transparent ball. Figure 1 shows how the images are reversed, because of construction of the system.

- ✓ **Capturing viewer's behavior**

  Images of the viewer can be captured from the backward of the system through mirrors and lenses (Fig.2). Though captured images are reversed and turned upside down, owing to the system composition, they are still useful for interaction purposes. The system can also rotate the ball latitudinally (-15 - +30 deg.) and longitudinally (-130 - +130 deg.) interactively according to the captured viewer's behavior.

System Configuration:

Figure 3 shows the system configuration of i-ball system. Stage unit is introduced for the purpose of rotating the ball.

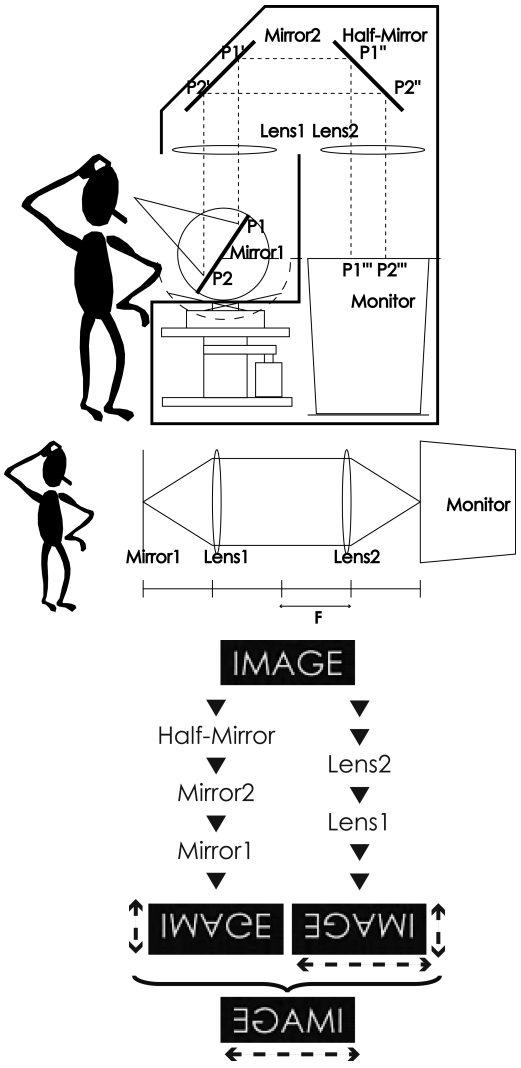


Fig.1 From monitor to viewer.

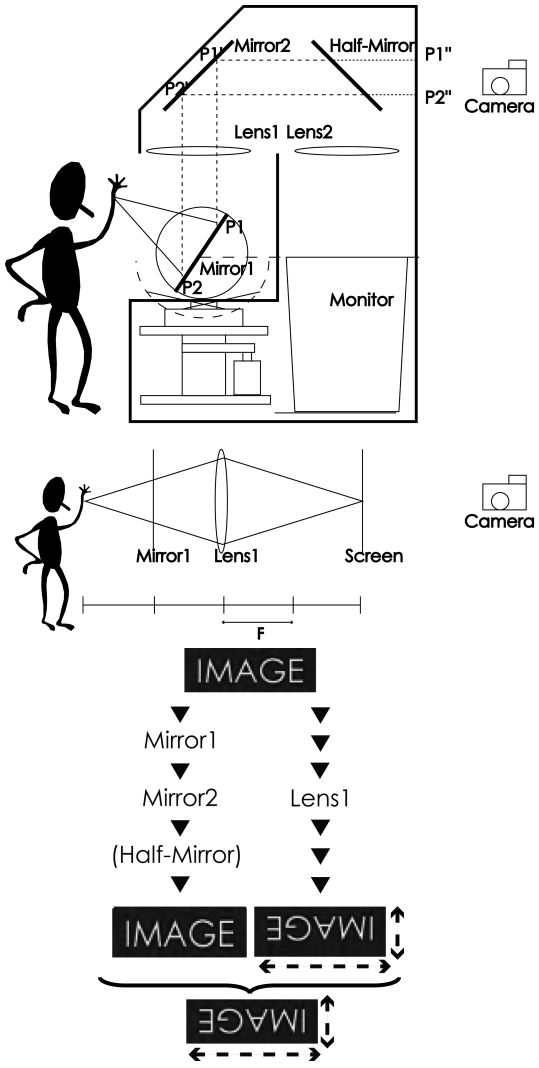


Fig.2 Capturing viewer's behavior.

