Visual Chatter in the Real World

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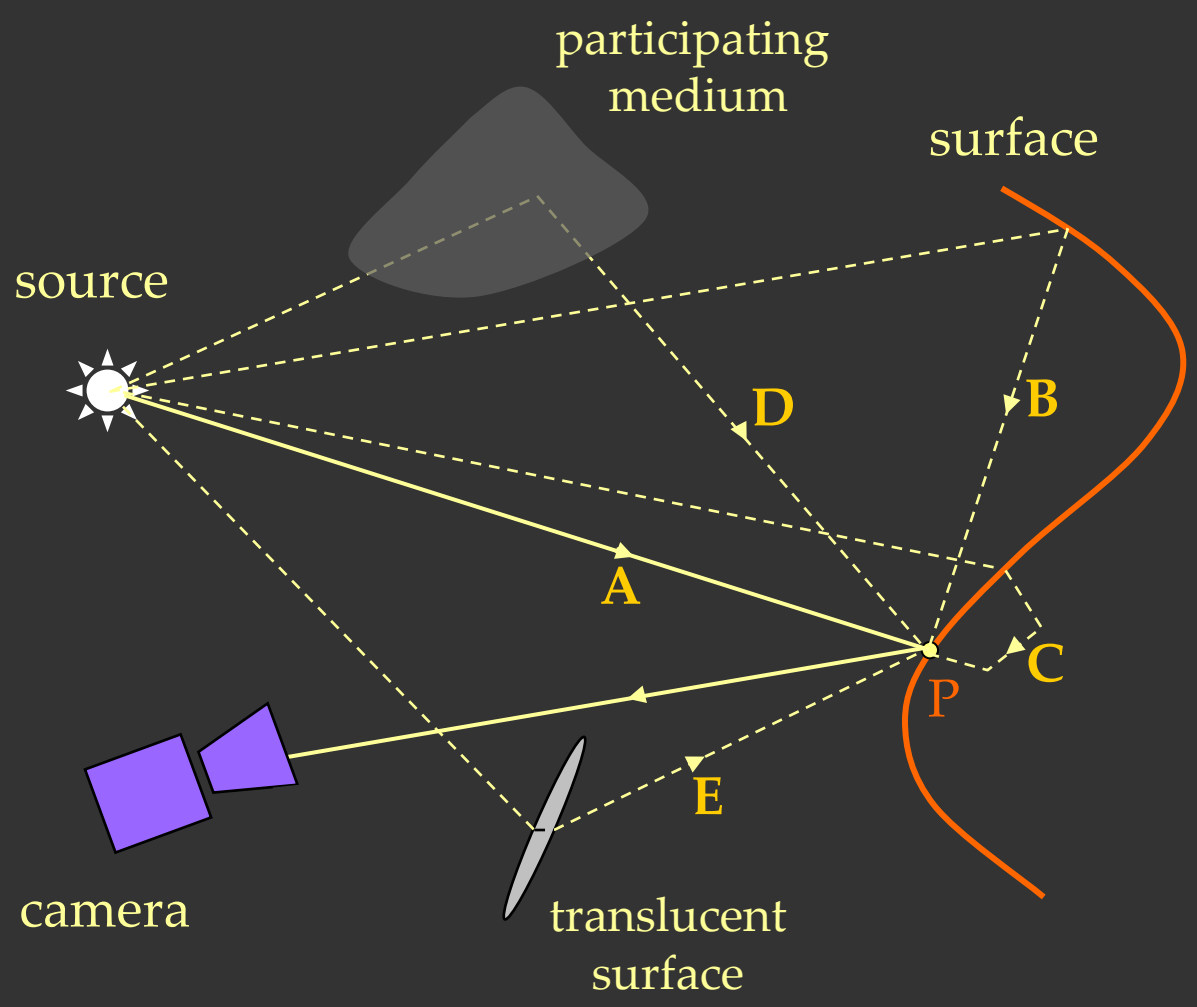
Support: ONR

Direct and Global Illumination



A : Direct

B : Interreflection

C : Subsurface

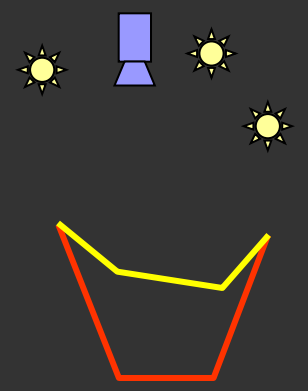
D : Volumetric

E : Diffusion

Related Work

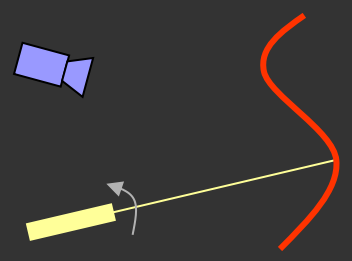
- Shape from Interreflections

  (Nayar et. al., ICCV 90)



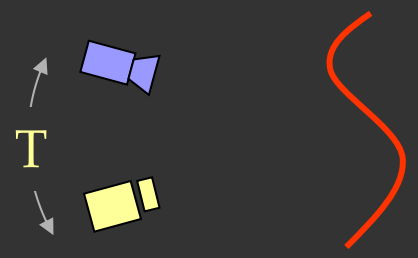
- Inverse Light Transport

  (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

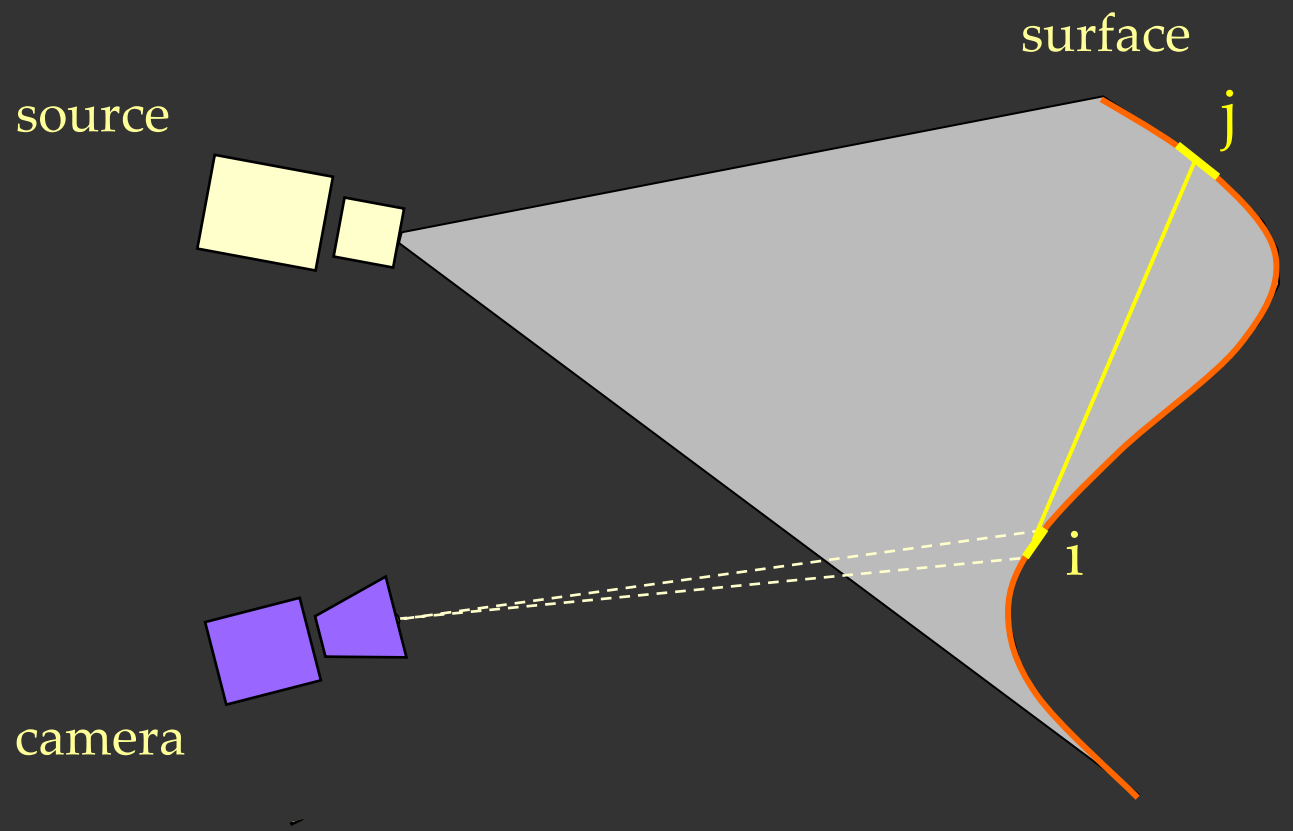
Compute Direct and Global Images of a Scene from Two Captured Images

