Creating a Virtual Window using Image Based Rendering

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Abstract

This paper describes the creation of a virtual window using image based rendering (IBR). The virtual window is an illusion of a real window created by a large screen plasma TV, a position tracker, and a database of systematically acquired photographs. Using IBR opens the possibility of providing a head tracked user with the impression of looking through a window to an entirely different, real place. The IBR technology used for the virtual window is provided by the Benogo [1] presence research project. During the process of designing and testing the window, several difficulties have been encountered and interesting observations have been made. These issues discovered in connection with the virtual window are discussed in this paper.

1. Introduction

The motivation behind creating a virtual window is the ambition to enable people to realistically experience distant places without travelling. Using a virtual window for this purpose provides a metaphor which is well-known and easily recognizable. Furthermore, an off-the-shelf large screen display can be used for the purpose of emulating the window pane itself, so the physical part of the window also has the advantage of being easy to acquire compared to more advanced VR display systems such as a CAVE [2] or a state-of-the-art head mounted display (HMD).

The possibility of creating a virtual window displaying real places is opened by the emergence of real-time IBR technology combined with modern PCs and motion tracking equipment. With IBR technology [3,4], artificial images are generated from real photographs as opposed to a detailed 3-D model. The IBR technique used, X-slits projection [3], enables IBR to display real, complex objects and places with motion parallax and stereo given a small set of images. The images used for a virtual window are acquired by a camera with a fish-eye lens moving along a line. At the time of acquisition, the camera travels sideways along the line, taking pictures at fixed space intervals. This is shown on Figure 1. Other attempts at creating a virtual window are described in [5] using a single, static environment map and [6] using a 3-D model of a room.

Once the images are acquired, images from new viewpoints in front of the acquisition line can be created. The illusion of a window is created when these viewpoints correspond to the position of a person walking in front of the line. This means that a user walking in front of the virtual window is presented with an image corresponding to what would have been seen from his/her current position through a window placed at the original acquisition line.

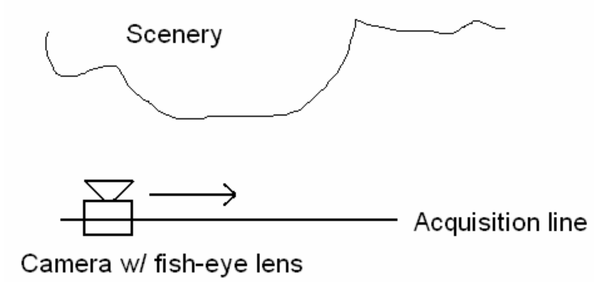

Figure 1: The acquisition of images occurs along a straight line.

2. Technical setup and tracking

The technical setup used for the window consists of a box-shaped tower containing a PC and tracking equipment. One tower wall has a hole for mounting a 42" plasma TV which is viewed from outside the tower. The only visible part of the TV is the screen. Schematically the setup works as shown on Figure 2.

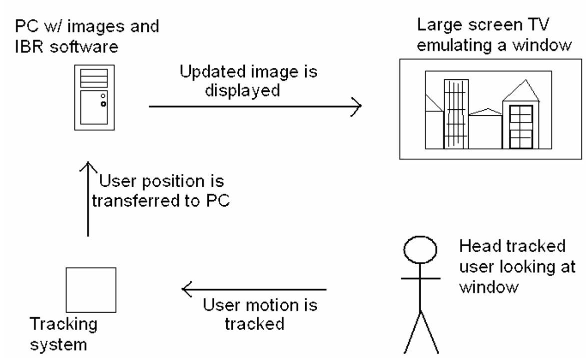

Figure 2: Schematic overview of the system.

Tracking the user is done using a Polhemus FasTrak electromagnetic (EM) tracking system which tracks 6 degrees of freedom. Only positional tracking is needed for a window without stereo, though. Using magnetic tracking for the virtual window setup has turned out to cause problems with robustness as EM tracking is sensitive to metallic objects and EM fields in the nearby environment. The TV casing is made from metal and user head movement close the window requires the most precise tracking, but it is unfortunately the region of movement that is most affected by noisy tracking. Therefore, another tracking technology would be desirable.