- ✓ CRT Monitor (15 inch)
- ✓ Lenses (Lens1 and 2)
- ✓ Mirrors (Mirror 1 and 2)
- ✓ Half-mirror
- ✓ Transparent ball
  Diameter: 200mm
- ✓ Stage unit
  Longitude:
  from -130 to +130 deg.
  Latitude:
  from -15 to +30 deg.
  Average speed:
  30 deg/sec

Fig.3 System configuration of i-ball.

Figure 4 illustrates the differences of displayed images between on the monitor and in the ball. Images in the ball are distorted under the influence of lenses. This distortion varies from viewpoint to viewpoint. This leads to that we observe different images with right and left eyes such as in Fig.5, and feel the illusion of depth sensation caused by the disparity.

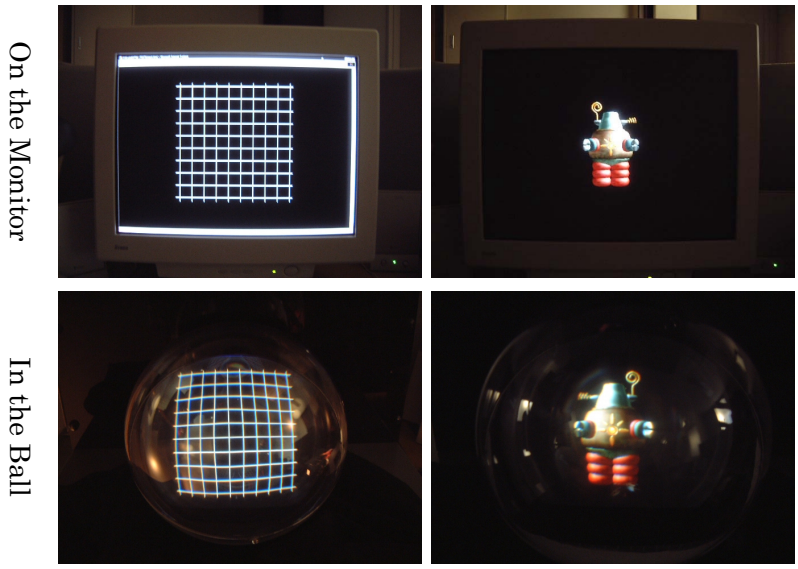
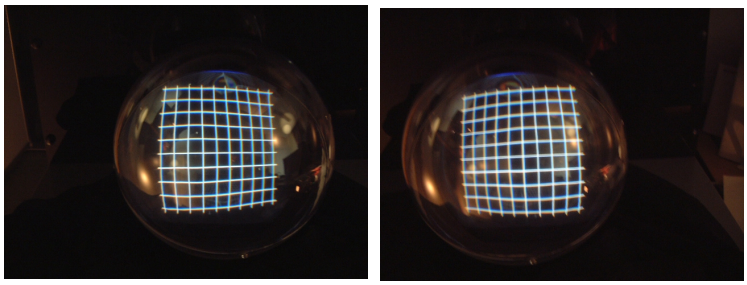


Fig.4 Comparison between a flat monitor and a transparent spherical display.



For the left eye For the right eye

Fig.5 The distortion provides stereoscopic effects.

Dark environment is suitable for observing images in the ball, while bright environment is required for capturing viewer's behavior. In order to solve this problem, we utilize light beams of fiber optics that have high degree of directivity. In the system, the fiber optics is set up so as to light up only user's hands.

Figure 6 shows a captured image. The image is divided vertically and horizontally, and averages of luminance values in each rectangle area are calculated. The area that has the largest value is regarded as the position of viewer's hand at that time. According to the motion pattern of the hand, the system displays images and controls the direction of the ball in real-time.