Create Novel Images of the Scene

Enhance Brightness Based Vision Methods

New Insights into Material Properties

Direct and Global Components: Interreflections



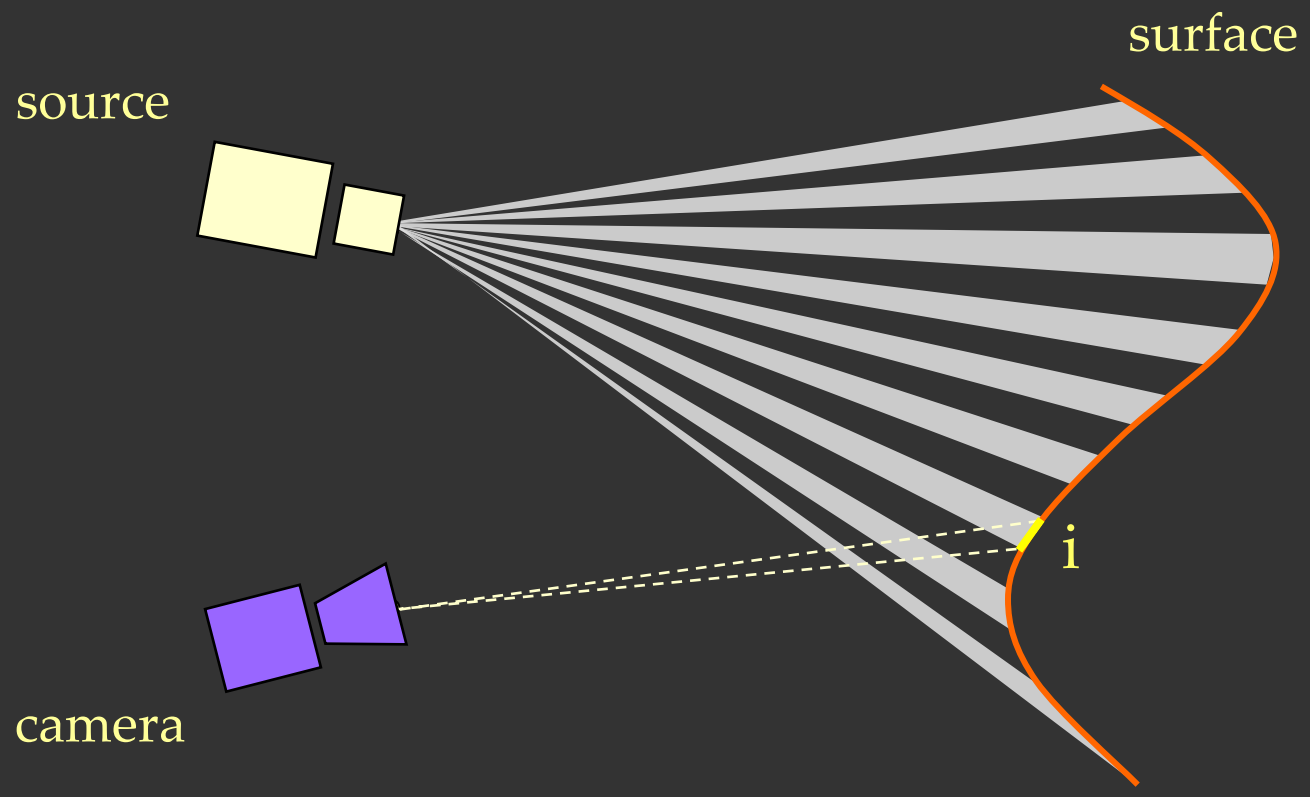
$$L[c,i] = L_d[c,i] + L_g[c,i]$$

radiance direct global

$$L_g[c,i] = \sum_P A[i,j]\, L[i,j]$$

BRDF and geometry

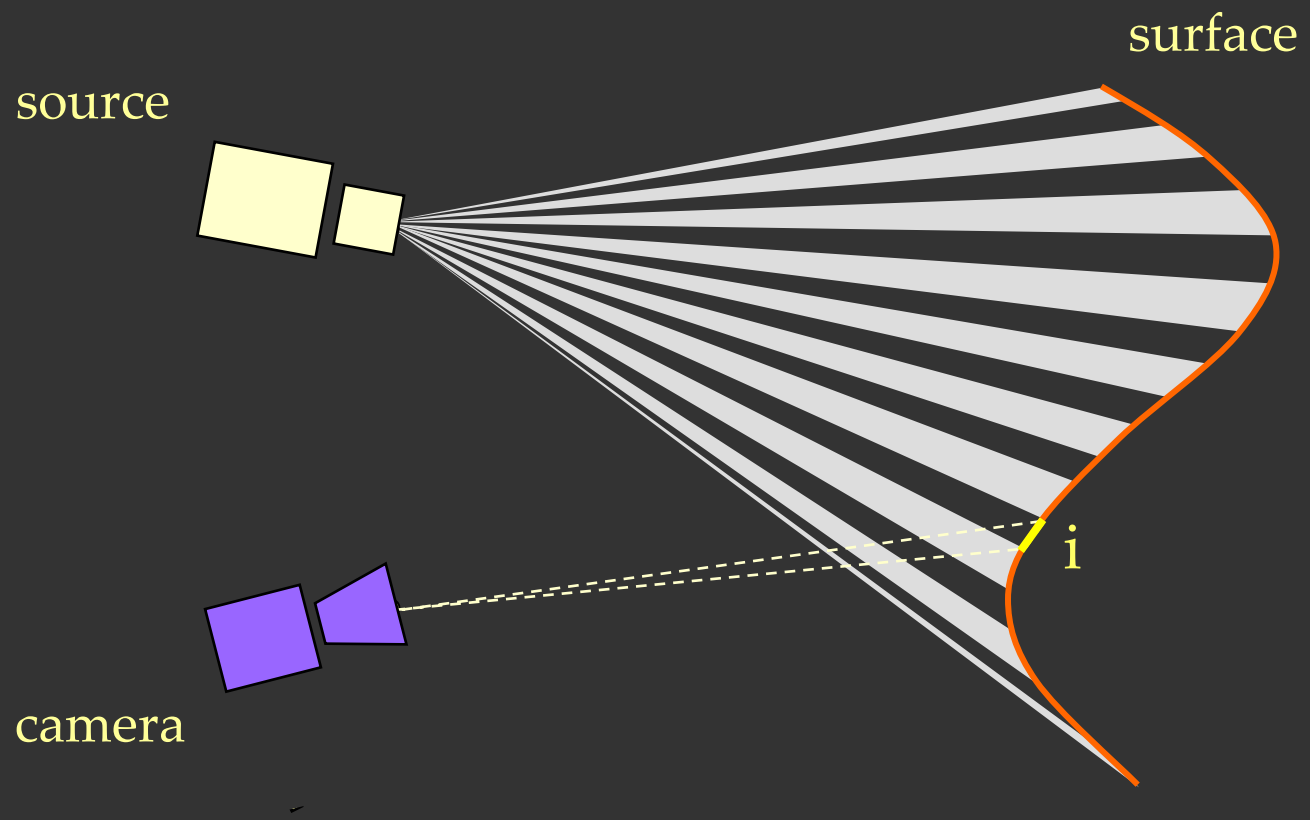
High Frequency Illumination Pattern



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

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

Separation from Two Images

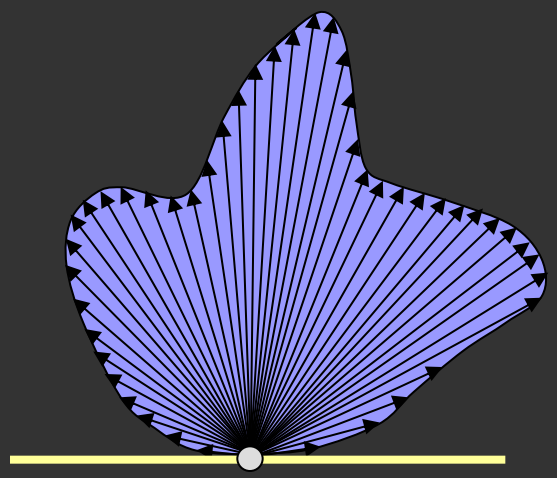
$$\alpha = \frac{1}{2}: \quad \boxed{L_d = L_{\max} - L_{\min}, \quad L_g = 2L_{\min}}$$

