A Mixed Reality System with Visual and Tangible Interaction Capability

— Application to Evaluating Automobile Interior Design —

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Abstract

This paper presents a mixed reality (MR) system with tangible interface as well as visual fusion in an MR space. The sense of touch is given by physical objects on which computer generated imagery is accurately registered and superimposed. The proposed approach is especially useful in industrial design where digital mockups and physical mockups are thoroughly utilized.

1. Introduction

Potential applications of mixed and augmented reality (MR/AR) are spreading along with intense study on component technologies such as the registration and HMDs. Once visual mixture of real and virtual objects is realized, tangible or haptic sensation should be registered with visual information in order to give natural feeling of presence.

A considerable number of studies, which utilize tangible and haptic interface, have already been done [1]. The tangible devices used there are symbolic control media, which Ishii calls "phicons" that stands for "physical icons." The device plays an intermediary role between the user and controlled objects in the virtual world. In other words, the user interacts with the physical control device that in turn controls the virtual objects (Figure 1(a)). In contrast, this paper introduces more natural tangible interface in an MR space as shown in Figure 1(b). In this configuration, the virtual object for observation and the physical object for tangibility are completely registered in the space. Thus they can be identified as one object and give natural interface in visual and tangible manners.

2. Visual and Tangible Feelings

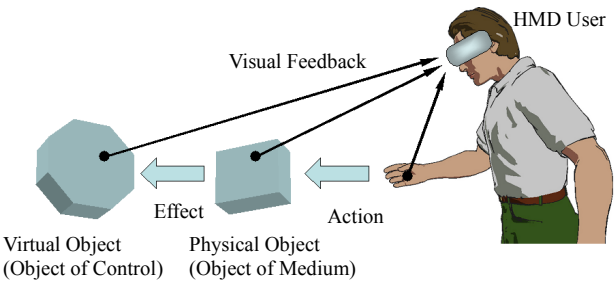
In order to give a high level of reality in an MR space tangibly and visually at the same time, the following two points are particularly critical:

a) Hand visualization

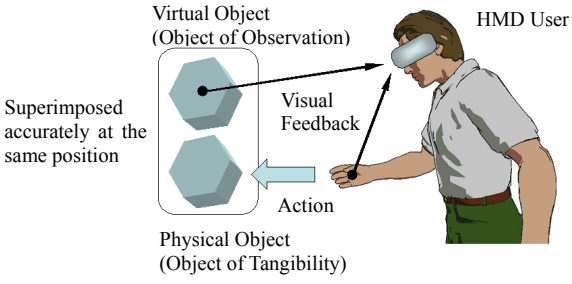
Usually, the virtual objects superimposed on the real objects hinder the view, thus the user cannot see his/her hands naturally in an MR space. In the proposed approach, on the other hand, the color space information enables the hands to be detected, thus the hands are visible in front of the CG images. In this way, the user can grasp the object for tangibility while seeing the object for observation, and operate the former one with natural feeling.

b) Accurate registration

In order to visually register virtual shape with the physical one, accurate registration should be achieved.



(a) Tangible AR as User Interface



(b) AR/MR with an Emphasis on Sensor Physical Tangibility

Figure 1. Tangible Interface in AR/MR

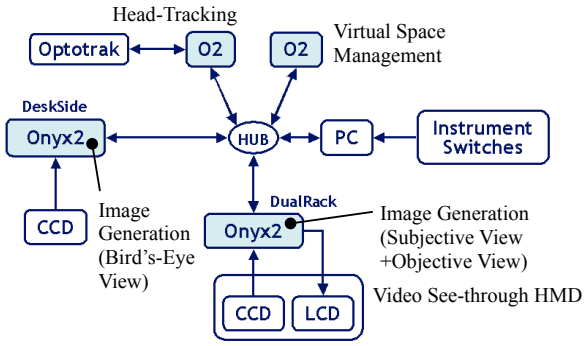


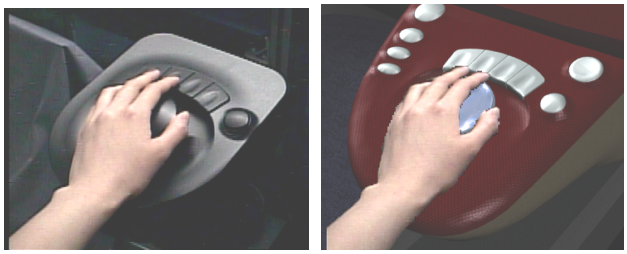
Figure 2. System Configuration

This is done by using a high precision Optotrak from Northern Digital Inc. While Optotrak is used to track the HMD, it is also used to measure and determine the position of the real object, so that the virtual object can be accurately superimposed on it. In order to match the shapes of the real and virtual objects, a real object is made using an NC manufacturing machine, and a polygon model for the virtual object is created from the identical CAD data.

3. Applying to Automobile Interior Design

As an example of proposed interface, we have designed and implemented it for an evaluation of automobile interior design. Figure 2 shows a configuration of the system. SGI Onyx generates images displayed on an HMD. Not only does this generate the subjective viewpoint images for the HMD, it also generates at the same time the objective viewpoint images of the user (driver) from the vicinity of the passenger seat. If two HMD units are used, two people can experience this MR simultaneously.

We placed a skeletal frame model of the instrument panel in front of the user and set the steering wheel and various switches on it (Figure 3). The user wears a video see-through HMD and sits on the real driver seat, and CG



(a) Real Image (b) MR View

Figure 5. Drawing Hand in MR Space

images are superimposed onto these real objects existing in front of her, creating an MR world (Figure 4). Figure 4 was generated by the system in real time.

Figure 5(a) shows a real image of a hand on the switches. In the MR space, as shown in Figure 5(b), the user can see her hand on the virtual device.

The steering wheel and the instrument panel (parts of the interior) are physically present and tangible. Because the user can see her own hands and actually feel the steering wheel, switches, etc. by reaching them with her hand, the sense of distance to the surrounding virtual world and the sense of scale are improved, becoming more direct than when only the visual sense is available.

4. Conclusion

The proposed approach is implemented for automobile interior design. It was tested in the Design Division of Denso Corporation. We found that the fact that the user can see his own hands, touch the steering wheel and other devices while seeing virtual image enhanced the feeling of reality and actually "being there."

References

[1] H. Ishii and B. Ullmer, "Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms," *Proc. CHI'97*, pp. 234-241,1997.



Figure 3. Real World (without HMD)



Figure 4. MR World (with HMD on)