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i-mirror: An Interaction/Information Environment Based on a Mirror Metaphor Aiming to Install into Our Life Space

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Abstract

We focus on information environments in our life space, which provide information services (including accessing) and interactive experience. When designing such systems, human interface is thought to be important and they should match the environment where they are placed. Based on the concept above, we propose a mirror-metaphor-based interaction/information environment: i-mirror. Basically, the i-mirror systems imitate a mirror using special optical systems, and the applications are based on virtualizing and enhancing features of a mirror. In this paper, three i-mirror applications are implemented: a mirror with gain, a look-younger/older mirror and a mirror with memory. We confirm the mirror-like interface is congruous for interaction.

Key Words: Information Environment, Mirror Metaphor, Eye Contact, Congruous Interface, Interaction

1. Introduction

Amazingly spread mobile network enables us to reach and access the cyber space "anytime, anywhere". In addition, human interface technologies have removed the restriction that once shut themselves up in display monitors, and rush out into the real world. These trends brought us to build information environments "anytime, anywhere". With this potential, our daily space on the aspect of information environments might become homogenized. On the other hand, it also means that information environments would support us with location-/context-awareness[*]. Based on this, we focus on information environments in the real world (i.e. our daily life space), in order to create value-added space with information services.

Here, we call these information environments "informative/interactive street furniture (情報街具 or *joho-gaigu*, in Japanese)"[†][1]. The reasons why we call so are:

- It should go with our daily lives, like street furniture.
- It is not an architecture which is difficult to be replaced but a replaceable component of a street.

We propose a designing principle for these information environments: enhancing an object in our daily space by virtualizing some aspect of it. In other words, functions for information environments are added to objects in our life space. The advantages of the principle are as follows:

Congruous interfaces: By designing interfaces which we could easily think of from the object that is to be enhanced, the system will be dealt with in a simple and clear way. It is important that users can easily understand how to use it (without a manual), because systems in our daily space might be used by a lot of people.

Matching the environment: By placing the system where the object to be enhanced should be, it will match the environment. In other words, it should not be an apple on a pile of oranges.

Based on the concept above, we propose a mirror-metaphor-based interaction/information environment: "i-mirror (interactive/informative mirror)". In this paper, we report:

- Concept of i-mirror
- i-mirror design
- i-mirror applications

[*] One of ultimate goals of this concept is a ubiquitous computing.

[†] "Street furniture" is a generic term of street features such as traffic lights, benches and garbage cans.

2. i-mirror: A Mirror-Metaphor-Based Interaction/information Environment

We designed and implemented two prototype systems of i-mirror. The point of issue in designing i-mirror systems is how to imitate a mirror in order to provide a mirror-like interface. We implemented two experimental systems to concretize and evaluate the concept of i-mirror.

2.1. The Concept of i-mirror

Now we focus on display-based information environment. We aim to give it a simple and clear interface for interaction in a natural way. i-mirror basically provides such information environments, and employs a mirror metaphor for congruous interfaces as mentioned above.

We all know (or have acquired) what a mirror is. We can regard a display system as if it were a mirror, when it has characteristic(s) of a mirror (s/he can see herself/himself in it). I.e. s/he can regard the image in the display as the phenomena in the real world and interact with objects and events in it naturally. In "ALIVE"[2] the user interacts with the virtual creature in the display in front of him/her. In the display the scene in front of it is "reflected" and the creature is superimposed on the scene, and s/he can regard the scene in the display as the real world. This idea is also seen in "Augmented Mirror"[3] and the scene in the mirror-imitating display is an augmented reality space. "HyperMirror"[4] is a videoconference system and superimposed images produce the sense that all participants are looking into the same glass.

As described above, a mirror metaphor is thought to be useful for congruous interfaces. i-mirror also employs the idea aiming at a comfortable interaction/information environment.

To achieve mirror-like displays, imitating a mirror is required. A mirror is a simple device but it is very difficult to be reproduced technologically, because a mirror may be regarded as an eye-contactable 3-D display. Imitating a mirror has resulted in reproducing just a part of its characteristics so far.

Simply, placing a camera near by a display realizes a mirror-like device (ALIVE and Augmented Mirror employ this method). But, when you gaze at your image in the display, it will gaze at another direction. You may feel inconsistency. In i-mirror, we assume that it is congruous for imitating a mirror to achieve eye-contactability: when you gaze at your image in a mirror, it gazes at you[‡].

2.2. Design and Implementation of i-mirror

Basically, the i-mirror system is both a mirror and a display. As described in 2.1., realizing eye contact is required to imitate a mirror.

