Sparse Lumigraph Relighting by Illumination and Reflectance Estimation from Multi-View Images (sketch_0335)

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Figure 1: Using our algorithm, the recovered illumination of the statue (lower left) is used to relight the fish (upper left) and generate the final composite image (right).

Abstract We present a novel image-based modeling technique which allows simultaneous estimation of illumination, diffuse, and specular albedo maps using only object geometry and multi-view images captured under a single, *unknown* illumination setting.

1 Overview

The images of a scene under varying illuminations and from different viewpoints are highly interrelated, which makes it possible to predict the object's appearance from new viewpoints or under different illuminations. Most research [1; 2] require known or controllable illumination, which is an impractical assumption for many scenes such as outdoors. Other research that relinquish this constraint often impose other restrictions, such as the uniform specular albedo assumption in [3].

In this research, we demonstrate for the first time that observations of the specular appearance from multiple viewpoints are sufficient to solve for illumination, diffuse and specular albedo maps simultaneously up to a scaling ambiguity. Our input images are taken with sparsely distributed viewpoints, in contrast to dense sampling required by many image based rendering methods.

Methodology We formulate the estimation problem as the decomposition of the observed 3D radiance tensor $\mathcal{R}$ into three components $\mathcal{A} \times_1 \mathbf{B} \times_2 \mathbf{H}$, where $\mathbf{B}$, $\mathbf{H}$, and $\mathcal{A}$ are the albedo matrix, illumination matrix, and the light transport tensor(LTT), respectively. LTT $\mathcal{A}$ transforms the contribution of each illumination component to each surface point and is fully specified by the object geometry and a base material's BRDF. This tensor also encodes the non-linear factors including rotation of directions to the surface normal coordinates and self-shadowing.

Figure 2: Left to right: photograph (not part of the input), resynthesized images with original lighting, partially edited lighting, and cathedral lighting. 30 input images were used in the estimation process.

Given the LTTs, our problem is reduced to solving the albedo matrix $\mathbf{B}$ and illumination matrix $\mathbf{A}$. To further constraint the solution, we assume directional environment lighting with no inter-reflection. We then solve this bilinear system by iteratively fixing one set of parameters ($\mathbf{H}$ or $\mathbf{B}$) and solving a linear least squares problem for the other. Because LTT is sensitive to reflection directions, we also optimize the bump maps along the process.

2 Results and Conclusion

We demonstrate our results on publicly available datasets using one specular LTT (Figure1-2). We would like to point out the effects of spatially varying albedo on the fish scales, and the bump map optimization on the statue's hair where geometric details were absent in the original dataset.

We have demonstrated with experimental results that view dependent light transport can be used to resolve the texture-illumination ambiguity. We are excited about the future prospects of this research and are currently investigating several applications as well as theoretical implications of the estimation process.

References

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