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i-ball 2: An Interaction Platform with a Crystal-Ball-Like Display for Multiple Users

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Abstract

The authors' aim in this work is to develop an easy-to-use computer-human interaction (CHI) platform. In this paper, i-ball 2 (interactive/information ball 2) is introduced as an attempt at the aim. i-ball 2 is a display-based interaction platform and designed to provide various interactive experiences, based on the concept of i-ball (an interactive display system which the authors' group has developed). i-ball 2's characteristics are: Firstly, the image is displayed with special optical system as if it were floating in the ball which is equipped in the i-ball 2 system. Secondly, up to two users can participate in interactive experiences (each user has his/her own display system). And lastly, i-ball 2 has various input interfaces and potential for various interactive applications. In this paper, the applications implemented on i-ball 2 are introduced: 3-D CG object viewer, QuickTime VR object movie viewer, interaction with the robot, i-ball 2 game controller and simplified telexistence (videoconference) system. Through these applications, i-ball 2 appears to have high potential as a CHI and communication platform.

Key Words: computer-human interaction, crystal-ball-like display, track ball, eye contact, telexistence

1. Introduction

Media technologies bring us new experiences and new lifestyles. Currently we are in the stream of amazingly developing computer technologies and our lifestyles and environments surrounding us are changed by them, as we know and feel. Computers are crucial for our life and we have to keep on the right side of them.

Fig. 1: The appearance of i-ball

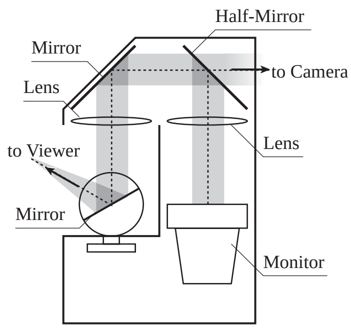

Fig. 2: The system diagram of i-ball

In this work, the authors focus on computer-human interaction (CHI), especially on CHI systems. The authors' group has developed a display-based interactive system: "i-ball (interactive/information ball)" and evaluated the system through exhibitions[1][2][3][4]. Now the authors are developing another interaction platform: "i-ball 2", with high potential for various interactive applications, based on i-ball's concept (as described below).

In this paper, the authors describe mainly:

- i-ball (concept, hardware and applications)
- The design and hardware of i-ball 2
- The applications currently implemented on i-ball 2

2. Previous Work: i-ball

i-ball is an object-oriented interactive display system with the motif of fortuneteller's crystal ball. The appearance and the system diagram are shown in Fig. 1 and Fig. 2.

2.1. The i-ball System [1]

i-ball has a transparent ball (20 cm in diameter) in which there is a mirror, as seen in Fig. 1. The image produced by the monitor passes the lenses and focuses on the mirror in the ball (see Fig. 2). The observer looks in the image* in the ball. When the image is displayed, it is a little distorted by the lenses, and the effect brings some depth sensation.

As shown in Fig. 2, i-ball has the mechanism to capture the observer from the back of the system. In addition, the optic axis of the image and that of the camera are met, i.e. eye contact is achieved.

i-ball has a motor to rotate the ball and the direction of the mirror (the direction from which the image can be observed) can be changed.

And, the remarkable characteristic of i-ball is what the users have to do to participate in interactive experiences is to sit in front of the i-ball system without any special equipment. The authors think that it is an important requirement for easy-to-use interactive platforms.

2.2. The Applications of i-ball

Interaction with the robot: A computer-generated robot appears in the ball. When you move the hand in front of the ball, the motion is captured and the robot reacts with amusing animation dependent on how you move the hand (a vision-based interaction). In addition, the ball rotates attuned to the robot's animation effectively[2].

Videoconference: As described above, i-ball has a mechanism to capture the observer with eye contact. Connecting two i-ball systems realized a congruous videoconference. The ball rotation is utilized for the user to look around in this application[3][4].