Eye contact is thought to be important in video-conference systems and methods to achieve it have been studied. For example, "ClearBoard"[6] employs a half-mirror and "MONJUnoCHIE"[7] uses a hologram screen for eye contact.

By the way, the basic processing flow in i-mirror is:

- Capturing the scene in front of i-mirror
- Some processing with the captured image and/or other inputs
- Displaying an image based on the processing above

This mechanism is installed into an eye-contactable display. In this paper, we designed and implemented two experimental i-mirror systems: one with half-mirrors and the other with a hologram screen.

One of the i-mirror systems employs half-mirrors for eye contact. The mechanism of the implementation is shown in Fig. 1. An additional half-mirror is equipped for a video projector to project images from below. And, Fig. 2 shows the implemented system. The size of the image is about 40 cm × 30 cm. From now, we name this implementation i-mirror-A.

The other employs a hologram screen. It is a holographic grating and diffuses the ray from around 35 degrees above and below. Rays from other directions are transmitted. Using this characteristic, rays from the front is transmitted and able to be captured from the back. And images projected on the back from above or below can be seen from the front (Note that the diffused rays can not be seen from the back). Thus, eye contact is achieved by placing a camera in the opposite side of the viewer. The configuration of the implementation is shown in Fig. 3. The remarkable characteristic of this implementation is that it is a genuine mirror when the projector does not project any image because the holo-

‡ Technologically, reproduction of a mirror is also a challenging topic. For more "accurate" mirror reproduction, there is an attempt like [5] (using video-based rendering technique).

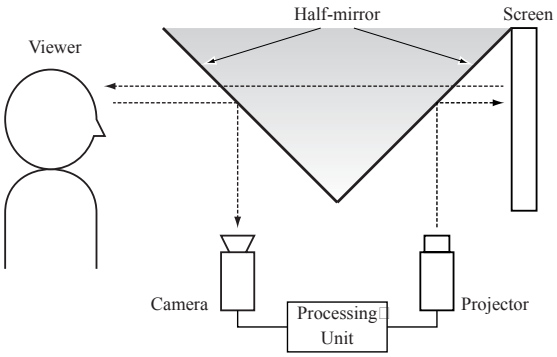

Fig. 1: The i-mirror system with a half-mirrors

Fig. 2: The overview of the i-mirror system with half-mirrors (i-mirror-A)

gram screen is pasted on a half-mirror and it is dark on the back of the screen. Fig. 4 shows the implemented system and we call it i-mirror-B. The size of image in i-mirror-B is about 80 cm × 60 cm.

3. Applications of i-mirror

This section describes applications of i-mirror. The applications are, so to say, enhanced features of mirrors. The mirror-like interface of the i-mirror system(s) is successful only in the mirror-like applications.

We know various characteristics of mirrors and have various images on mirrors. For example:

- Mirrors reflect rays.
- We can see our figures in a mirror.
- A mirror is a mysterious item.
- In a mirror there is another world (Through the Looking-Glass!)

We focus on these features for i-mirror applications.

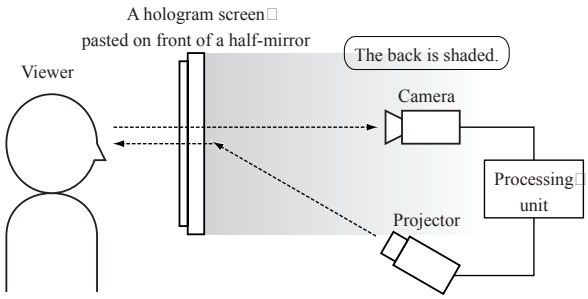

Fig. 3: The i-mirror system with a hologram screen

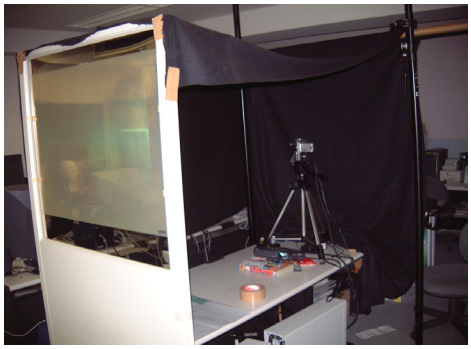

Fig. 4: The overview of the i-mirror system with a hologram screen (i-mirror-B)

The i-mirror applications introduced in this paper are:

A mirror with gain: The mirror reflects brightly though it is dark.

A look-younger/older mirror: The mirror image of you looks younger or older using real-time image processing.

