Fly-through Heijo Palace Site

Historical Tourism System Using Augmented Telepresence

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ABSTRACT

We have developed an augmented telepresence system which enables virtual tourism beyond time and space. Augmented telepresence provides a user with both the view of a remote location and related information using augmented reality techniques. This study deals with the geometric and photometric registration problems to generate movie-quality augmented omnidirectional videos automatically. The user can look around the scene from the sky above Heijo palace Site which is an ancient capital in Nara, Japan in the technical demonstration.

Categories and Subject Descriptors

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

Keywords

Augmented telepresence, aerial omnidirectional image, unmanned airship

1. INTRODUCTION

The developed system for demonstration superimposes computer graphics (CG) of an old palace built 1,300 years ago on recorded video captured from an unmanned airship using an augmented telepresence technique. The year 2010 was the 1,300th anniversary of Nara Heijo-kyo, an ancient capital in Japan. Today, almost all of the ground in Heijo-kyo is covered by a field of grass excepting some buildings and bases that were physically restored for the commemorative events of the anniversary. The proposed system generates augmented videos by superimposing CG models of buildings that existed 1,300 years ago on the "plain grassland" images using an augmented telepresence technique. Omnidirectional aerial videos are used to provide users with a wider view than on the ground.

In this study, augmented telepresence (AT) refers to a type of telepresence that provides the user with both the view of a remote site and related information using augmented reality (AR) techniques. Note that this study deals with offline AT; that is, AT using recorded video, by which the user can experience the augmented scene offline. Offline AT should consider not only the problems of geometric and photometric registration like usual AR systems, but also the immersiveness of offline telepresence. Related AT systems using recorded images cannot resolve geometric or photometric registration problems, and/or they do not provide for immersive telepresence. Ghadirian et al. [1] visualized vegetation information of various ages in a GIS database by superimposing CG models of plants generated using the database onto a single panoramic image. In addition, Grosch [2] realized an offline AT system for an interior design using a single panoramic image and generated 3D shapes of a real scene. Although Grosch's proposal [2] contains realtime lighting using a light source designated by the user, the work did not use multiple omnidirectional images to enable the user to change their viewpoints.

In this study, we have developed an offline AT system using an unmanned airship and an omnidirectional multi-camera system (OMS) [4]. This study resolves the geometric and photometric registration problems in order to generate high-quality augmented videos using omnidirectional videos. The omnidirectional videos captured by the OMS attached to the airship increase the immersiveness of the telepresence by providing the user with the sense of being able to look around the location. To render augmented scenes, we use image-based-lighting (IBL) and global illumination (GI) techniques with an omnidirectional environmental map.

2. AUGMENTED OMNIDIRECTIONAL VIDEO GENERATION

To overcome the geometric registration problem, the proposed system estimates the camera position and orientation. The proposed system employs offline process which is a high-accuracy camera position and orientation estimation method [6] with a video and position data measured by GPS. Each frame of the omnidirectional video is aligned using the position and orientation of the OMS (e.g. Figure 1(a)).

The omnidirectional video has missing area including sections that is out of field of view of OMS and background scenery occluded by the airship as shown in Figure 1(a). To use the omnidirectional video as an environmental map for IBL, the missing area must be filled-in and complete environmental maps must be generated. To fill-in missing areas and generate a complete environmental map, other frames in the video are searched for an area similar to the missing area, and the pixel intensities belonging to this area is copied to the pixels of the missing area. The all-sky-model [3] is used to fill-in the areas having no corresponding areas, where the background scene is occluded in all the frames. The all-sky-model is a statistical model representing luminance of

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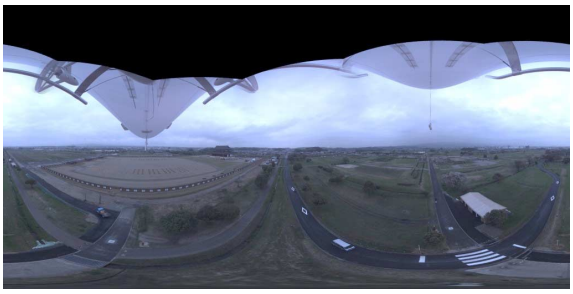
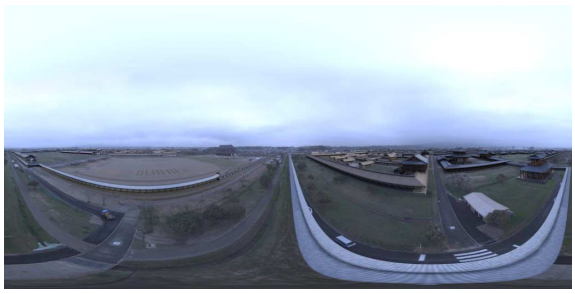


(a) An omnidirectional image aligned by the orientation of omnidirectional camera. A missing area appears at the top of the image.



(b) An omnidirectional image with virtual buildings using the illumination environment of real world. Missing areas are filled using sky model.

Figure 1: Omnidirectional images generated by the proposed augmented telepresence system.

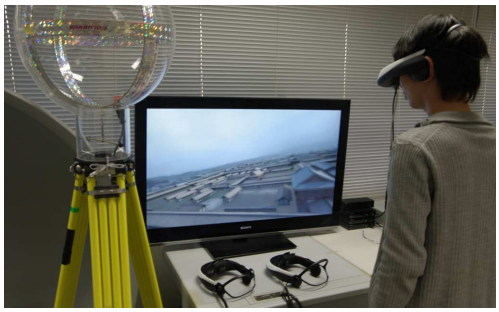


Figure 2: Appearance of virtual tourism system.

Figure 3: A view-dependent perspective image generated from an augmented omnidirectional image.

various skies with some parameters. In this study, the parameters are estimated from intensities of background scene except missing areas.

Augmented video is rendered using a commercial GI rendering software 3ds Max (Autodesk, Inc.) and Mentalray (Mental Images GmbH.), as shown in Figure 1(b). The virtual objects are registered geometrically using the estimated location and position of the OMS. An omnidirectional augmented video is generated through IBL and GI rendering using a complete environmental map.

3. CONFIGURATION OF DEMONSTRATION SYSTEM

Figure 2 shows appearance of the system for the demonstration using HMD and motion tracker. The augmented omnidirectional video is converted to view-dependent perspective video (see Figure 3) in real-time [5] using view direction of the user captured by an electromagnetic motion tracker FASTRAK (Polhemus, Inc.) attached to the HMD. The view-dependent perspective video is presented to the user via a HMD.

The user can freely look around the augmented scene moving viewpoint on the captured path of the omnidirectional image sequence. The system also switches sequences with and without virtual objects. A similar system was demonstrated at the Commemorative Events for the 1,300th Anniversary of Nara Heijo-kyo Capital, and over a thousand people experienced the system.

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