Fig.6 Capturing user's behavior.
(left) way of interaction, (right) captured hand image.

Interactive Application:

According to the motion of observer's hand, 3D CG animation (Fig.7) is rendered and the ball is rotated effectively. For example,

- ✓ If you wave your hand to a robot in the ball, he will wave back to you.
- ✓ If you suddenly stretch your hand toward the ball like punching, the robot will break to pieces.
- ✓ If you cover the ball with your hands, the robot will dislike it and shake his head and the ball rotates right and left.
- ✓ If your hand moves from right to left, the ball will rotates and the robot will jump to the surface of the ball.

In this way, the viewer is able to enjoy interaction with the robot in the ball.

On September in 2000, a prototype of i-ball system was exhibited, and these interactions were demonstrated at the Annual Conference of the Virtual Reality Society of Japan. Each viewer moved his/her hands in various ways, and enjoyed finding reactions of the robot. At that time, a lot of people were also surprised at the impression of depth of displayed images.

Fig.7 3D CG animation. The robot looks like living in the ball.

Video Conferencing Application:

According to the motion of observer's hand, 3D CG animation (Fig.7) is rendered and the ball is rotated effectively. For example, the i-ball is capable of displaying real images as

well as CG. Various interactions can be designed for this system.

For example, i-ball can be utilized as a video conferencing application (Fig.8). Since the mirror in the ball does double duty as a reflector for both displaying objects and capturing viewer's behavior, the optical system in i-ball can easily realize the gaze awareness. Furthermore, the person at the distant place can control the direction of the ball, so that it looks like he/she is turning his/her head during the communication.

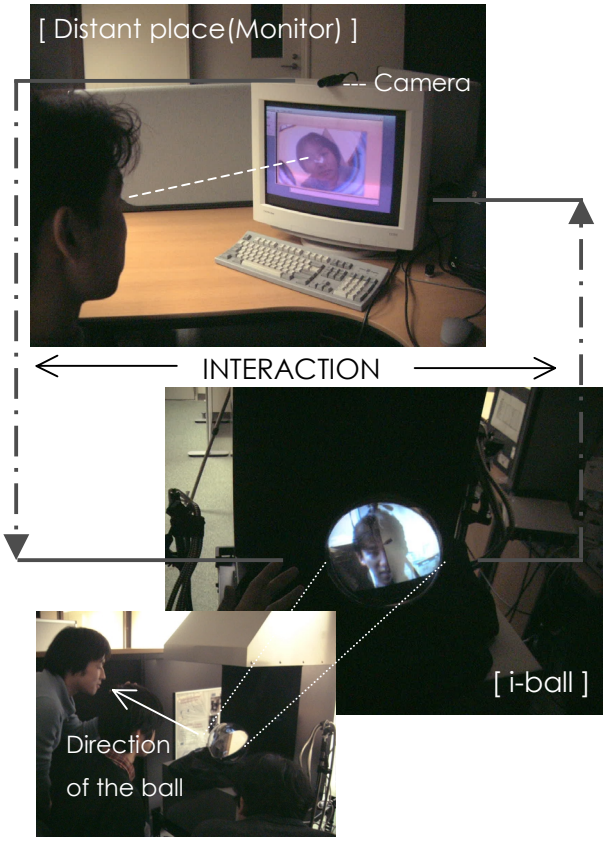


Fig.8 Video conferencing through i-ball.

Others:

- ✓ Interaction is limited to just one user at a time.
- ✓ The duration of the user experience is 1 or 2 minutes.
- ✓ Any preparation time is not required for users to interact with this system.

NEXT PLAN:

The future direction of this study will be one that encompasses both approaches for interaction and communication. For example, it is obvious that i-ball system is useful for displaying QuickTime VR[2] object movies.

[2] Shenchang Eric Chen: "QuickTime VR – An Image-Based Approach to Virtual Environment Navigation", SIGGRAPH '95, pp. 29-38, 1995.