Real Illumination from Virtual Environments

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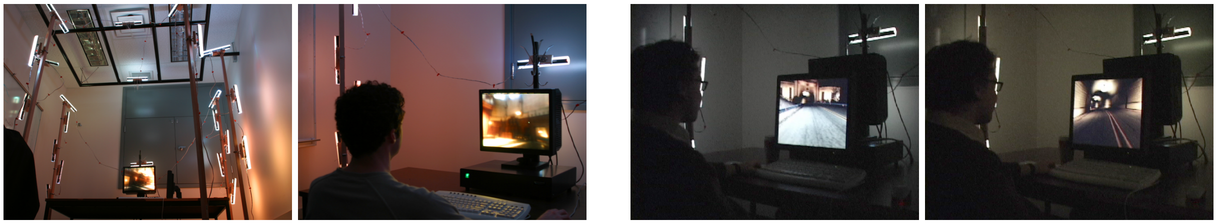

Figure 1: Left pair: room photograph with the illumination set to the Grace Cathedral environment map, and a user exploring the environment. Note the correspondence to the illumination on the HDR display. Right pair: room lighting corresponding to the driving game NFS underground 2 with a passing street lamp on the left and inside a tunnel on the right.

Abstract

We present a method for actively controlling the illumination in a room so that it is consistent with a virtual world. This procedure triggers natural adaptation processes in the human visual system. Combined with conventional or high dynamic range displays, the system improves the realism of transitions from dark to light environments and vice versa. It also helps with directional illumination in the user's peripheral field of view. We describe both the hardware and the software aspects of this approach, and discuss the results of an informal user survey that we conducted to verify the concept.

1 Introduction

Research targeting perceptual realism has so far had to deal with two major restrictions. First, conventional display technology was incapable of representing the full range of dark and light intensities in the real world. This problem has mostly been addressed by recent high dynamic range (HDR) display technology [Seetzen et al. 2004]. Second, the viewing conditions are largely unknown, meaning that parameters such as the viewer's light and color adaptation cannot be considered in the image generation process. This problem becomes particularly obvious with HDR displays, which can produce a range of intensities from moonlight to daylight. The display behaves like a window into a virtual world, but a sense of immersion can only be achieved if the illumination levels in the real and the virtual worlds are compatible.

In this work, we propose to actively control lighting in the room according to the illumination in the virtual environment. Our prototype system consists of 24 RGB LED lights (ColorKinetics iColor Cove), each of which can be individually programmed to a 24 bit RGB color value. This setup allows us not only to raise or lower the ambient light in the room, but also to create some degree of directional illumination. This results in a low-resolution dynamic room illumination approximating an environment-map for the assumed viewing position.

2 Setup and Calibration

We assembled our prototype system in a separate room, approximately 15.5' long, 9' wide, and 9.5' high. The room remained as-is: the walls were kept in the original pastel color, and specular objects such as a whiteboard and the reflectors of the houselights were left in place. We used both an 18" LED HDR display [2004] and a standard 18" flatpanel (NEC Multisync LCD 1850e) for our experiments. We used seven poles with stands to mount the 24 light sources. The lights were positioned and oriented such that they predominantly illuminated the ceiling, as well as the walls in front of, and to the left and right of, the viewer (Figure 1, extreme left).

We performed geometric and photometric calibrations in order to drive the light sources. Geometric calibration was performed by placing a light probe at the inteded viewing position and by taking photographs of each light source individually. We then model the impact of every light source by fitting Gaussians to the obtained environment maps. Photometric calibration was performed using an 18% gray card to match the monitor intensity with the room illumination.

3 Content Creation and Experiments

The lighting system is easy to integrate into fully synthetic scenes, such as in computer games or animated films. For our experiments we used footage from Electronic Arts' racing game "Need for Speed Underground 2" (Figure 1, right pair). We used captured environment maps generated by the existing shading system. The layers of the environment map, which correspond to lights, sky, and objects in the scene, were scaled by different factors and added up to produce the HDR information used to drive the system. It is also possible to retro-fit conventionally shot video material. We have done this by driving the lights with a uniform brightness which was estimated for a set of key frames and interpolated across the sequence of frames. When shooting new films, a light probe can be used to capture the surrounding environment. This can then be used to drive the lights similar to relighting applications [Debevec et al. 2002].

We tested the effectiveness of our system with conventional and HDR display in an informal user survey covering HDR panoramas, real video material and game footage from NFS Underground 2. A total of 12 graduate and undergraduate students participated in our survey. All participants preferred the dynamic (uniform and directional) illumination over a room of constant brightness, with preference of directional over uniform illumination. The participants also believed that the additional cues provided by directional illumination helped them keep track of orientation in the virtual world (Figure 1, left-middle).

References

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