Accurate Image Based Re-lighting through Optimization

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Image-based relighting represents a class of techniques that apply new lighting conditions to a scene, given a set of basis images. In this sketch we present a relighting technique that, for a single viewpoint, accurately captures the reflectance field of objects, without restrictions on their geometrical complexity or material properties. Once the reflectance field is captured, the objects can be relit under arbitrary lighting conditions. To achieve such accurate results, our method combines the strengths of both the Light Stage [Debevec et al. 2000] and environment matting [Zongker et al. 1999; Chuang et al. 2000] into a single framework.

To capture the reflectance field, the object is lit by several light patches located on a hemicube around the object. Each patch emits a series of illumination patterns, and for each pattern, a high-dynamic range photograph is recorded. Currently, we use a calibrated CRT monitor for each hemicube side (Figure 1).

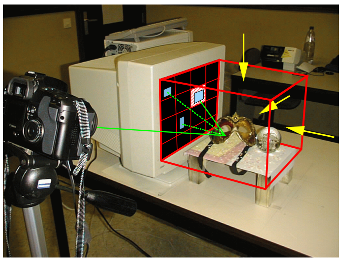

Figure 1: Current setup limits monitor placement to 4 sides, excluding the side where the camera is located. Each hemicube side consist of a 4×4 grid of patches and we use 9 different gradient patterns per patch.

The illumination of each pixel due to emitted radiance from each light patch is approximated by a reflection coefficient and a rectangular support area on the light patch. The reflection coefficient and support are optimized through a least square minimization on the pixel radiance values.

To relight the scene using an arbitrary light map, the illumination is averaged over the support and multiplied by the reflection coefficient, for each pixel and each patch.

Due to the spacial variation of the hemicube in light patches, diffuse materials are captured accurately. However, this subdivision is too coarse for correctly capturing specular materials. The use of illumination patterns makes it possible to find sub-patch areas which are needed for specular materials. This approach combines the advantages of both the Light Stage and environment matting, methods which handle only one of the above features adequately.

Figure 2 shows a scene, containing a decorative glass sphere and a Venetian mask, captured and relit using our framework. The results show that the proposed technique handles soft shadows correctly, specular and diffuse materials are faithfully reproduced, and even caustics (at the base of the sphere) are captured.

Our framework enables a whole new range of applications: the digital capture and display of objects with a mix of diffuse and specular appearance (e.g. jewelry or sensitive archaeological objects), augmented reality applications, (interactive) relighting of fully virtual scenes, ...

Future research will focus on faster capturing of the reflectance field, the use of other projection devices that can accommodate larger objects, and reducing the number of necessary photographs by using better illumination patterns and optimization procedures.

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References

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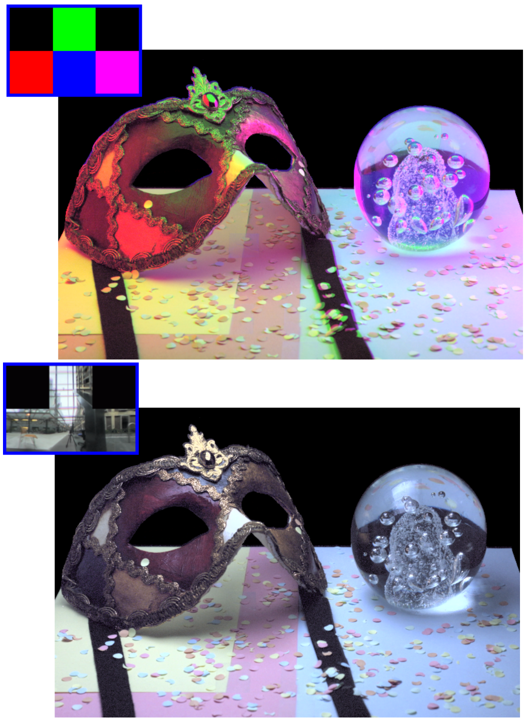

Figure 2: Venetian mask and glass sphere lit by an artificial light map and a light map taken inside a building with glass ceiling (http://www.debevec.org/Probes).