Light Transport Analysis for 3D Photography

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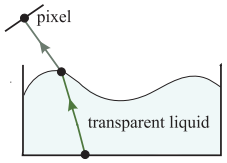
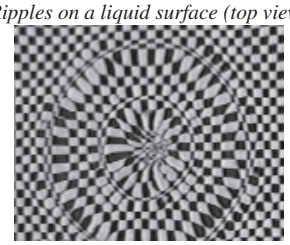
Abstract

While 3D photography research has enjoyed tremendous success in recent years, many everyday objects and materials are still difficult or impossible to capture in 3D. An important stumbling block is that typical algorithms do not consider the effects of light transport, i.e., the sequence of bounces, refractions and scattering events that may occur when light interacts with an object. This puts objects with transparent materials or highly-reflective surfaces (clear plastic, crystal, liquids, polished metal, etc.) outside the reach of current 3D scanning techniques. To overcome these limitations, we have been investigating algorithms that explicitly analyze the light transport process caused by such objects [1–3]. These algorithms rely on 2D photos taken from multiple views and reconstruct the individual 3D path(s) that light must have traced in order to reach each pixel. Despite the apparent intractability of this endeavor, our results suggest that reasoning about light transport can produce rich descriptions of surface geometry for objects with complex optical properties.

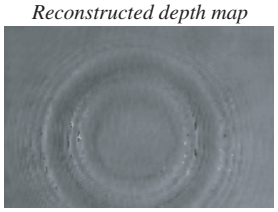
Analyzing one-refraction light paths [1]



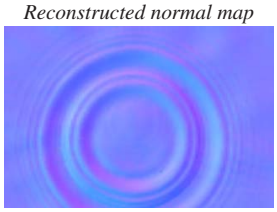
Ripples on a liquid surface (top view)



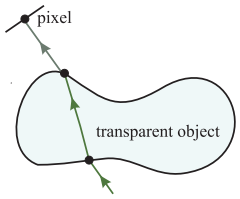
Reconstructed depth map



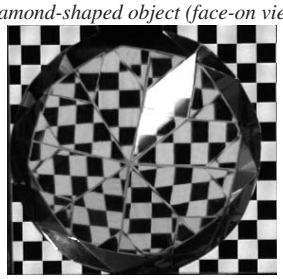
Reconstructed normal map



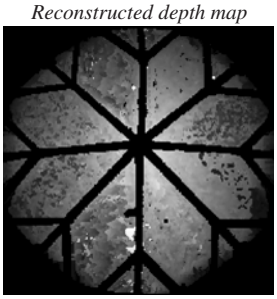
Analyzing two-refraction light paths [2]



Diamond-shaped object (face-on view)

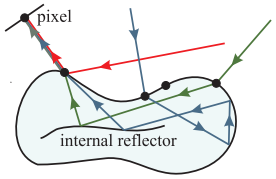


Reconstructed depth map



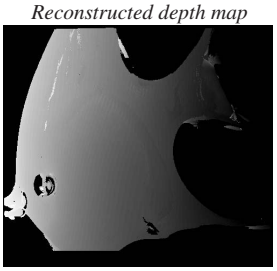
Reconstructed normal map

Analyzing & separating the contribution of one-bounce (red) & multiple-bounce light paths [3]

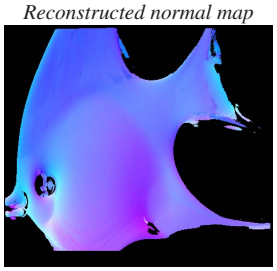


Crystal ornament w/ painted interior

Reconstructed depth map



Reconstructed normal map



References

[1] N. Morris and K. N. Kutulakos, "Dynamic refraction stereo," *Proc. ICCV'05*, pp. 1573–1580.

[2] K. N. Kutulakos and E. Steger, "A theory of and refractive and specular 3d shape by light-path triangulation," *Proc. 10th ICCV'05*, pp. 1448–1455.

[3] www.cs.toronto.edu/~kyros/research/scatter-trace/

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