3. The Design and the Hardware of i-ball 2

i-ball 2 is an interaction platform based on i-ball's concept: an object-oriented interactive display with a transparent ball in which images are displayed. The major features of i-ball are inherited to i-ball 2 (details are described later). And major differences between i-ball and i-ball 2 are:

- Up to two users can participant in interactive experiences
- Various input interfaces are equipped for various interactive applications
- The hardware is modularized for further extension
- Downsizing

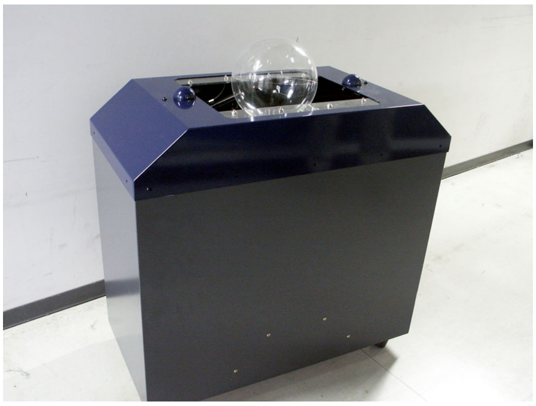

Fig. 3: The appearance of i-ball 2

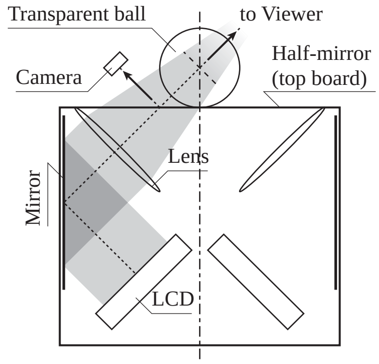

Fig. 4: The system diagram of i-ball 2

Fig. 3 shows the appearance of i-ball 2. The size of i-ball 2 is 80 cm (W) × 40 cm (D) × 78 cm (H) (without the protrusion and the transparent ball). i-ball 2's transparent ball (20 cm in diameter) is empty, different from i-ball's. The system diagram of i-ball 2 is Fig. 4.

The hardware of i-ball 2 chiefly consists of displaying system and input interfaces.

3.1. Displaying System

The rays of the image emitted by the LCD (15 inch, XGA) pass the lens and the image focuses as real image in the ball (see Fig. 4)†. This optical system gives observers a feeling as if the image were floating in the

* As studies of displays such as the observer looks in the displayed object (object-oriented), there are MEDIA³[5], MEDIA X'tal[6], etc.

† In principle, the ball is not necessary for displaying image (the image is displayed in midair). But the ball helps the observer to focus on the image.

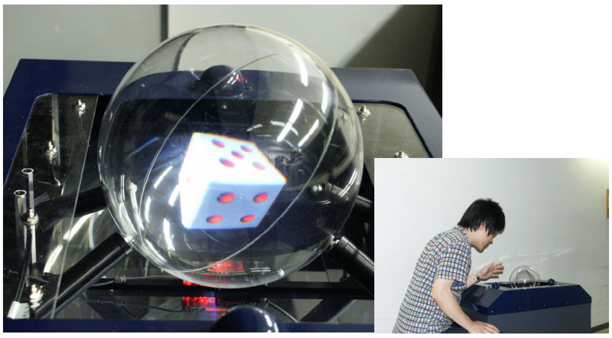

Fig. 5: The image seen from the observer's viewpoint and the observer

Fig. 7: Two users are observing images from each viewpoint

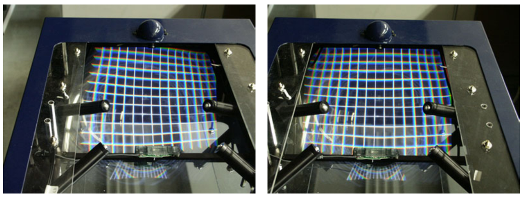

Fig. 6: When the viewpoint moves, the image is distorted

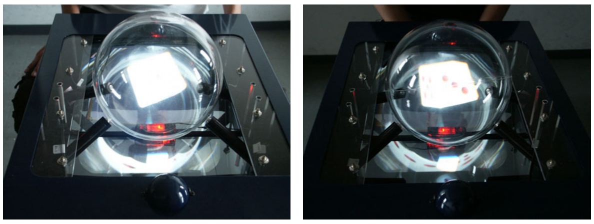

Fig. 8: Displayed images from each observer's viewpoint

ball (Fig. 5). Note that the observed image is the mirror image since the rays are reflected with the mirror. As for lighting condition to observe the image, a little darker condition than room lighting is preferable not to reduce the clearness of the displayed image. And indirect lighting is more preferable not to be annoyed by reflected lights on the ball.

