3D Pointing Interface by using Virtual Diorama for Attention Sharing

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ABSTRACT

We propose a new graphical user interface based on a Mixed-Reality (MR) technique by using a miniature CG model of surrounding environment of user. We call the CG model "Virtual Diorama (VD)." The interface easily specifies a 3D position on the surface of buildings outdoors so that others can easily understand where the point is. In cooperative task, it is important but difficult to indicate a specific point (e.g., a fourth floor window on a building) when the point is invisible from the indicator and co-workers have different viewpoints. Our system provides a user's view that is free from these problems. Our interface enables the indicator to specify any attention points including an invisible place at his actual viewpoint because he can move the VD virtually on the interface. The point is then sent and shown at the VD co-worker side. The VD overlapped on the real image of the co-worker viewpoint is aligned either to the world or to the view of the co-worker. As both alignment methods have pros and cons, we have had a user study for evaluating them.

CR Categories H.4.3 [Information Systems Applications]: Communications applications – Attention sharing; H.5.2 [Information Interfaces and Presentation]: User interfaces – Graphical user interfaces (GUI); I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism – Virtual reality

KEYWORDS Outdoor Mixed-Reality, 3D Pointing, Attention Sharing, Cooperative Task

1 INTRODUCTION

When we do some cooperative tasks such as setup of event site, we often need to draw a co-worker's attention to the place we are discussing. Ordinarily the target point is indicated by a finger or such equipment as a laser pointer. However, pointing to invisible places for users and indicating the exact location of distant objects by these ways is difficult. As a result, our communication ability is limited especially in such large-scale spaces as outdoor environments. Using maps addresses this limitation, but ordinary map has only 2D information and does not represent height information. Using a 3D map generated by CG technology is one of the solutions to support cooperative tasks in outdoor environment. In order to make users feel comfortable with browsing 3D maps, it is important to consider about the methodology to display 3D maps. Since, most users are not familiar with browsing 3D maps, even though it gives much geometrical information.

A Head Mounted Display (HMD) is a common display device for MR. In outdoor environments, however, HMD has a few problems. To conduct outdoor activities, users have to pay attention to obstacles and hazards, a task is complicated by the narrow field of view that is limited by the size of HMD's display screen. Power supply and video transmission cables also restrict user movements. Therefore, we use a mobile hand-held device with a video camera such as a Personal Digital Assistant (PDA) or a cellular phone [1] for an outdoor MR system. Users can watch the surrounding environment with their own eyes without being disturbed by cables. It is important to know that a user lose institutive understanding for spatial relationship between the real world and VD, instead of keeping their safety and comfortableness.

We propose a new attention point sharing system for outdoor environment that uses mobile hand-held device and 3D map. The system makes it possible to indicate invisible or distant places. As illustrated in Fig. 1, the system shows miniature CG models of the surrounding environment. We call the CG models "Virtual Diorama (VD)." Users can easily grasp the geometrical relationship of the virtual and real worlds by observing the VD in a MR fashion that displays the models in front of users. The scenario is as follows: When user indicates an attention point to some place on the VD by using a 2D input device such as a touch screen, the mobile device sends 3D position of the point to a server via a wireless network. The server sends the position to other users. They can see a visual icon on the position of their VD shown in their mobile device.

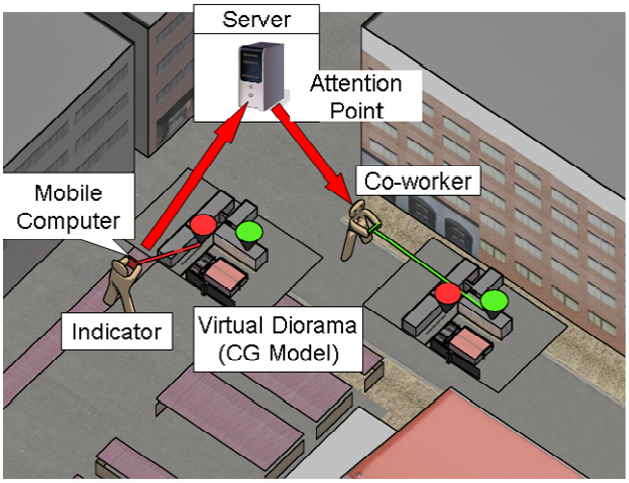

Fig. 1 Concept of Virtual Diorama. Users can observe a miniature CG model of real world around themselves through mobile hand-held device's monitor.