direct global

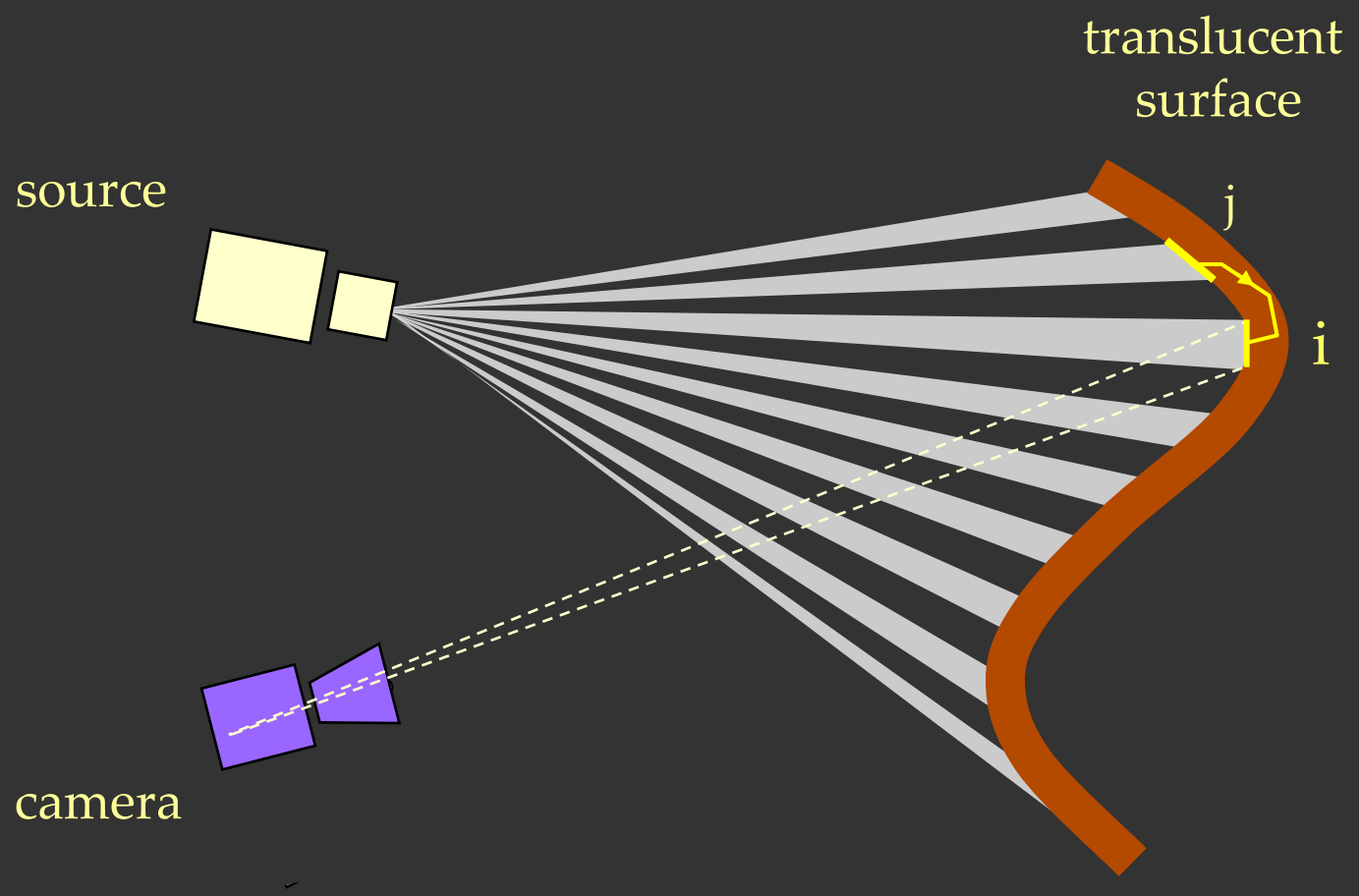
Minimum Illumination Frequency

$$\alpha L_g = \int A(y)\, L\ (y)\, dy$$

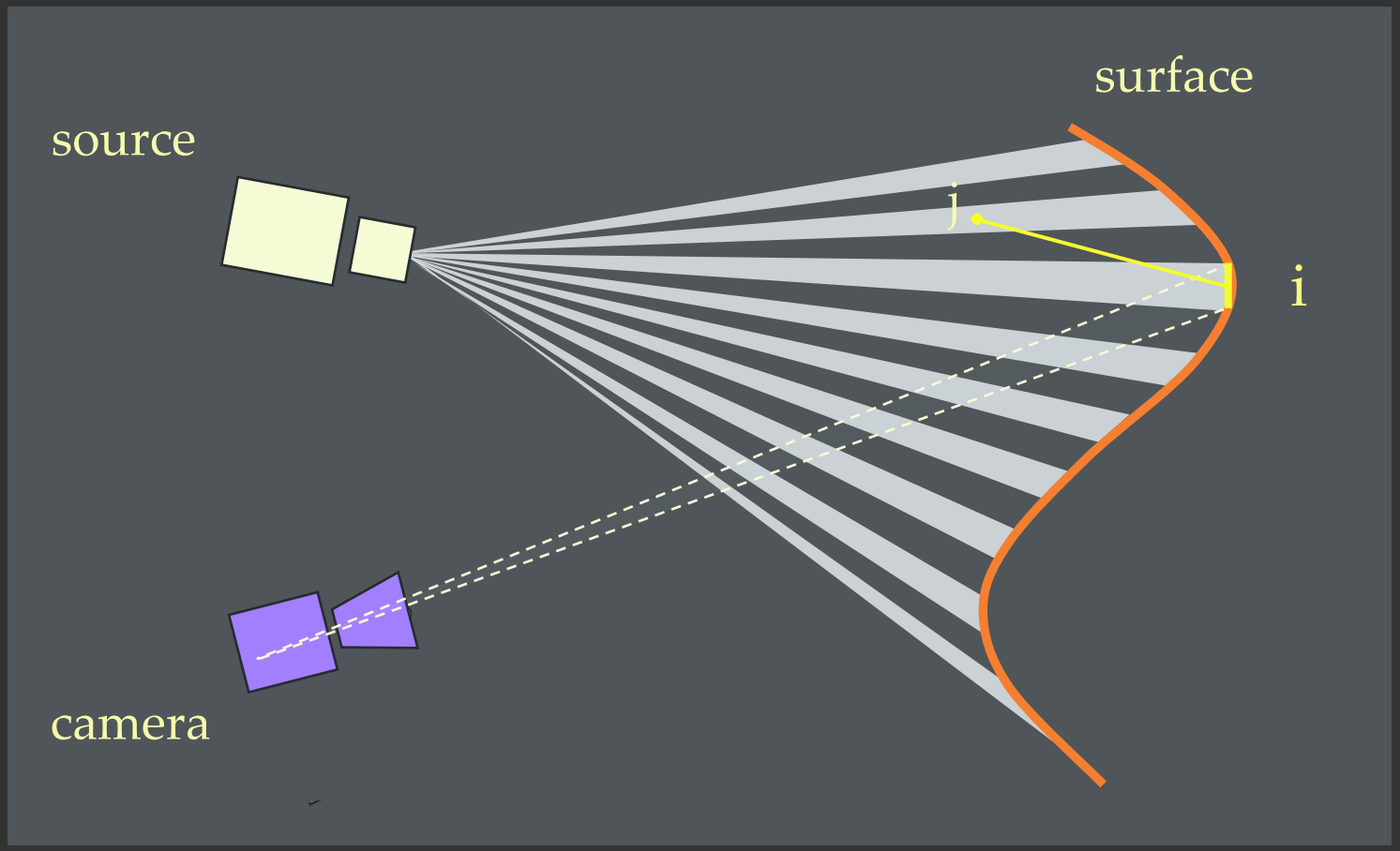
$$\boxed{(\omega_A + \omega_L)}$$



Other Global Effects: Subsurface Scattering

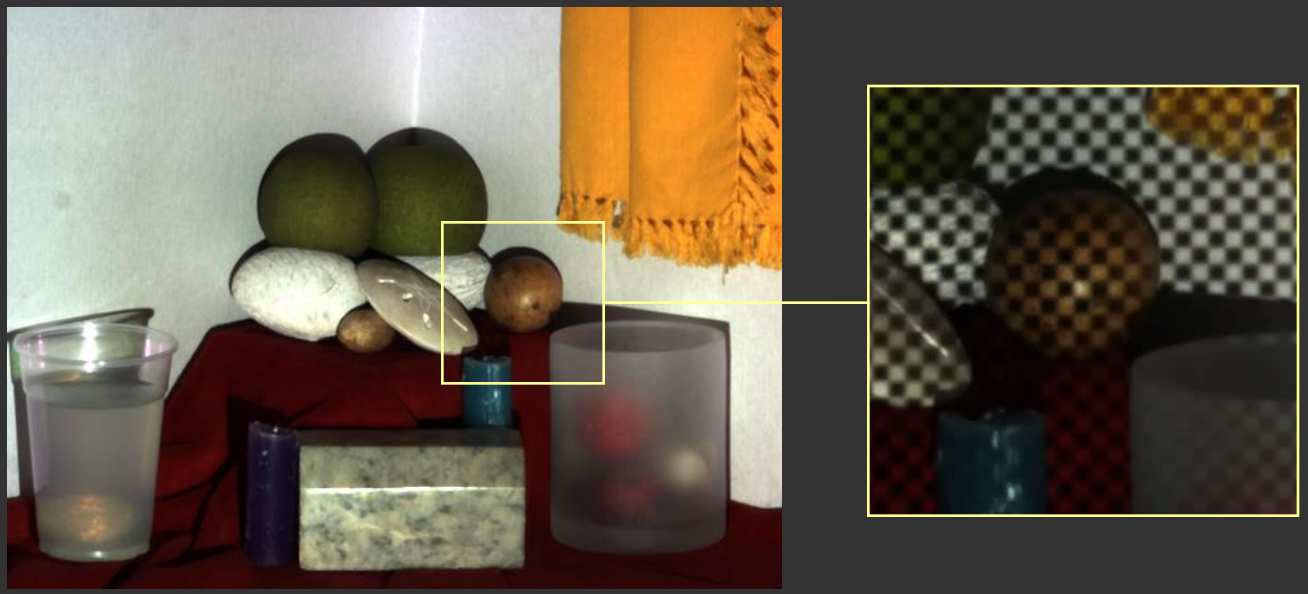


Other Global Effects: Volumetric Scattering