A mirror with memory: The mirror remembers the scene of the room, you can handle time in the mirror and the mirror reflects the past scenes.

The processing flow of i-mirror was mentioned in 2.2. The implementation depends on how and what to capture, process, and display.

3.1. A Mirror with Gain

"A mirror with gain" enhances a characteristic of a mirror: "reflecting rays as they are". In this application, the mirror is bright-reflecting and you can see your image in it though it is dark.

The implementation is simple. All we have to do is to employ a night-vision video camera for capturing and configure it according to the lighting condition. Captured images are displayed directly to the screen.

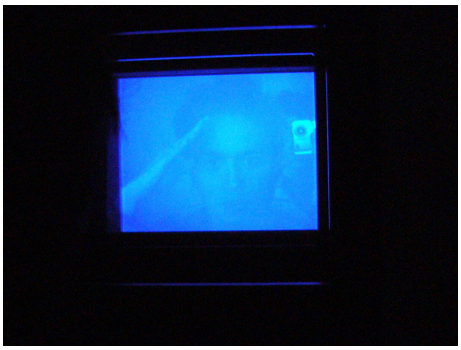

Fig. 5: A mirror with gain—The viewer in the dark is "reflected" brightly in the "mirror"

In Fig. 5, you can see a bright-reflected figure though the room is dark. The frame rate and latency depend on the camera configuration: in Fig. 5, 10 frames/s and about 0.1 second, respectively. Note that i-mirror-A is preferable for this application (mainly because the optical system of i-mirror-A is simpler and configuration is easier).

3.2. A Look-Younger/Older Mirror

"A look-younger/older mirror" enhances "reflecting the figure as is". In this application, when you look in the mirror, you will find you look younger or older.

The trick of this application is real-time image processing. A nonlinear filter "β-filter"[8] extracts low-amplitude noise in images, which corresponds to wrinkles and freckles in facial images. Thus, when the extracted noise is emphasized, facial images would look older, and vise versa. An "E-make" machine[9] is a real-time image processor for "skin make-up" as mentioned above. The configurations are:

- Captured images (from normal video camera) are input to the "E-make".
- "E-make" makes up faces in the images to look younger or older.
- The processed images are displayed.

You can see the interaction overview in Fig. 6. The viewer looking in i-mirror-A looks younger in the "mirror" (Fig. 7) or older (Fig. 8). All processes are done in video rate.

Note that this application is also more suitable in i-mirror-A, since captured image through the hologram screen are not good enough for fine image processing like β-filtering.

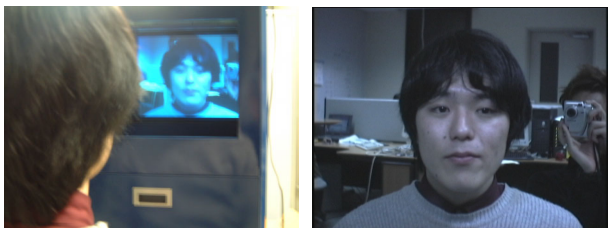

Fig. 6: Interaction overview of "A look-younger/older mirror" (left: overview, right: before processing image)

Fig. 7: "Look-younger make-up"
(left: overview, right: displayed image)

Fig. 8: "Look-older make-up"
(left: overview, right: displayed image)

3.3. A Mirror with Memory

This application focuses on the characteristic of a mirror: "reflecting rays all at once". By enhancing it, a mirror comes to have "memory". And, the viewer handle "time" in the mirror as shown in Fig. 9 and the mirror reflects the past scenes.

The system diagram is Fig. 10. Captured images are continuously recorded (MPEG-2 encoded) on the PC disk. As long as the user does not touch i-mirror, it behaves as a normal mirror because of no time gap between the real world and the mirror-reflecting world.

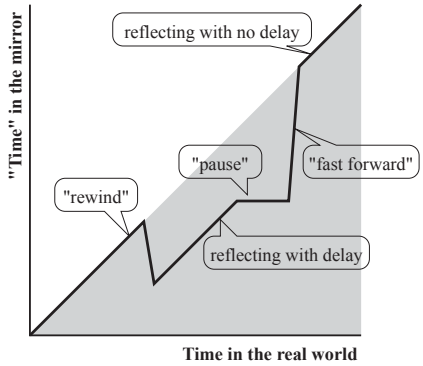

Fig. 9: In "a mirror with memory" the viewer can interact with time in the mirror

