Multiple Devices as Windows for Virtual Environment

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ABSTRACT

We introduce a method for using multiple devices as windows for interacting with 3-D virtual environment. Motivation of our work has come from generating collaborative workspace with multiple devices which can be found in our daily lives, like desktop PC and mobile devices. Provided with life size virtual environment, each device shows a scene of 3-D virtual space on its position and direction, and users would be able to perceive virtual space in more immersive way with it. By adopting mobile device to our system, users not only see outer space of stationary screen by relocating their mobile device, but also have personalized view in working space. To acquiring knowledge of device's pose and orientation, we adopt vision-based approaches. For the last, we introduce an implementation of a system for managing multiple device and letting them have synchronized performance.

Keywords: Multiple device, immersive VR, AR, Shared virtual space.

Index Terms: I.3 [Computer Graphics]: Three-Dimensional Graphics and Realism - Virtual Reality; I.4.8[Image Processing and Computer Vision]: Scene Analysis - Detection and Tracking

1 INTRODUCTION AND RELATED WORK

There have been intensive researches for making use of 3-D virtual space for information with multiple users. For example, with Massively multiplayer online virtual environment, users share identical virtual space and proceed certain task together[1]. However, in this kind of environment, it is rather hard to make in-person communication and match user's location and user's view on the virtual world. For making it possible to in-person communication during collaborative work, CAVEs can show its significant value by generating immersive virtual space with life scale presentation[2]. However, its usefulness is hardly achieved in daily lives, as it requires huge cost to be equipped and it is also hard to find enough space to set them. In our research, we introduce a system for constructing collaborative work space with multiple devices which can be easily found in daily life. Each device behaves as a window to see virtual space on its position and orientation.

2 APPLICATION

In this section, we explain overall system structure and visualization method for 3-D virtual space with multiple devices to make them windows for VR. As the most important idea of all, we explain how to get knowledge of device's pose.

2.1 System Structure

The entire system can be divided into three main parts. Figure 1 shows diagram of system structure. Main server, desktop PC application and Mobile application. Main server's role is mainly to generate 3-D virtual space and transfer proper scene image for each devices. To acquire well-synchronized result of multiple devices, it monitors state of every device and adjust size of scene information data adaptively. A desktop PC application takes account for visualization of stationary displays. A mobile device application is added to get an image of the scene, which is needed for estimating pose of each devices in actual space, with its innate camera sensor. Mobile device provides a way to see 3-D scene out of screen of stationary displays. Furthermore, with mobile device, user can have his or her personalized view.

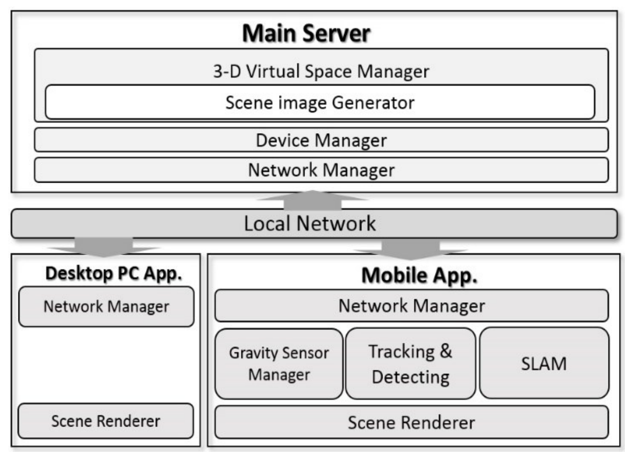

Figure 1: System Structure

The entire system procedure is proceeded like this. If request for connection is arrived from clients connected within local network, main server recognizes it and start the process. If the desktop PC has got a connection with server, it displays initial image. When user places a mobile device in the actual space, mobile device detects those initial images which are shown on a display and estimates display's pose. After detecting and estimating pose of displays, mobile application proceeds localization and mapping of feature points which appears around display. This step is needed for estimating a pose of camera which is dynamically changed during runtime. After getting an information of the scene, each device starts to shows a 3-D virtual environment based on their own poses.

2.2 Detecting pose of display device

Nowadays, as mobile device's capability grows, it is possible to detect multiple planar objects in real-time[3]. It is also possible to proceed real-time parallel localization and mapping with corner feature points[4]. We implement vision-based pose detection

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method with mobile device. Mobile application has descriptors of feature points in initial images which is displayed on each devices in initialization step. With feature information in descriptors, mobile device detects display device from a scene images. Even though we are able to detect a display device, information we can have is relational location and orientation between devices.