Diffuse Interreflections
Specular Interreflections
Diffusion
Volumetric Scattering
Subsurface Scattering

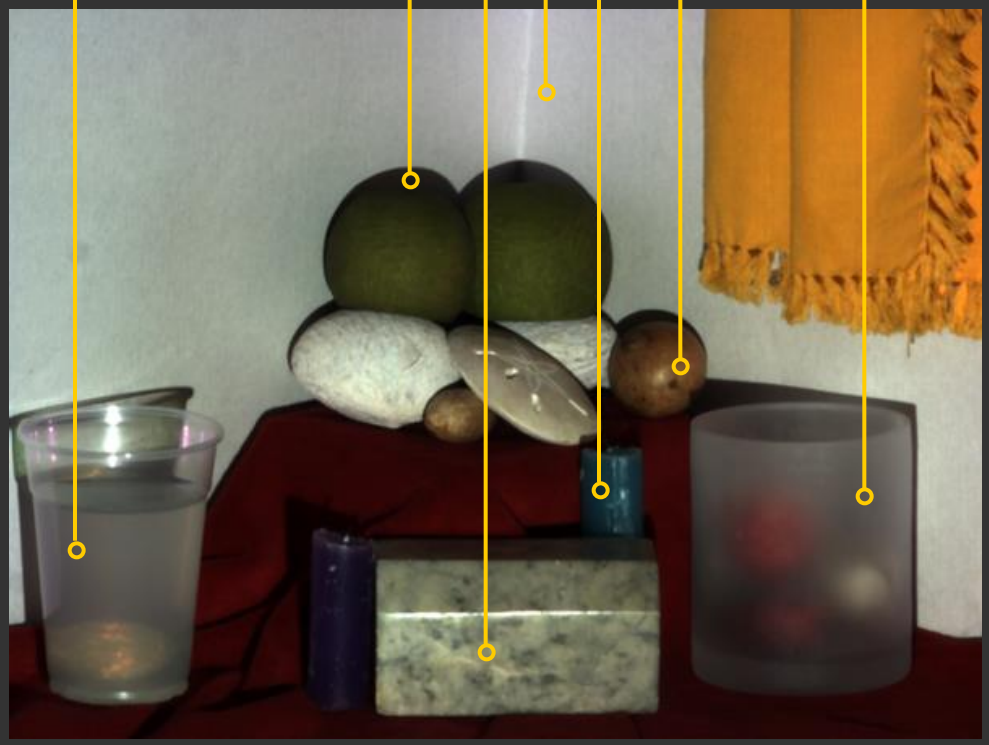
Scene



Direct

Global

Verification



A: Diffuse Interreflection (Board)

B: Specular Interreflection (Nut)

C: Subsurface Scattering (Marble)

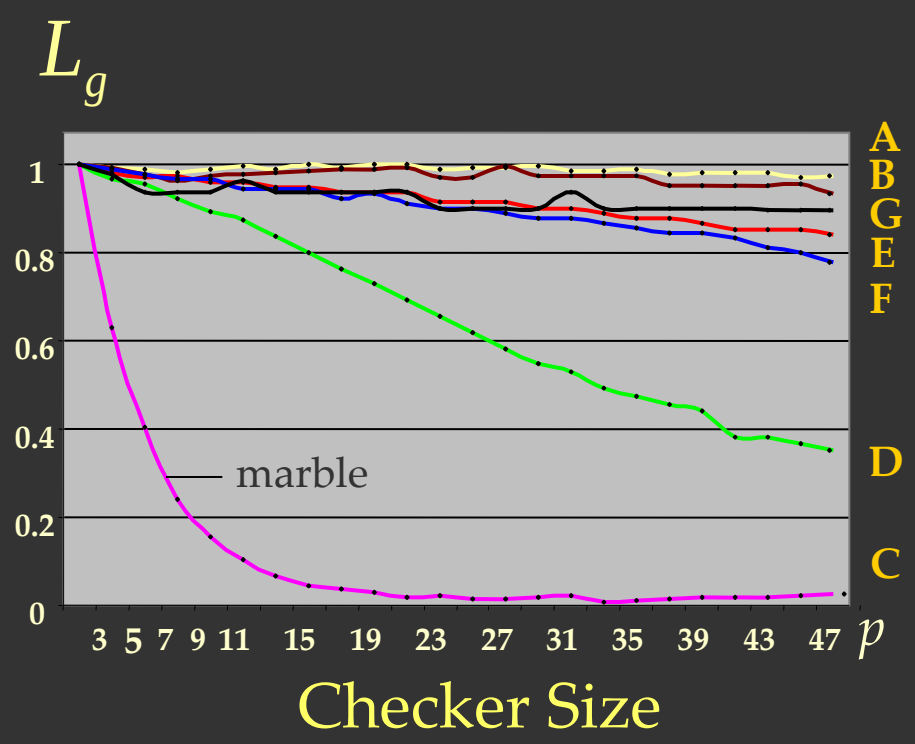
D: Subsurface Scattering (Wax)