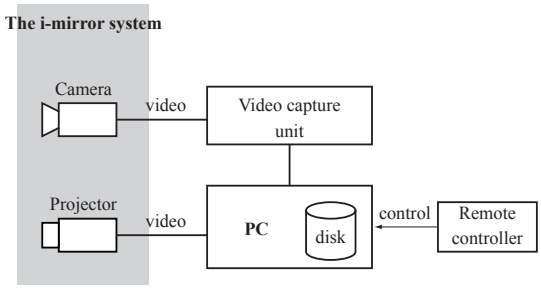

Fig. 10: A mirror with memory—system configuration

The viewer can interact with time in the mirror using a remote controller. S/he can "stop", "rewind" and "fast forward" events in the mirror like a video player. Fig. 11 and Fig. 12 illustrate a case. In Fig. 11 a viewer in front of i-mirror sees his image as a mirror (no latency), and few minutes later another viewer comes and rewinds time in the mirror with the remote controller (Fig. 12). He can see the event which took place a few minutes ago (the scene at Fig. 11). Note that while the mirror "reflects" the past scenes, capturing the scene in front of it still continues.

In i-mirror-B, when time in the real world and time in the mirror-reflecting world are the same, i-mirror-B can behave as a genuine mirror displaying no image (as described in 2.2.).

By the way, there is another version of a mirror with memory. It uses a cellular phone device for operation instead of a remote controller. Since time in the mirror is handled with his/her accustomed device, it is interesting in terms of interface. Details of its interface design are described in [10].

Fig. 11: A mirror with memory—no time gap between in the real world and in the mirror
(left: overview, right: displayed image)

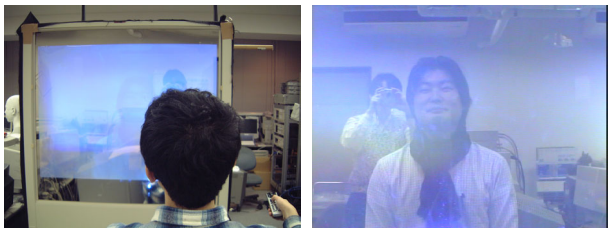

Fig. 12: A mirror with memory—a few minutes later from Fig. 11, another viewer rewinds time in the mirror and sees the scene at Fig. 11
(left: overview, right: displayed image)

4. Discussion

We exhibited "a look-younger/older mirror" at 11th symposium of Japanese Academy of Facial Studies and Interaction 2002 (a domestic conference). Users who looked at their figures in i-mirror seemed a little surprised and gazed at their younger or older faces in the "mirror". In general, they just looked in and did not care about a camera (when you see a captured image of you, you will wonder where the camera is). They might regard i-mirror as something like a mirror. We think that observed naturalness in interaction was brought from the concept of interface design and application of i-mirror. They seemed to enjoy the strange mirror.

"A mirror with memory" is an attempt for an information environment implemented to the real world. Imagine a mirror in a lounge. There, a lot of people are resting, talking and waiting for others. Some come in and others go out. The mirror remembers activities of people and when someone call the mirror it turns into an information environment that recalls the past scene in the lounge to show when the person whom s/he is waiting for or searching for was there (Fig. 13). A mirror is both furniture of a room and information environment, which is one of informative/ interactive street furniture.

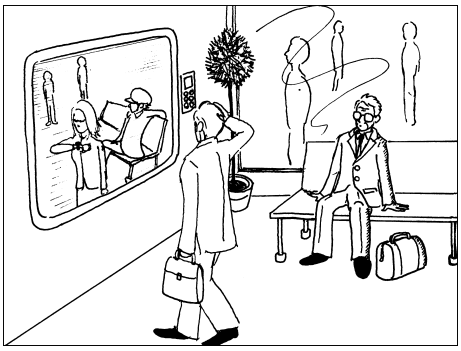

Fig. 13: A lounge with i-mirror—he is late, rewinds time in the mirror and knows that his girlfriend got angry and has gone

On the other hand, "a mirror with memory" records the scene in the room. Some say that it must dealt with carefully because it concerns a privacy problem. Others say that it will be OK because anyone could be looked at by others in public space. This issue needs more discussion.

5. Conclusion

In this paper we propose a design principle for information environments in the daily life space and a mirror-metaphor-based information environment: i-mirror and implemented two experimental system and applications.

From users' reaction (at the exhibitions), interfaces of i-mirror seem natural and i-mirror has the potential for interaction/information environments for people in the daily life space.

Future works are:

- Detailed evaluation. By placing it to more public space, how the i-mirror system(s) are dealt? For placing, both hardware and software improvement are (surely) required.
- Discussion on design principle and issues. The privacy problem described in 4. is one of the topics. And deepening the concept based on [1] is also an important task.

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