Transparent Interface: A Seamless Media Space Integrating the Real and Virtual Worlds

Masahito Hirakawa+, Yuki Kojima*, and Atsuo Yoshitaka*
+ Faculty of Integrated Science and Engineering, Shimane University
1060 Nishikawatsu, Matsue 690-8504, Japan
hirakawa@cis.shimane-u.ac.jp
* Graduate School of Engineering, Hiroshima University
1-4-1 Kagamiyama, Higashi-Hiroshima 739-8527, Japan
{kojima, yoshi}@isl.hiroshima-u.ac.jp

Abstract

This paper presents an augmented reality system with a film-type transparent display. When the user selects a real world object by pointing at it with his/her finger, the associated information is projected onto the display which is located between the user and objects, resulting in the visual integration of the computer-generated digital information with real world objects. It is noted here that the user doesn't need wearing any special devices. Applications of the system are also presented.

1. Introduction

Augmented/mixed reality [1], [2] is promising for ordinary people since they don't need to be aware of the computer. What to do for them is just behave as usual in the real world – for example, placing a book on a desk and opening it. The information associated with an object in the real world is presented to the user in a visual and/or auditory form. It should be noted here that the computer-generated digital information is mixed with real-world objects and they are perceptually assimilated. In other words, he/she can feel that objects in the real world are augmented in their properties/functions with the help of a computer (though it is invisible).

In this paper, we present an augmented reality system which organizes a seamless media space integrating the real world and the virtual world. A key idea is to use a film-type transparent display which is placed between the user and objects in the real world. The information associated with a real-world object being pointed at by the user with his/her finger is presented and overlaid on the display so that the information can be assimilated with the object.

Interestingly the proposed system does not request the user to wear special devices such as a head-mounted display. Wearing such devices is bothersome for the user and impediment to his/her work. In addition, the display used in the proposed system doesn't have a frame which divides a display screen from surroundings – i.e., the real world. It can be expected to construct a smart real-world media space which is augmented by a computer.

In the following, in Chapter 2, an overview of the system is presented. Chapter 3 explains a method of analyzing the gesture of the user. Applications of the system are demonstrated in Chapter 4. Finally, in Chapter 5, a conclusion is given.

2. System Overview

2.1 Architecture

Figure 1 shows an architectural scheme of the system. The system is organized by a transparent display, two video cameras, a video projector, and a PC.

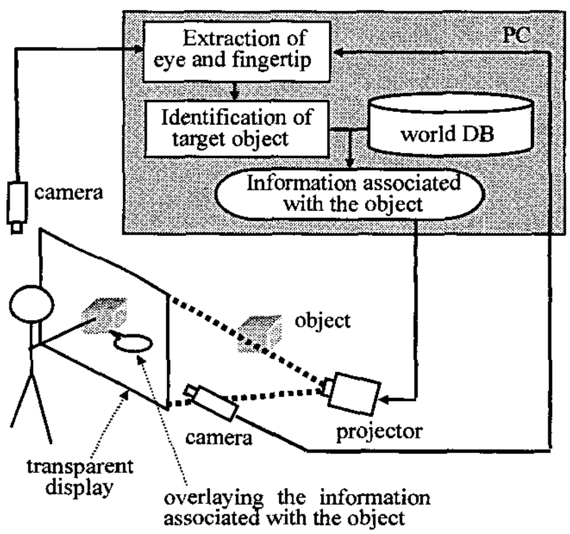

Figure 1 System architecture

Interaction with the system is realized by gesture. When the user points at an object which is seen through the transparent display, his/her fingers and head are extracted from images taken from two cameras located at the top and side of the working space, and the position of a fingertip and a dominant eye is decided to identify a target object the user intends to refer to. The information associated with the object is then presented on the display by a projector located behind the display.

2.2 Related work

In augmented reality systems, the user selects an object that he/she is interested in. Methods to select an object in augmented reality systems are classified into three categories listed below.

(1) bring a device near to the object [3]

(2) shoot the object by a camera that the user wears on his/her head [4]

(3) point at the object by a finger [5]

In (1), the user selects an object with a camera or a bar code reader by bringing it near to the object. In (2), an object is selected by a camera which is worn on the user's head. The system recognizes the object by its color histogram or bar code attached on it. Those trials assume that the user wears/brings a special device. Meanwhile, in (3), the user points at an object by his/her finger and doesn't need wearing a special device. This point-based interaction technique is obviously natural for the user.

Our system proposed in the paper uses a transparent display and can be used in a wide variety of applications while keeping the natural and intuitive gesture-based interaction scheme.

3. A Method of Object Pointing Analysis

3.1 Detection of fingertip and eye positions

Tracking of the user's finger and head in 3D space is carried out without any devices attached to the user. After regions of his/her fingers and head are extracted in each input image taken from the cameras, their positions in the 3D space are determined based on triangulation.