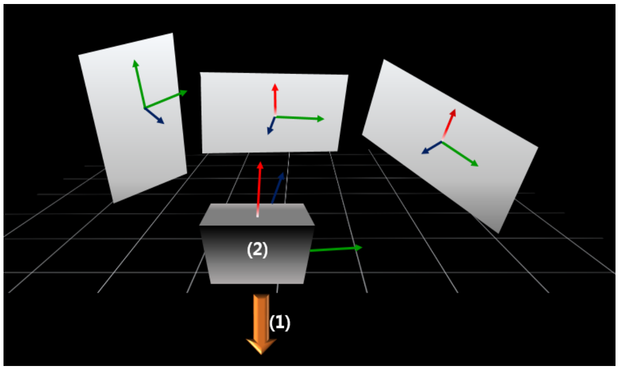

Figure 2: Axis alignment using mobile sensor

It still needs to have additional information to have a specific location in 3-D space. It sets the origin on user's location in the scene at the beginning. And then, Y axis is set as a direction of perpendicular to ground plane, and Z axis is set as a direction of parallel to users view direction in the scene. After setting Y and Z axis, X axis can be easily derived by calculating cross product of those two. To have a direction perpendicular to ground, it uses gravity sensors which returns a direction of perpendicular to ground regardless current pose of mobile device. In figure 2, (1)-arrow represents direction vector of gravity. (2)-box represents mobile device. The other planar objects shows alignment result in 3-D virtual space, which is derived from mobile gravity sensor and camera sensor. After assigning coordinates, for the last step, it is necessary to provide scale factor for making them have a certain size. We assign constant value to the first display and let the other one also have certain size considering ratios between size of the first display and those of the others.

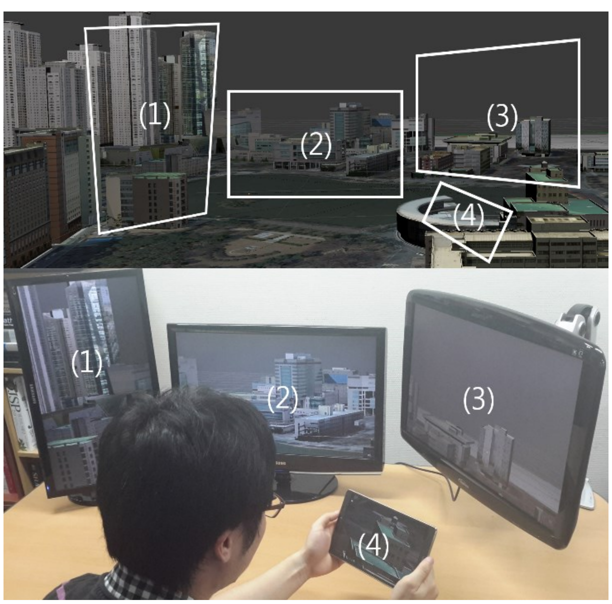

Figure 3: Multiple devices as windows for VR

2.3 Generating 3-D scene image for multiple device

After getting a pose of each device, in main server, it generates multiple viewport in 3-D virtual space considering poses of devices. At this point, the size of viewport is decided based on actual screen size not on resolution. Because emerging of displays which has high DPI, rendering result about same scene can be differently shown on each screen. After generating a viewport for stationary displays, it also generates viewport for mobile device which is dynamically relocated as user moves it. On mobile displays, as a personalized device, it is not only possible to see outer region of stationary displays, also possible to have personalized information which can be overlapped with original scene. Figure 3 shows result of using multiple devices as windows for VR. An upper image shows 3-D virtual space and generated windows and a lower image shows a rendering result.

3 Conclusion and Future Work

We introduce a method for generating 3-D virtual space with multiple device which is possible to be shared by multiple users. Device's display acts as a window seeing a 3-D virtual space. Scene images for each device is generated based on location and pose estimation of each device. A pose of each device in 3-D virtual space is detected by using features on screen or surrounding area and tracked for updating its current pose during runtime. Currently, it only shows a simple 3-D scene presentation and provides basic interaction method. To make a more usable workspace, providing diverse interaction method should be considered. The interaction methods for devices need to be defined with intuitive way in a user's point of view. To accomplish this goal, devices are modeled in detail considering capability of each device.

Acknowledgements

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