There is a sweet spot for observation, which is adjusted to the observer's face position when he/she sits on the chair in front of i-ball 2. When the viewpoint is away from the sweet spot, the image is distorted (for example, Fig. 6) and vanishes when it is more away (except forward and backward). Same as i-ball, in the case of i-ball 2, this distortion gives some depth sensation.

i-ball 2 has two display systems[‡] (as shown in Fig. 4) and each system can work independently. For example, in such a situation that two observers sit facing each other like Fig. 7, the images of an object from each observer's viewpoint can be displayed to each observer (Fig. 8).

3.2. Input Interfaces

One of the characteristics of i-ball 2 is that various input interfaces are equipped for various interactive applications. Currently three kinds of input interfaces are equipped:

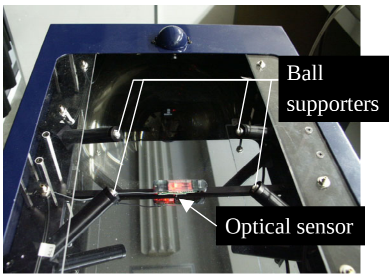

Fig. 9: The ball rotation mechanism (the ball supporters and the optical sensor)

- Ball rotation
- Optical switches
- Capturing the observer

Ball Rotation (Track Ball Interface)

The most remarkable input interface of i-ball 2 is that the ball in which the image is seen can be rotated like a track ball. The ball is supported with bearings at four points and its rotation is picked up by the optical sensor under it (Fig. 9). In the current implementation, two of three axes (to simplify the hardware) of rotation can be detected. This interface enables intuitive operation in interactive applications.

[‡] In principle, more display systems can be equipped (however implement becomes larger).

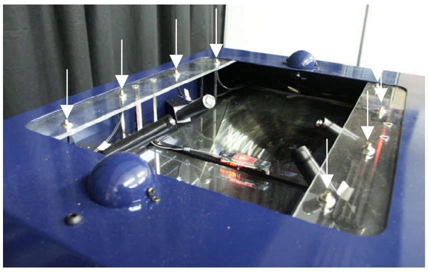

Fig. 10: The eight optical switches around the ball (indicated with arrows)

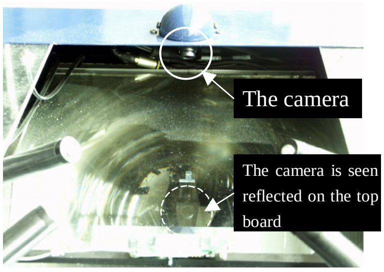

Fig. 11: The camera installed in the top cover

Optical Switches

There are eight optical switches around the ball (see Fig. 10). The switch is turned on, for example, when the hand are held above it.

By introducing these switches the observer's gesture can be detected roughly. And they are also utilized as normal click buttons or switches.

Capturing the Observer

i-ball 2 equips two CMOS cameras for each observers. The camera captures the observer's figure reflected on the top board (the top board is a half-mirror). Note that eye contact is achieved since the optical axis of the image and that of the camera meet. Fig. 11 shows the camera and you can see how eye contact is achieved (see also Fig. 4).

3.3. The Principle of the Design of i-ball 2

The hardware of i-ball 2 is highly modularized. The basic components are the displaying system and the track ball interface and the other components are exchange-able. For example, the optical switches can be exchanged to push buttons and the cameras also. Besides, i-ball 2 is ready for additional components. The authors are ready to equip additional hardware components for further applications.

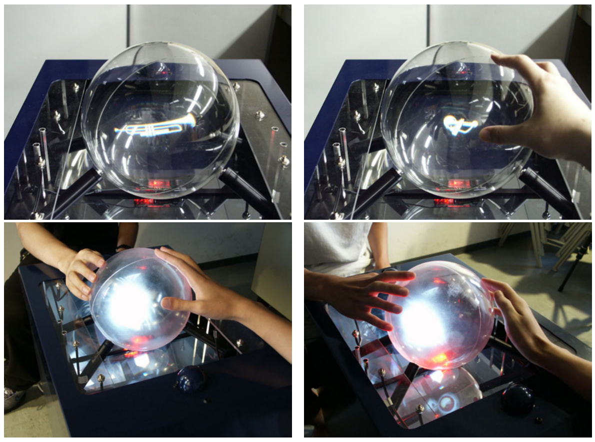

Fig. 12: 3-D CG object viewer

3.4. Developing Applications for i-ball 2

i-ball 2 is carefully designed to be able to develop applications in a simple way. In order to develop applications i-ball 2 is usually connected to a PC, but the PC does not recognize i-ball 2 as any special hardware. So applications can be developed easily and rapidly. In addition, if the developer uses limited features of i-ball 2, even programming is not necessary. He/she can use authoring environments instead of programming environments.