3. Window experiences

One of the issues with the virtual window regards the physical context of the experimental setup. When a person standing in front of the virtual window has to believe that he/she is standing in front of a real window, the experience is described as confusing. However, if the same scenario is set up in the CAVE, the experience is quite believable even though the technical set up is the same. This observation is interesting, and we have not yet come up with the definitive explanation to this phenomenon. One of the explanations, however, could be that a virtual window integrated into the tower in our visualization laboratory is far out of its original context: A small tower is unlikely to contain large scenery, e.g. a museum hall.

If people cannot relate to the physical surroundings as being ‘a place with a window’, e.g. the tower in the lab, they cannot believe that they are standing in front of a window. The CAVE setup is only different with respect to the physical context. In the CAVE you can not as easily imagine or see, what really is on the other side of the walls or the virtual window, and this may well be an important factor for maintaining the window illusion. Consequently it may be easier to believe the illusion of looking out on the world through a window from inside a room, than looking into a large world inside a relatively small box such as the tower. This is illustrated on Figure 3.

A small scene may be more acceptable for the outside-in case, since people are accustomed to looking at such scenes from an outside-in perspective, e.g. museum displays. Conversely, large scenes like the view of a city or a large room is more commonly viewed inside-out through a window. Future tests will investigate this matter further.

Ego motion is another important aspect of the user experience in a virtual environment (VE). During the work process with the virtual window we have made an interesting empirical observation. It seems easier to perceive the virtual window as a real window if we watch it on a video recording, than when standing in front of the actual window. Our preliminary experiments have found that people who are exposed to the recording of the virtual window quite vividly perceives the filmed window as being real. The reason for this difference has not been further investigated yet. A possible explanation, however, is that when standing in front of the virtual window, the entire body is used in the experience. When a tracked video camera records the window, the experience has changed to another medium. Some of the flaws of the system, e.g. the tracking lag, are no longer detectable. Therefore, we may perceive the recorded scenario to be more realistic.

5. Conclusions

In this paper we described some of our experiences with building a virtual window using the image based rendering technology provided by the Benogo project. The window can give an acceptable illusion of reality, when viewed from a distance that keeps the TV screen's influence on the tracker minimal, and the visualization from becoming too pixelated. The illusion of a window by means of IBR, however, still has some way to go, before it becomes entirely believable by a moving, human observer.

The solution to the persisting problems seems to require further experiments with the window. Especially experiments where the surroundings of the window are changed from the outside-in type setup of a box shaped tower to an inside-out outlook on a scene.

One of the most interesting empirical observations made during work on the virtual window is the fact that the window seems more believable when viewed on a film recorded by a tracked video-camera. This gives rise to the question why this is so, and indicates that there may be a perceptual difference between watching a film of someone else’s viewpoint in a virtual environment and experiencing that same VE first-hand.

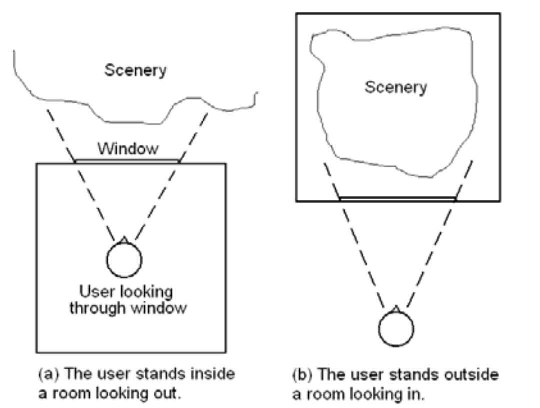

Figure 3: The difference between looking through the virtual window (a) inside-out or (b) outside-in.

Acknowledgments

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