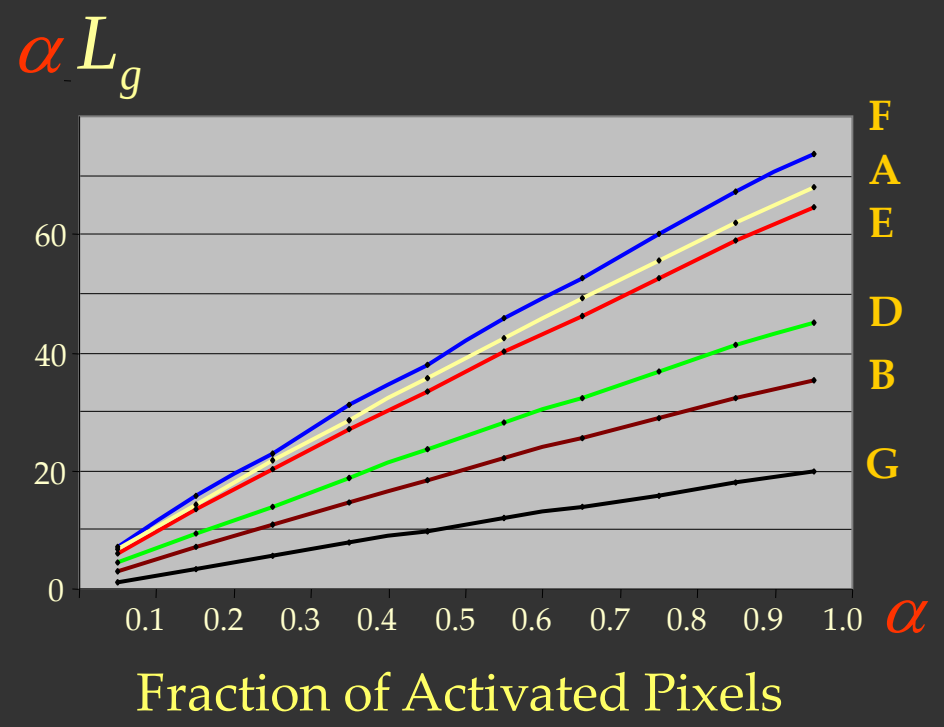
E: Translucency (Frosted Glass)

F: Volumetric Scattering (Dilute Milk)

G: Shadow (Fruit on Board)

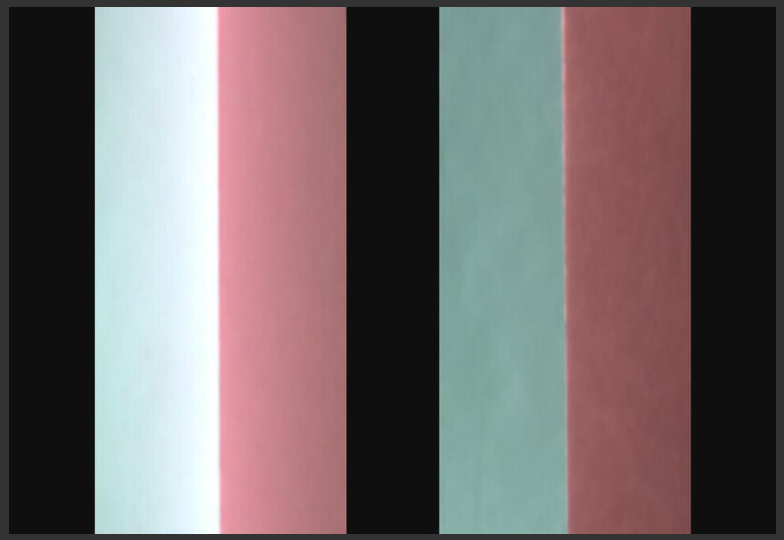
Verification Results



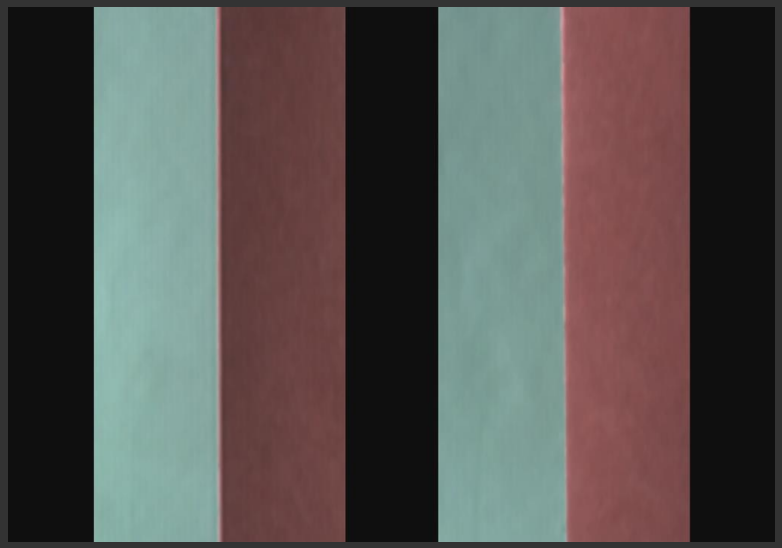


V-Grooves: Diffuse Interreflections

concave convex



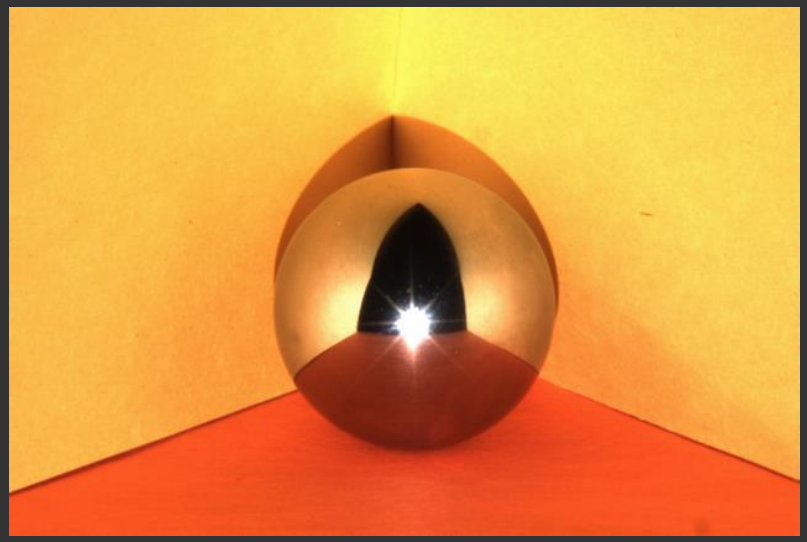
Psychophysics:
Gilchrist 79, Bloj et al. 04

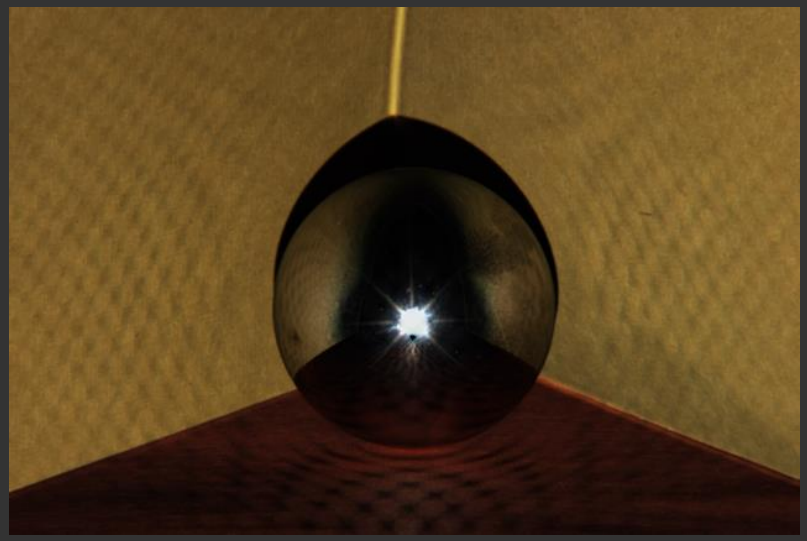


Direct

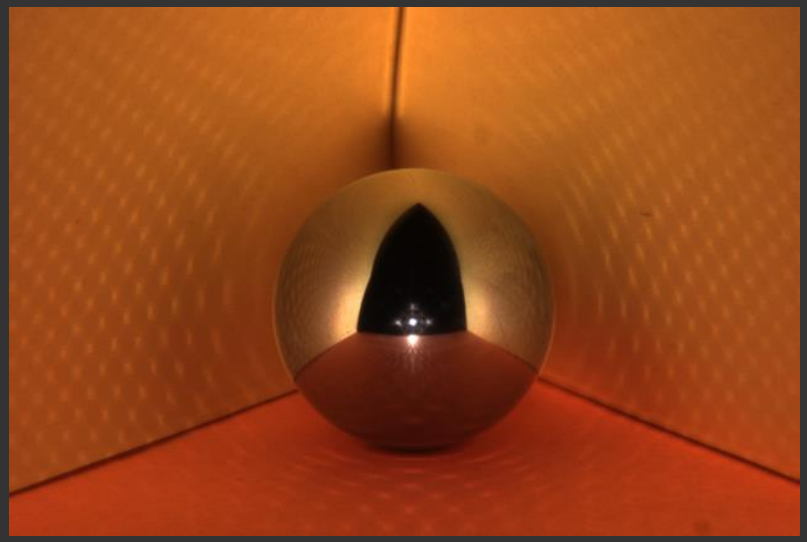
Global

Mirror Ball: Failure Case





Direct



Global

Real World Examples:

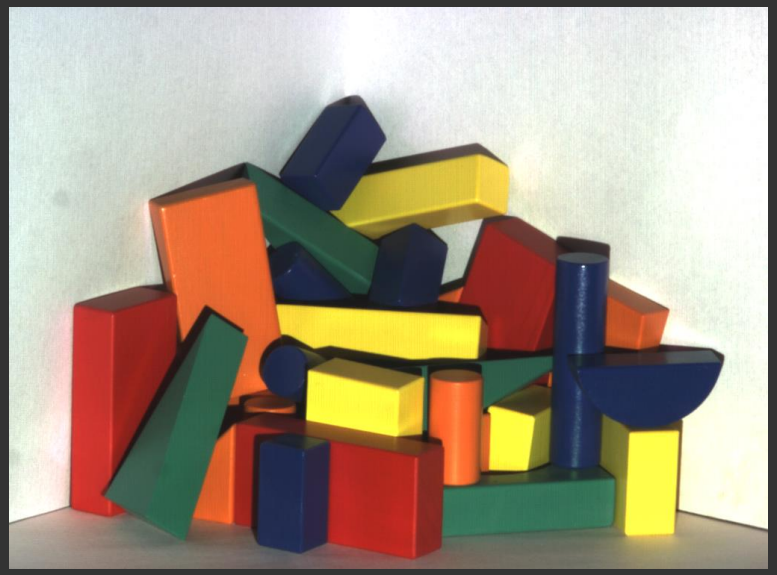
Can You Guess the Images?