2 RELATED WORK

2.1 Mixed Reality Navigation System

Many mixed or augmented reality systems [1,2] have been developed that realize visual navigation in outdoor environments. For example, Kanbara et al. [2] developed a human and car navigation system for outdoor MR with a real time kinematic global positioning system and an inertial navigation system to

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measure a user's position and orientation in real time. The system shows users such virtual objects as an arrow for navigation. Many such mixed or augmented reality systems, especially those using HMD, need to realize geometrical consistency to overlay virtual objects onto the real world. When position and orientation estimation (camera registration) is incorrect, the virtual objects are displayed at the wrong position, and navigation fails.

There are two ways to solve this problem. One is to improve camera registration accuracy by installing high-end devices [3]. The other is devising a display method that is insensitive to the camera registration error. Our proposed method is the latter case. It displays a visual icon that indicates the 3D attention points on the VD that are not in the real world. Thus, user input is always accurately allocated at the intended position, even though geometrical inconsistency is not well estimated. VD does not require accurate 3D position of mobile hand-held devices, because it works with only rough location information such as names of streets or blocks, and users set the 3D gazing position on VD by themselves using such input devices as keyboards. Therefore, our system has a feature that simplifies the camera registration problem as 3D orientation estimation of mobile hand-held devices.

2.2 Worlds in Miniature

The concept of Virtual Diorama resembles Worlds in Miniature (WIM), which was developed by Stoakley and Paush [4]. Originally, WIM was developed as a visual assistant technique for virtual reality environments. Thus, most WIM systems use HMD, and the target space is indoor environments, although there are WIM applications for outdoor environments. Höllerer et al. [5] developed a pedestrian navigation system that resembles our system. They use WIM in an MR fashion in outdoor environments by mobile hand-held devices and HMD. Our system's target space is also outdoor environments, but it uses a mobile hand-held device to show miniature CG models in an MR fashion. Moreover, different from ordinary systems, our proposed system can indicate and share 3D points with users in outdoor spaces.

3 Virtual Diorama

We propose a system that indicates and shares 3D attention points by displaying a Virtual Diorama of the real world on a mobile hand-held device, as if a real diorama exists in front of the user. Users can simultaneously observe both the real and virtual worlds. As shown in Fig. 2(a), when the orientations of the two worlds are different, users may lose their sense of orientation. To avoid this, our system aligns a VD to maintain the heading direction of both worlds coincident (Fig. 2(b)). Therefore, the system requires pose information of the mobile hand-held device. Users can intuitively control the virtual viewpoint to render the VD by moving a mobile hand-held device.

Figure 3 shows how to input an attention point using VD. When a user touches a point on the mobile hand-held device's display, the system sets a visual icon at the intersection point of a miniature 3D model and a line connecting the virtual viewpoint (e.g., point A) with the touching point. For example, if the user wants to indicate an invisible point occluded by buildings, he/she can move the virtual viewpoint so that the target point is visible, like virtual viewpoint B in Fig. 3.

The attention points given by other users are displayed as visual icons with different colors. Pose information of the mobile hand-held device is required to realize the system. Our system does not track the actual viewpoint of users to simplify the system. Thus, the virtual viewpoint is fixed in front of the mobile hand-held device's monitor.

(a) (b)

Fig. 2 Orientation issue of a miniature CG model: (a) orientation of real and virtual worlds are different. User may lose their sense of orientation: (b) orientation of two worlds are aligned to keep user's sense of orientation.

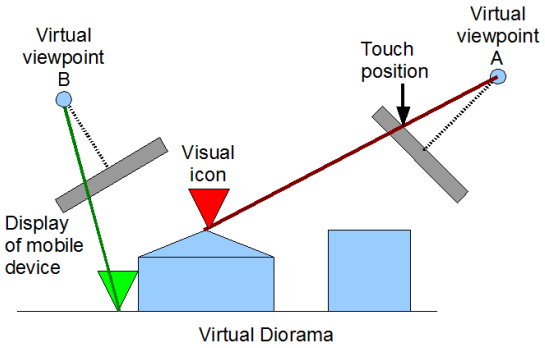

Fig. 3 Input method of attention point by Virtual Diorama. Users can input an attention point on a miniature 3D CG model. Our system shows visual icons with different colors for each user at the attention point.

4 Conclusion

We proposed a graphical user interface using a Mixed-Reality (MR) technique called "Virtual Diorama" and a system with which users can easily point and share 3D positions in outdoor spaces. Our system solves the problem of ordinary pointing methods in outdoor environment by introducing a user interface technique that displays a miniature CG model of the real world around the user on mobile hand-held devices, just as if the modeled environment exists in front of the user.

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