Fast Separation of Direct and Global Images Using High Frequency Illumination

Shree K. Nayar
Gurunandan G. Krishnan
Columbia University
Michael D. Grossberg
City College of New York
Ramesh Raskar
MERL

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Support: ONR, NSF, MERL
Direct and Global Illumination

- A : Direct
- B : Interreflection
- C : Subsurface
- D : Volumetric
- E : Diffusion
Related Work

- Inverse Light Transport
  (Seitz et. al., ICCV 05)

- Dual Photography
  (Sen et. al., Siggraph 05)
Fast Separation of Direct and Global Images

• Create Novel Images of the Scene

• Enhance Brightness Based Vision Methods

• New Insights into Material Properties
Direct and Global Components: Interreflections

\[ L[c, i] = L_d[c, i] + L_g[c, i] \]

- **radiance**
- **direct**
- **global**

\[ L_g[c, i] = \sum_{P} A[i, j] L[i, j] \]

- **BRDF and geometry**

Diagram showing the relationship between source, camera, surface, and the equations for direct and global components.
High Frequency Illumination Pattern

\[ L^+[c, i] = L_d[c, i] + \alpha L_g[c, i] \]

fraction of activated source elements
High Frequency Illumination Pattern

\[ L^+[c,i] = L_d[c,i] + \alpha L_g[c,i] \]

\[ L^-[c,i] = (1 - \alpha) L_g[c,i] \]

fraction of activated source elements
Example
Separation from Two Images

\[ \alpha = \frac{1}{2} : \]

\[ L_d = L_{\text{max}} - L_{\text{min}}, \quad L_g = 2L_{\text{min}} \]

direct \hspace{2cm} \text{global}
Other Global Effects: Subsurface Scattering
Other Global Effects: Volumetric Scattering

participating medium

source

camera
Real World Examples:

Can You Guess the Images?
Eggs: Diffuse Interreflections

Direct

Global
Wooden Blocks: Specular Interreflections

Direct

Global
Novel Images
Mirror Ball: Failure Case

Direct

Global
Photometric Stereo using Direct Images

Bowl
Source 1  Source 2  Source 3

Global

Direct

Shape

Nayar et al., 1991
Kitchen Sink: Volumetric Scattering

Volumetric Scattering:
Chandrasekar 50, Ishimaru 78
Peppers: Subsurface Scattering
Novel Images
Hand

Skin: Hanrahan and Krueger 93, Uchida 96, Haro 01, Jensen et al. 01, Cula and Dana 02, Igarashi et al. 05, Weyrich et al. 05
Face: Without and With Makeup

Without Makeup

Direct

Global

With Makeup

Direct

Global
Blonde Hair

Hair Scattering: Stamm et al. 77, Bustard and Smith 91, Lu et al. 00
Marschner et al. 03

Direct

Global
Variants of Separation Method

• Coded Structured Light

• Shifted Sinusoids

• Shadow of Line Occluder

• Shadow of Mesh Occluders
Summary

• Fast and Simple Separation Method

• No Prior Knowledge of Material Properties

• Wide Variety of Global Effects

• Implications:
  • Generation of Novel Images
  • Enhance Computer Vision Methods
  • Insights into Properties of Materials