4. The Applications of i-ball 2

In this section, the applications currently implemented to i-ball 2 are introduced. Here, i-ball 2 is connected to a Windows PC, CPU of which is an Intel 2.0 GHz Pentium 4 processor and GPU of which is an ATI RADEON 9000.

4.1. 3-D CG Object Viewer

In the ball, a 3-D CG object is displayed. When the observer rotates the ball, the object rotates accordingly and can be seen from various directions, as if he/she "took" the object in the ball.

This application is compatible with two users. Each observer can see the object in the ball from his/her viewpoint and manipulate it (Fig. 12).

Basically, the object rotates tightly according to the ball rotation. In addition, viewers with some effects are implemented:

- Ball rotation accelerates rotation of the object
- When the ball is rotated, the object is rotated as if the ball is filled with water

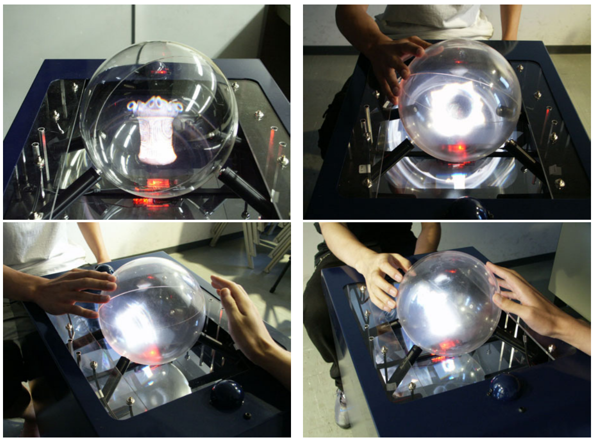

Fig. 13: QuickTime VR object movie viewer

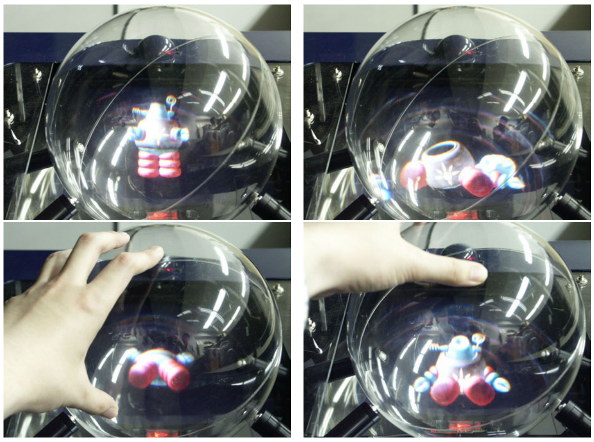

Fig. 14: Interaction with the robot

Viewing an object with these effects is also funny and curious.

4.2. QuickTime VR Object Movie Viewer

Similar to the application mentioned in 4.1., the observer can watch a QuickTime VR object movie. The ball rotation also allows the observer to see the object from different directions.

This application is also compatible with two observers. The image from each observer's viewpoint is displayed to him/her (Fig. 13).

Note that manipulation of QuickTime VR object movie is a little different from that of 3-D CG object because the head and tail of the photos are fixed. Because of the hardware limitation mentioned in 3.2., longitude rotation is assigned to leftward and rightward rotation. Some users were confused about this operation at first, but in a minute they got accustomed to it and "took" the object.

4.3. Interaction with the Robot

In this application, a computer-generated robot appears in the ball. When you rotate the ball quickly or slowly, a little or a lot, or even draw a circle, he shows amusing reaction (animation). Fig. 14 shows the snapshots of the interaction with the robot.

This application is basically the same as that of i-ball's (described in [2]), but the input interface is changed to ball rotation instead of vision recognition of the observer. And i-ball 2's version is compatible with two users.

4.4. i-ball 2 Game Controller

If you want to play games in a curious style, i-ball 2 provides the platform. The game screen is in the ball and the controller is the ball. You can enjoy familiar games in funny style (Fig. 15).