Eggs: Diffuse Interreflections

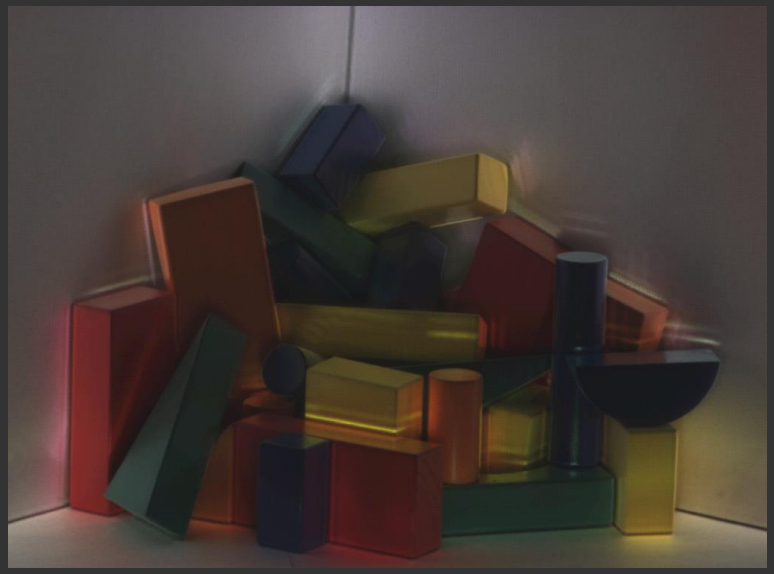
Direct

Global

Wooden Blocks: Specular Interreflections

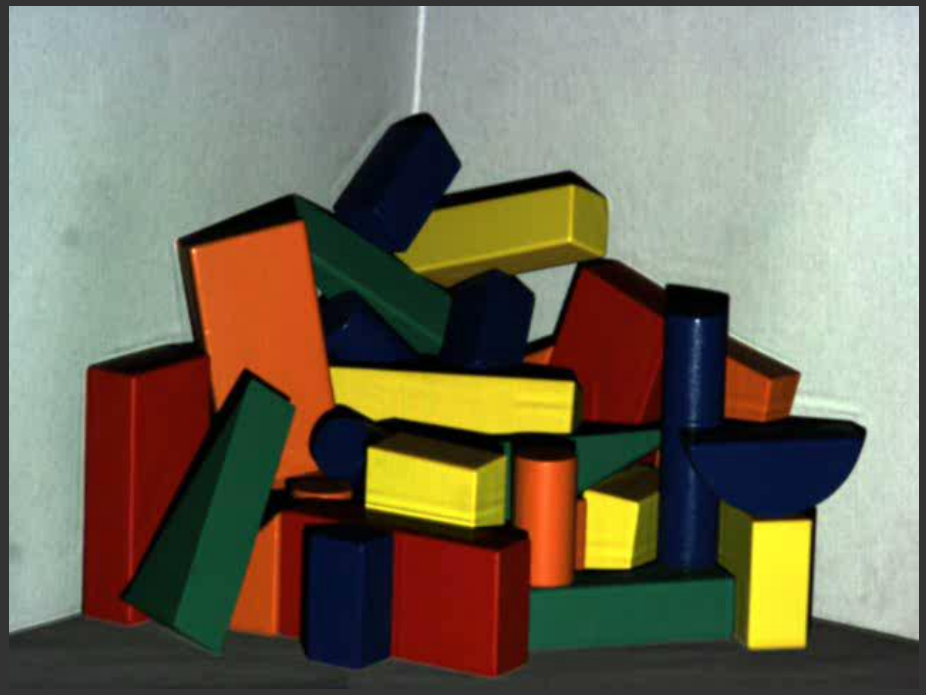


Direct



Global

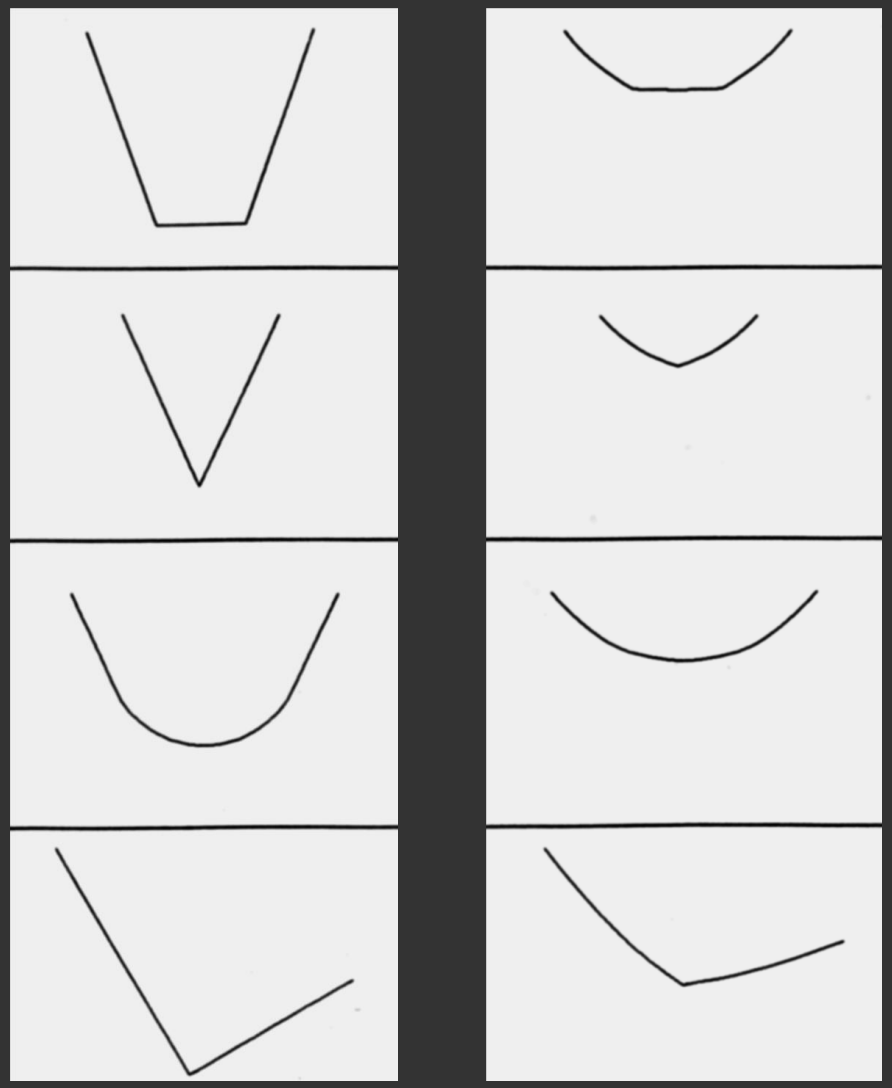
Novel Images



Photometric Stereo: The Pseudo Shape

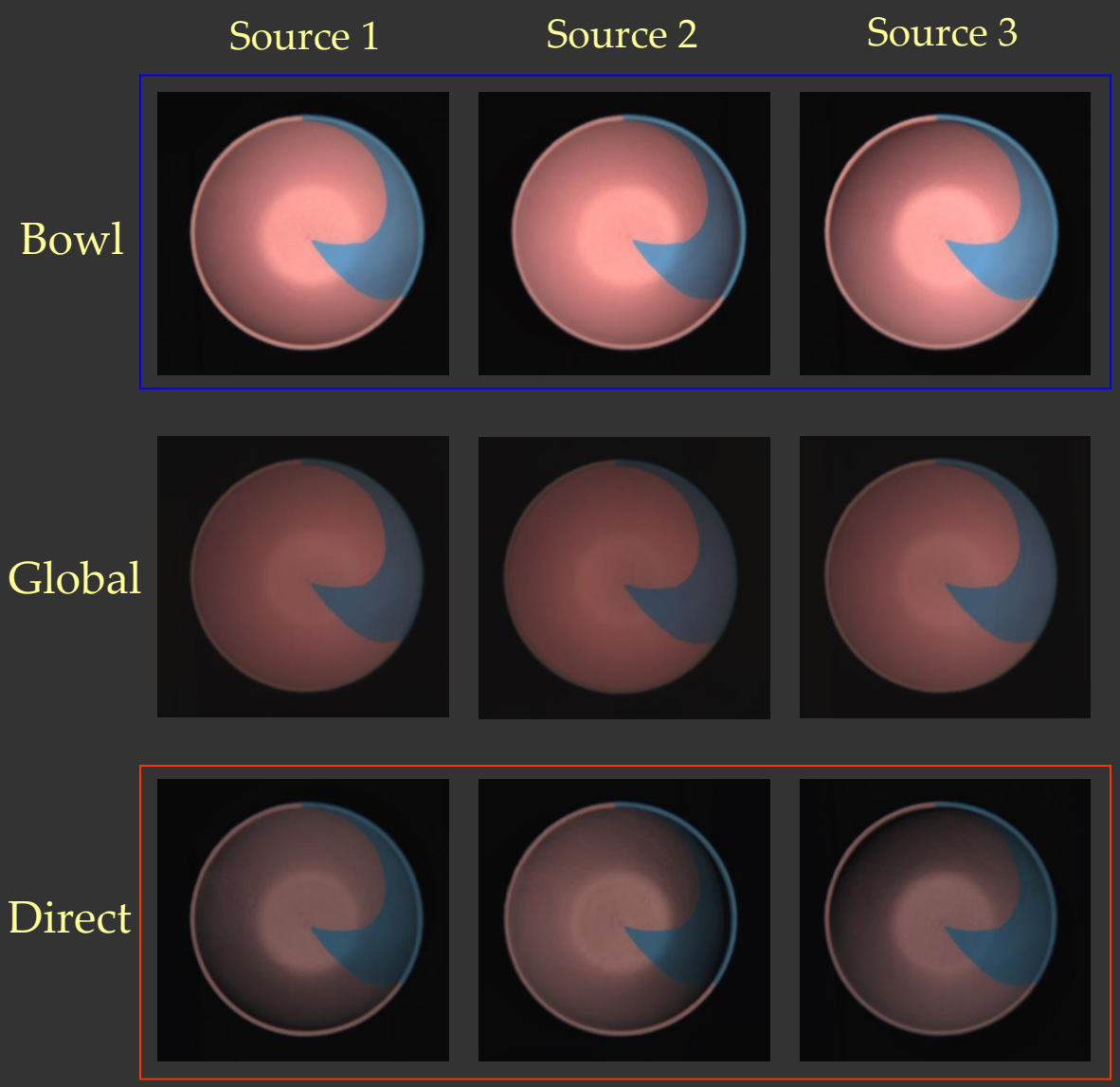
Actual Shape
($\rho = 0.95$)

Pseudo Shape

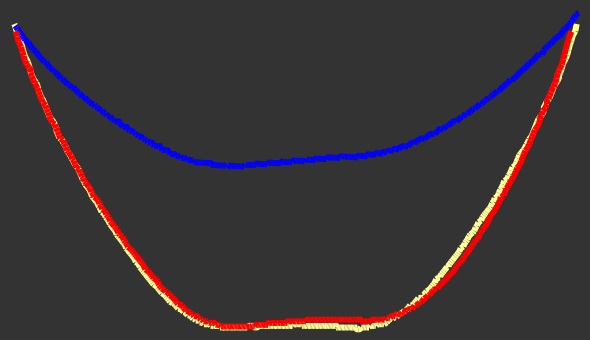


Nayar et al., 1991

Photometric Stereo using Direct Images

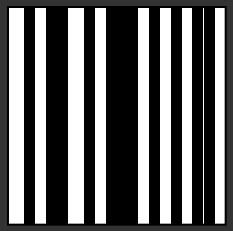


Shape

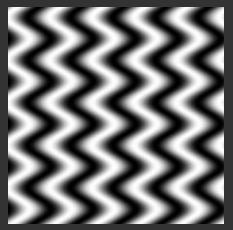


Variants of Separation Method

- Coded Structured Light

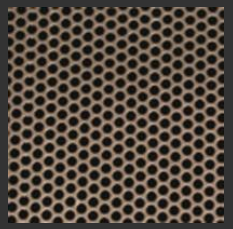


- Shifted Sinusoids



- Shadow of Line Occluder

- Shadow of Mesh Occluders



Building Corner

Stick

Shadow

3D from Shadows:
Bouguet and Perona 99

$$L_d = L_{\max} - L_{\min}, \quad L_g = L_{\min}$$

direct

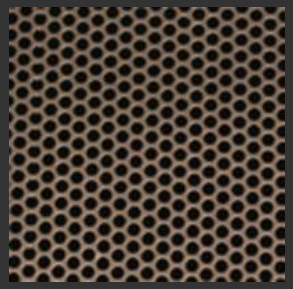
global

Building Corner

Direct

Global

Shower Curtain: Diffuser



Mesh

Shadow

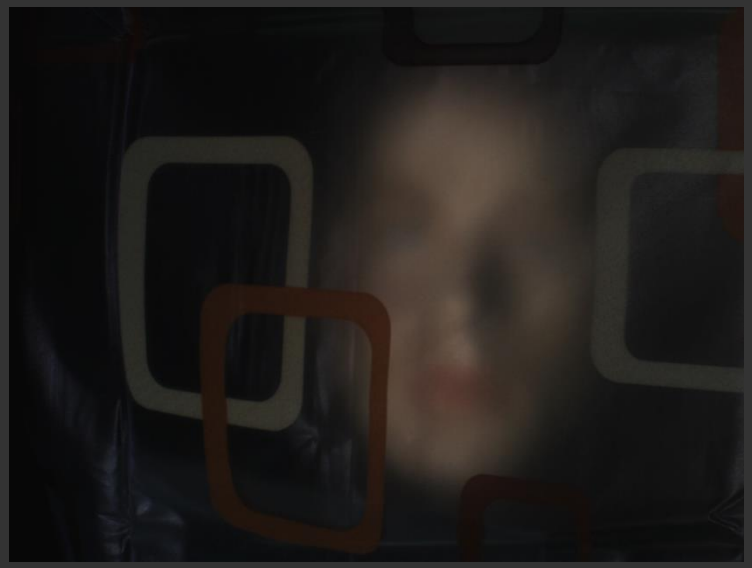
$$L_d = L_{\max} - \beta L_{\min} \ , \quad L_g = \beta L_{\min}$$