Here a fingertip is naturally considered the point which is closest to the display. Meanwhile, to determine the eye position, we need consideration due to the fact that one side of the eyes serves as a dominant one and affects the vision. In our implementation the position of the dominant eye is estimated experimentally by giving the distance from the center of the head to the dominant eye and the distance from the bottom of the head to the dominant eye. Those parameters are determined through an experiment in which 10 university students participated.

3.2 Identification of target object

The dominant eye, fingertip, and object are assumed to be positioned on one line. Therefore, if the position of the dominant eye and fingertip is determined, a target object the user intends to refer can be decided. An issue to be considered is how the system notices whether the user is now pointing at an object. This is done by evaluating the distance between the user's fingertip and the transparent display. If the distance is shorter than a threshold (5cm in our trial), the system recognizes that the user intends to point at an object.

To evaluate the performance, we made an experiment. Five markers are placed at four corners plus the center on a board (100×80cm wide) and the board is placed in 0.5, 1.0 or 2.0 meters from the transparent display. The distance between the marker and the line through the fingertip and the dominant eye is measured when a subject points at a marker. Ten university students participated in the experiment and, for each point, five trials were done. The result is summarized in Table 1.

Table 1 Result of experiment

Distance between board and display (meter)	Error (centimeter)		
	Ave.	Min.	Max.
0.5	6.8	2.5	11
1.0	12	6.3	17
2.0	18	13	24

4. Application

4.1 Application for exhibits

In a place where exhibits are presented in public, such as museum, zoo, and aquarium, an explanatory note is attached to each exhibit to provide better understanding for the guests. However, in such situation, a guest feels difficulty in finding the correspondence of a note to an exhibit since they are spatially separated, and he/she has to pay special attention. Using the proposed system, a guest can get the information related to an exhibit with ease.

Figure 2 shows a snapshot of the system. The user sees and points at an object (miniature model of animals in the current implementation) in a 3D space. The associated information is presented onto the display. For example, when the user points at an object, say a tiger, the relationship of food chain can be presented with an arrow (see Fig. 3). It is noted that target objects are not necessarily stationary and the system is applicable to such environments where objects move.

4.2 Enhanced Bookshelf

Enhanced Bookshelf is another application where books are placed on a bookshelf with a sliding glass door and the transparent display is attached to the door. When he/she points at a book, the information (abstract, table of contents, and so on) associated with the book is presented. Figure 4 shows the system in use.

Meanwhile, a 2D color code is attached to each book for identification. When the user picks up a book from the bookshelf or returns it to the bookshelf, the code attached to the book is taken by the side camera and analyzed by the system. The system keeps a record of the date when

Figure 2 Physical setup

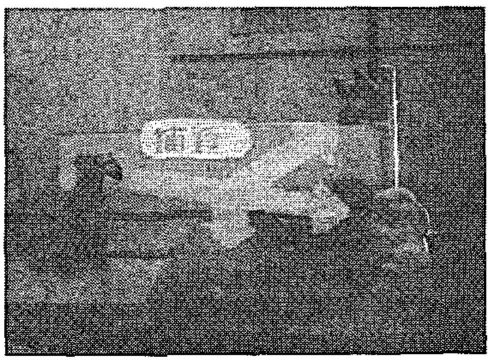

Figure 3 Association between objects

the book was referred to and the count of references. This information is helpful since, when the user looks for books, he/she may think books that have been read many times are important.

5. Conclusion

In this paper, we proposed an augmented reality system where a transparent display is used as a means for presenting the computer-generated information. The proposed system doesn't request the user to wear special devices, and enables the seamless integration between the virtual world and the real world. As for object identification, an object in the real world is selected by the action of pointing at the object by his/her finger.

The proposed framework represents an intuitive paradigm and is useful when the user needs to be informed about objects that are near to him/her but that can't be touched (e.g., for security reasons).

Acknowledgement

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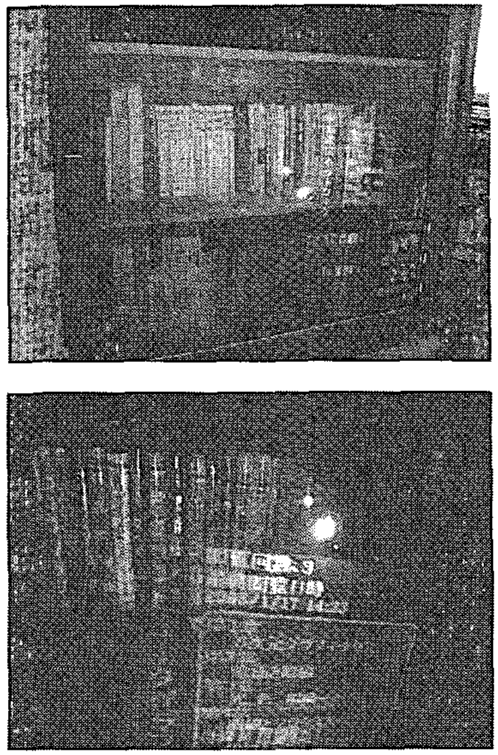

Figure 4 Enhanced Bookshelf application

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