Interactive Relighting of Arbitrary Rough Surfaces

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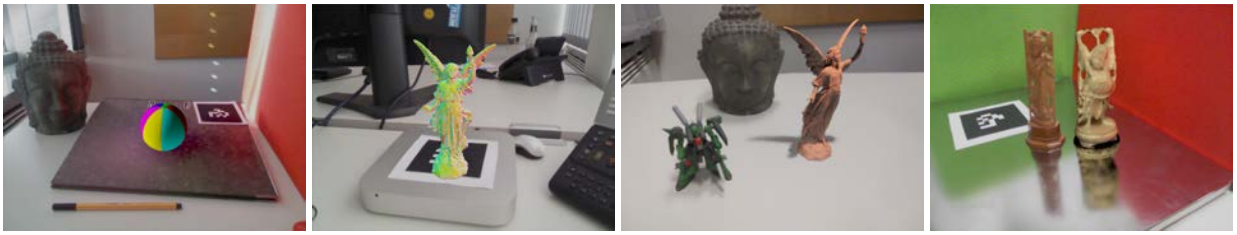

(a) Diffuse bounce (b) Voxelized augmenting object (c) Cone-traced shadow (d) Mutual light interaction

Figure 1: *With DVCT, indirect illumination from both synthetic and real objects can interact with other objects. Hard- and softshadows can be traced with a single cone per pixel. All images rendered on a NVIDIA GTX 780 at 20ms to 35ms per frame.*

1 Introduction

When presenting synthetic objects in a real environment – for instance for pre-visualization in advertisements – special attention needs to be directed at the mutual interaction of light reflecting off synthetic and real surfaces to form a coherent appearance. If the user is to be convinced that the synthetic object is part of the real scene, a relighting method has to handle shadowing and reflecting illumination between both synthetic and real surfaces. Even though a range of relighting methods are available for static scenes such as photographs, this aspect has been traditionally ignored in *real-time augmented reality* (AR) systems. A method often employed to merge synthetic light and shadows cast from synthetic objects with a real background is Differential Rendering, leaving out indirect illumination. Attempts have been made to resolve this issue with Differential Instant Radiosity [Lensing and Broll 2012], however requiring many VPLs to suppress flickering. Delta Light Propagation Volumes [Franke 2013] cluster many VPLs in a small volume, but suffer from bleeding artifacts. A GPU raytracer in [Kan and Kaufmann 2013] supports diffuse bounces with Differential Irradiance Caching, albeit at much higher cost than rasterizer based counterparts. We present a novel relighting solution called *Delta Voxel Cone Tracing* (DVCT) to enable mutual diffuse, glossy and specular indirect bounces between real and synthetic geometries. The method is temporally coherent and to our knowledge the first real-time solution to support arbitrary glossy reflections in AR.

2 Technical Approach

A manually reconstructed model of the real scene is geometrically registered with a marker and real light sources are importance sampled from a hemispherical camera image. Consider an existing radiance field L^μ. When we insert another object O into the scene covered by L^μ, the properties of the radiance field change: light is either blocked or scattered by the newly inserted geometry. To account for this *change* in the radiance field, consider another field L^ρ which has the same light configuration as L^μ and additionally contains O. The change in a radiance field L^μ by introducing O is therefore $L^\Delta = L^\rho - L^\mu$. To generate the *Delta Radiance Field* L^Δ we render two Reflective Shadow Maps (RSM) R^ρ and R^μ for each reconstructed real light source: one contains the reconstructed scene geometry with the introduced object O, and one without O. We then voxelize O and its near real surrounding (a cube two times the largest edge of the bounding box of O) into a volume V^η of 256^3 entries or more. We create another two volumes V^ρ and V^Δ of the same size. In a step called *split-injection* both RSMs are used to initialize the indirect bounces in those volumes. Each pixel of R^ρ is injected into V^ρ, while the differential $R^\rho - R^\mu$ is injected into V^Δ. As a consequence, some voxels will contain negative values (Antiradiance). This is important to remove existing indirect energy from the camera image, for instance when a synthetic shadow should be visible in a real mirror. After injection, we filter all three volumes. When relighting real surfaces, we calculate the necessary adjustment by tracing on V^Δ, whereas for synthetic surfaces we sample contribution from V^ρ to add mutual indirect bounces from both synthetic and real surfaces. Soft-shadows are calculated per pixel with one cone in direction of a light source. The evaluation cost for this split-voxel hierarchy differs from regular VCT [Crassin et al. 2011] in the additional volume V^Δ and the split-inject. A limitation of the current approach is that the spatial size of the volume constraints the range of real bounces that can reach O and is therefore only suitable for near-field relighting of O. Real surfaces however gather light from V^Δ and therefore indirect bounces from O can be handled on the entire reconstructed real scene.

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References

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