What Happens at the Border Between Real and Virtual Worlds - The MR Project and Other Research Activities in Japan

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Abstract

This paper is an extended abstract for the invited talk at ISAR 2000 that describes major topics of the MR Project now propelling in Japan and overview of newly started themes. Major results of the project and other related research activities in Japan will be presented at the talk with video.

MR PROJECT AND ITS IMPACT

We have been participating the "Key-Technology Research Project on Mixed Reality Systems (MR Project)" in Japan. This project is expected to produce an innovative information technology that could be pragmatically utilized in the first decade of the 21st century while breaking a limitation on the traditional virtual reality (VR) technology.

"Mixed reality (MR)" is a kind of VR, but a broader concept than "augmented reality (AR)" which augments the real worlds with synthetic electronic data. On the opposite side, there is a term "augmented virtuality (AV)" which enhances or augments virtual environments with data from real worlds. MR covers a continuum from AR to AV. This concept inherits the definition of MR stated by Paul Milgram [1].

As the core organization of the project, the Mixed Reality Systems Laboratory Inc. (MR Lab) was launched in January 1997 on the investment by the Japanese government and Canon Inc. This national project is planned to be extended to March 2001 collaborating with three universities, Univ. of Tokyo (Prof. M. Hirose), Univ. of Tsukuba (Prof. Y. Ohta), and Hokkaido Univ. (Prof. T. Ifukube). The outline of this project and the results of first two years are stated in [2].

The impact of MR Project is proving to be not insignificant, as it reinvigorates the related R&D activities. For example, the Special Interest Group on Mixed Reality was formed within the Virtual Reality Society of Japan (VRSJ). In March 1999, the First International Symposium on Mixed Reality was held at Yokohama, Japan [3]. In addition, a panel named "Mixed Reality: Where Real and Virtual Worlds Meet" gave a good opportunity to discuss the state-of-the-art technology and attracted a great deal of attention at SIGGRAPH 99 [4]. We also presented most recent results of our MR Project in a session called "When Reality Meets Virtuality" at Imagina 2000 in Monaco.

The Second International Symposium on Mixed Reality (ISMR 2001) will be held in March 2001 again in Yokohama [6]. Since the time coincides with the finishing period of the MR Project for about four years, we are planning to present all the results of our project there. IEEE VR 2001 will be held at the same time and place. We are expecting various research results and a lot of technical demonstrations related to MR technology from other groups.

MAJOR TOPICS

The followings are some of the research themes with which we have been working in the MR Project. For the framework of our research themes and some progression after the launch of the project, refer to [2].

Virtualization of complicated objects and wide area in real world

As an approach to AV system, which augments or enhances the virtual world with raw data from the real world, a new paradigm called "image-based rendering

(IBR)" is focused on. Our IBR method can reconstruct an arbitrary view directly from captured multiple images. CyberMirage is a system that utilizes the method and integrate it with a conventional polygon-based graphic system. The system is designed to target a cyber shopping in a virtual mall with photo-realistic products [7].

The extended CyberMirage now has shading and shadow casting functions [8]. Data compression technology has also been dramatically improved. Since we have established basic methods, we are now designing a dedicate rendering hardware as an acceleration board for PC shown in Fig. 1.

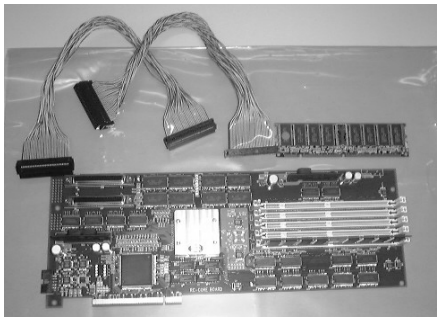


Fig.1 RaySpace rendering engine

AV methods are not only used to render complex objects, but also applicable to construct a large-scale virtual environment based on the actually existing city. The aim of Cybercity Walker system is to enable complete virtualization of an actual city space [9]. Users of this system can walk through and look around a cyber city space with high photo-reality, although the space is modeled without any geometric data. Since we could recognize usefulness of the methods, now we are propelling the second stage in which we have to redesign the data acquisition system to obtain more precise data.

Multi-player entertainment in MR space

As the counterpart of AV, an AR system superimposes computer generated images and data onto the real scene. As the target of real-time collaborative AR system, multi-player entertainment was chosen. The first system is called AR^2 Hockey where players hit a virtual pack with their physical mallets while seeing each other through see-through head mounted displays (HMDs).

RV-Border Guards is an extension of the technology developed for AR^2 Hockey. More than three players, surrounding a physical game field and wearing HMDs, defend the border between the real and virtual worlds by destroying virtual invaders. This system fully utilizes the physical space in front of the users as a 3D virtual space.