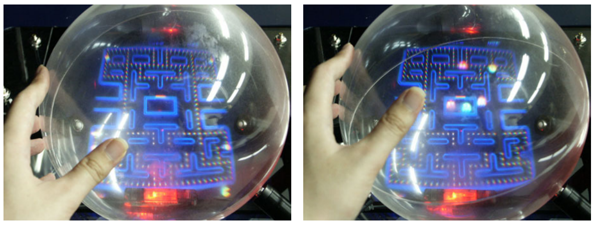

Fig. 15: i-ball 2 game controller§

Technically, this application is realized by converting the ball rotation to the input of the target game.

4.5. Simplified Telexistence System

As described in 3.2., i-ball 2 has a mechanism for capturing the observer with eye contact. And the characteristic of displaying system of i-ball 2—the image is seen as if floating in the ball—brings some reality. Here the authors describe the experiment on the prototype system of the simplified telexistence (video-conference) system as mentioned in [7].

The setting of the experiment is shown in Fig. 16. As seen in the figure, i-ball and i-ball 2 are connected (note that i-ball also has eye-contactable capturing mechanism, as mentioned in 2.1.). Captured images by i-ball are sent to i-ball 2, and vise versa.

The snapshots of the experiment are shown in Fig. 17. The user of i-ball is displayed in i-ball 2's ball with some reality (and vise versa). A congruous videoconference

§ From Microsoft® Return of Arcade Anniversary Edition; Screen shots reprinted with permission from Microsoft Corporation.

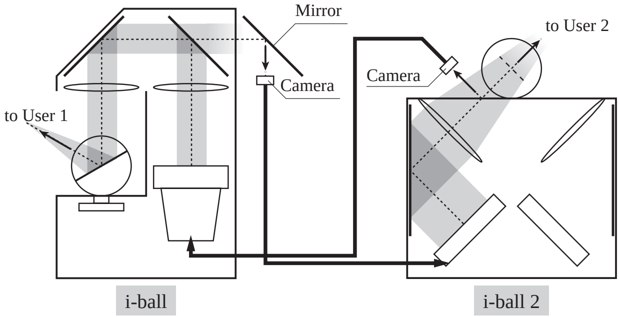

Fig. 16: The setting of the experimental simplified telexistence system

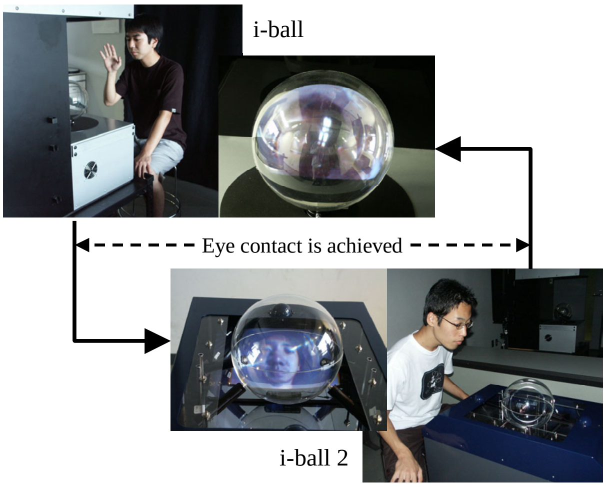

Fig. 17: The videoconference between i-ball and i-ball 2

is realized because eye contact is achieved.

Most videoconference systems orient to high presence, for example by employing large screen for real size displaying. On the other hand the authors' system is unique and interesting since the users appear in the ball mysteriously.

5. Conclusion and Future Works

In this paper the authors introduced an interaction platform with a crystal-ball-like display: i-ball 2, and described the design and hardware of i-ball 2 and its applications. What you have to do to interact with i-ball 2 is to sit in front of it. Through the reaction of these applications, i-ball 2 appears to have high potential for a CHI platform.

So far, the authors have not developed i-ball 2 applications using its full hardware features yet. The authors continue developing interactive applications for i-ball 2, and will examine and improve the hardware when needed. And i-ball 2 is expected to improve as an all-round home information terminal as well as a telexistence terminal, as mentioned in [7]. It is also an interesting topic to develop an interaction environment featured i-ball 2, which provides easy-to-use and fruitful interactive experiences and communication.

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