ACHIEVING INTERACTIVE-TIME REALISTIC ILLUMINATION IN MIXED REALITY

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Proper lighting of synthetic objects is critical to the effectiveness of any immersive experience, and even more so when these objects are seen in the same context as real objects. The work we present is applicable across the entire range of Mixed Reality, from augmented reality to augmented virtuality. In particular, our techniques can be used to react rapidly to changes in real world ambient lighting, and to the dynamic adding, positioning and orienting of virtual lights.

This research has been applied to military training, in the context of the MR MOUT (Mixed Reality for Military Operations in Urban Terrain) project, an augmented reality application that uses video see-through HMDs to create an anytime, anywhere MOUT training facility. Our techniques are also being applied to a collaborative augmented virtuality system, the DEMO DOME, and to the augmentation of a science exhibit. This latter application does not involve an HMD, but rather uses an MR Dome Projection system (a Dome Projection system with attached camera(s) to capture the real world), an approach that helps address issues of cost, hygiene and maintenance in a high-use setting such as a museum.

In our paper, we present two distinct contributions to combining live video with rendered content, which we have integrated with the MR System at UCF's Media Convergence Laboratory. The first method uses changes to the colors of objects in the real world, as captured by video cameras (typically those in the HMD), to shift and scale the pixel data in each virtual object so that the mean and variance of the pixel colors in its rendering move in the same way as those of the real scene (Figure 1). In its simplest form, this means that a shift in the colors of the real world, e.g., their darkening in reaction to the lights being dimmed, results in a similar shifting in the colors of all virtual objects. The key here is to choose the color space correctly (RGB is a poor choice, whereas $L\alpha\beta$ color opponent space appears to be quite effective) and adjust for differences in the composition of each virtual object relative to that of the real scene. Of course, this paradigm can be reversed, in the sense that a change to virtual ambient light can be used to adjust the colors of real world objects in the same manner. Although our approach of having the virtual react to change in the real world works in any see-through technology (video or optical), the paradigm reversal only works in the context of a video see-through HMD where we can alter reality before the user gets to see it.

Our second contribution is biased toward video see-through technologies, including video see-through HMDs, MR Dome Projections systems and MR Windows (screens that can pivot to change orientation and that have attached real world capture camera(s)). Here we perform lighting computations, using dynamic virtual lights to illuminate real and virtual objects, based on the location, direction, beam width and radius (distance the light travels). We also use the silhouettes of virtual objects to create shadows on real objects, as well as other virtual objects. In a similar manner the silhouettes of real objects block the propagation of virtual light to objects that they (partially) occlude (Figure 2). The key in this work is the creation of algorithms that are implemented as shaders found in modern graphics cards, e.g., those from ATI and nVidia. These GPU implementations achieve the interactive rate required for a successful MR experience.

(a) Note how dark background affects Pegasus logo

(b) Note how light background affects Pegasus logo

Figure 1. Effects of Ambient Light

Figure 2. Virtual Flashlight Illuminating Virtual/Real Objects