RV-Border Guards was given a special introduction at the Innovation Village of Imagina 2000 in Monaco. This opportunity was taken to rework the real world objects, and the resulting millennium version was presented at the Centre de Congress Auditorium Monaco from January 31 to February 2, and a large number of participants enjoyed this advanced attraction.

The newest version in this series was presented in "Emerging Technologies: Point of Departure" at SIGGRAPH 2000 in New Orleans. The virtual creatures, the real world objects, and the interface were all renovated. After this RV-Border Guards E.T. Special version, the name was changed to "AquaGauntlet."



(a) Without augmentation



(b) With see-through augmentation

Fig.2 AquaGauntlet: A multi-player shooting game in MR space

Embodied conversational agent in MR space

Such image overlay and registration techniques are also applied to a virtual interior design in an actual living room which is half-equipped with real furniture and fixtures. As a guide of this MR application, we embodied an anthropomorphic interface agent [10] who can understand the user's demand, and move and replace the virtual objects (Fig. 3). Most of other conversational agents exist in a rectangular window on a computer monitor, but our MR agent is living in 3D space shared with a user. The agent's behavior and the user's preference are good subjects in HCI research.

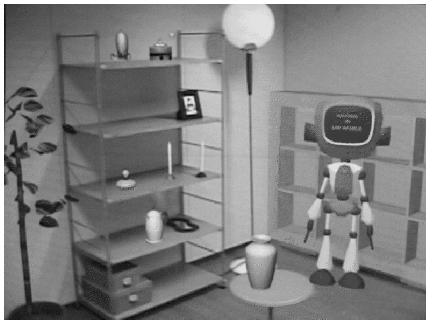
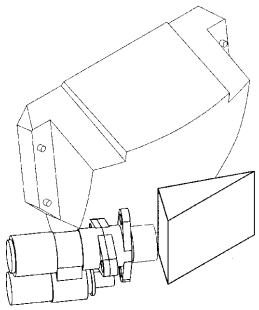


Fig.3 Embodied conversational agent in MR space

3D displays and their hazardous effects

Using the state-of-the-art optics, we are pioneering two kinds of stereoscopic displays for MR; a compact and lightweight see-through HMD (ST-HMD) and a high-luminance and wide-angle 3D display without eyeglasses. In addition, quantitative measurements and analysis of their impact on the human body are performed to obtain physiological information for preventing and minimizing hazardous effects.



(a) Optical configuration



(b) Outlook

Fig.4 Parallax-less video ST-HMD

We have developed our own optical ST-HMD and video ST-HMD. However, a new type of video ST-HMD is used in AquaGauntlet (Fig.4). This stereoscopic video ST-HMD has a pair of built-in video cameras and designed so that the optical axes of camera and display optics are coincide. See the details in [11].

ONGOING PROJECTS

In the last half of our MR Project, we are struggling with new difficult problems that lie in front of the leading point in this field. Below are themes we think interesting for AR research communities.

Occlusion of moving objects in mixed reality space

Since the geometry of the real and virtual spaces are correctly registered, the remaining problem to solve is the occlusion between real and virtual objects. To solve this problem, we have to know the geometric model and the position of a real object in MR space. It is easy when the real objects are static, however, the problem becomes drastically difficult when they start moving.

In order to solve this problem, we decided to introduce a realtime range finder which can sense the real world in the rate and resolution of video. We have to convert dynamic range data obtained from the range finder device to the data seen from the observer's view point so that we can determine which is nearer to the observer than others.

Wearable AR for outdoor use

All the systems so far developed in the MR Project are capable to be interacted with the user in real time, but their use is limited to indoors. We are planning to redesign them for outdoor use in a wearable fashion. For this purpose, some efforts are required to obtain ST-HMD usable in bright environments and head tracking methods available at outdoors.

We have developed a new optical ST-HMD that can adjust transmittance depending on the brightness of surrounding light (Fig. 5). Although this gives a pair of stereoscopic images, a video camera is built at the center of unit so that it can be used for vision-based registration. The magnetic trackers are not suitable for outdoor usage, now we are trying to combine high precision gyroscope and vision-based registration. In addition, a small image processing hardware, a PC, and a battery as well as the wireless network are packed in a backpack so that the system works in outdoor environment.

MR platform for R&D use

After completion of MR Project, an MR platform will be released for R&D use. It serves as the core of various



(a) Optical ST-HMD



(b) Total system in an outdoor scene

Fig.5 Wearable AR system for outdoor use

MR applications and includes the above video ST-HMD and a variety of programs involved in geometric registration. The specification of this software are now discussed in a working group consists of major groups in this field.

OTHER RESEARCH ACTIVITIES IN JAPAN

Our MR Project has triggered active researches on MR in Japan. Transactions of VRSJ held on December 1999 was a special issue on Mixed Reality [12]. It contains 15 papers reviewed and accepted. Some of them are contributing to the MR Project directly, while others continue to undertake complementary activities. We are planning to introduce typical research achievements in the invited talk at ISMR 2001.

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