direct

global

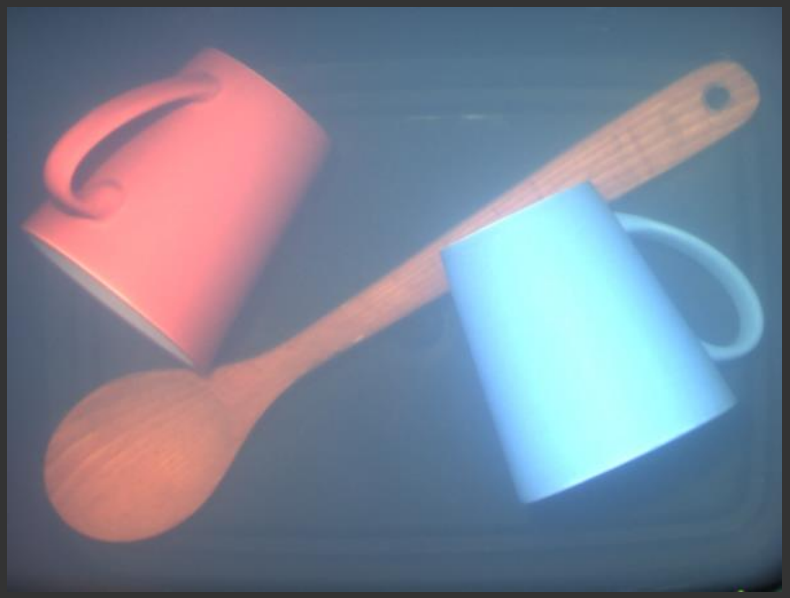
Shower Curtain: Diffuser

Direct



Global

Kitchen Sink: Volumetric Scattering

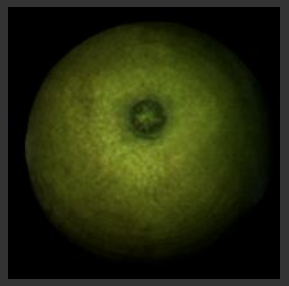


Volumetric Scattering:
Chandrasekar 50, Ishimaru 78

Direct

Global

Novel Image



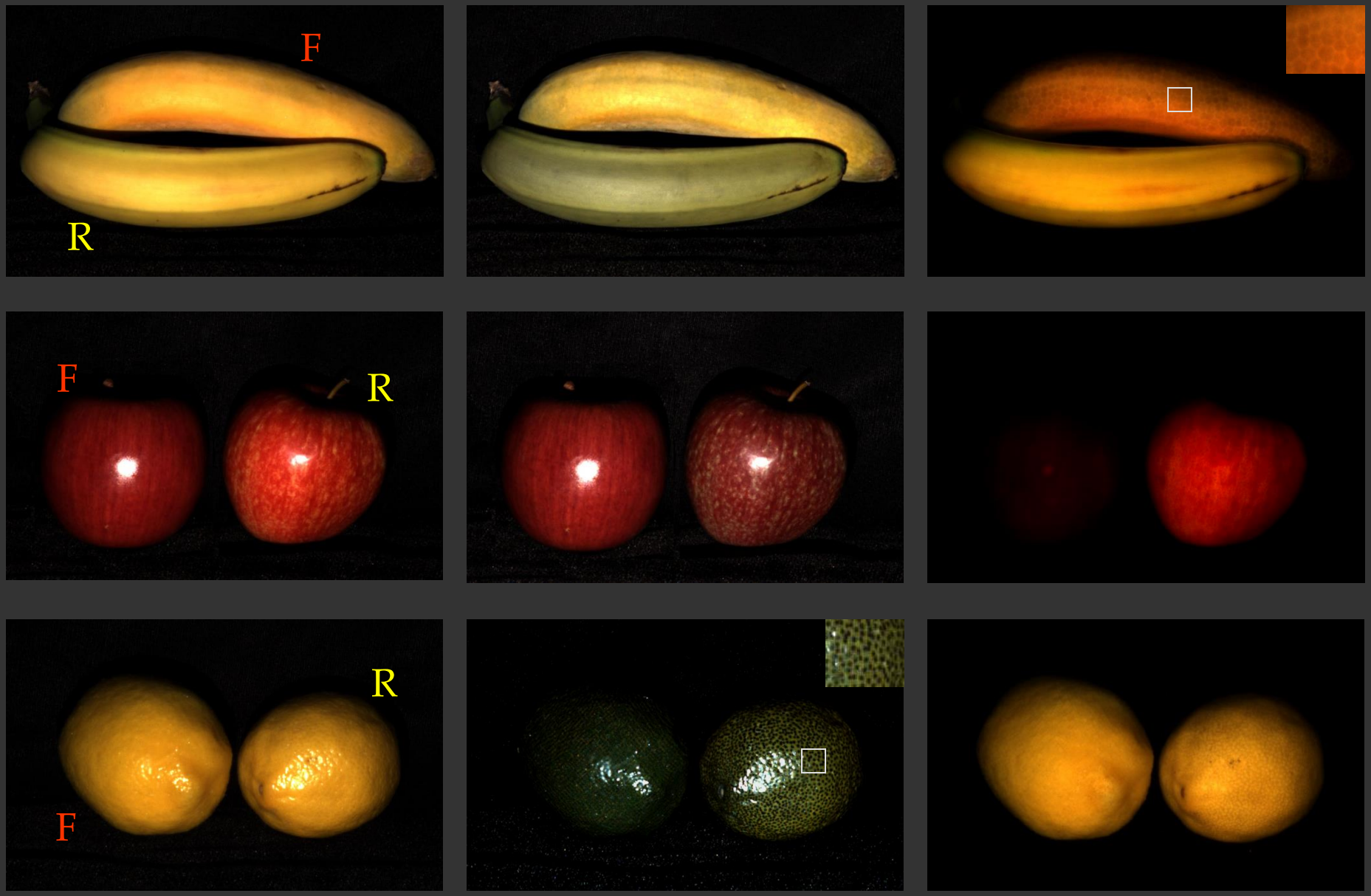
Peppers: Subsurface Scattering

Direct

Global

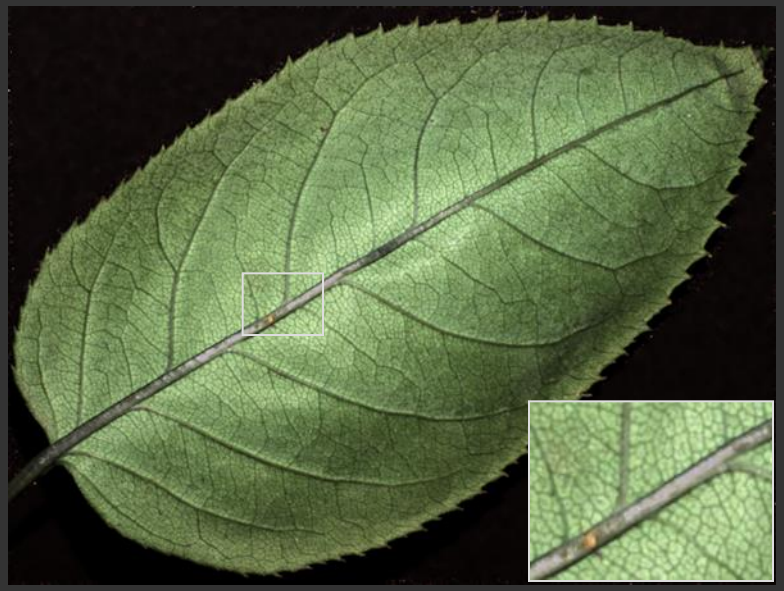
Novel Images

Real or Fake ?



Tea Rose Leaf

Leaf Anatomy: Purves et al. 03

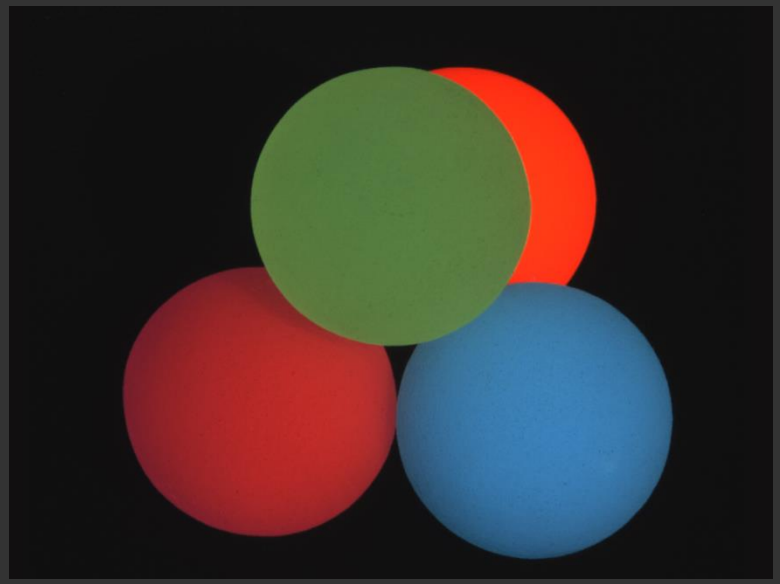


Direct

Global

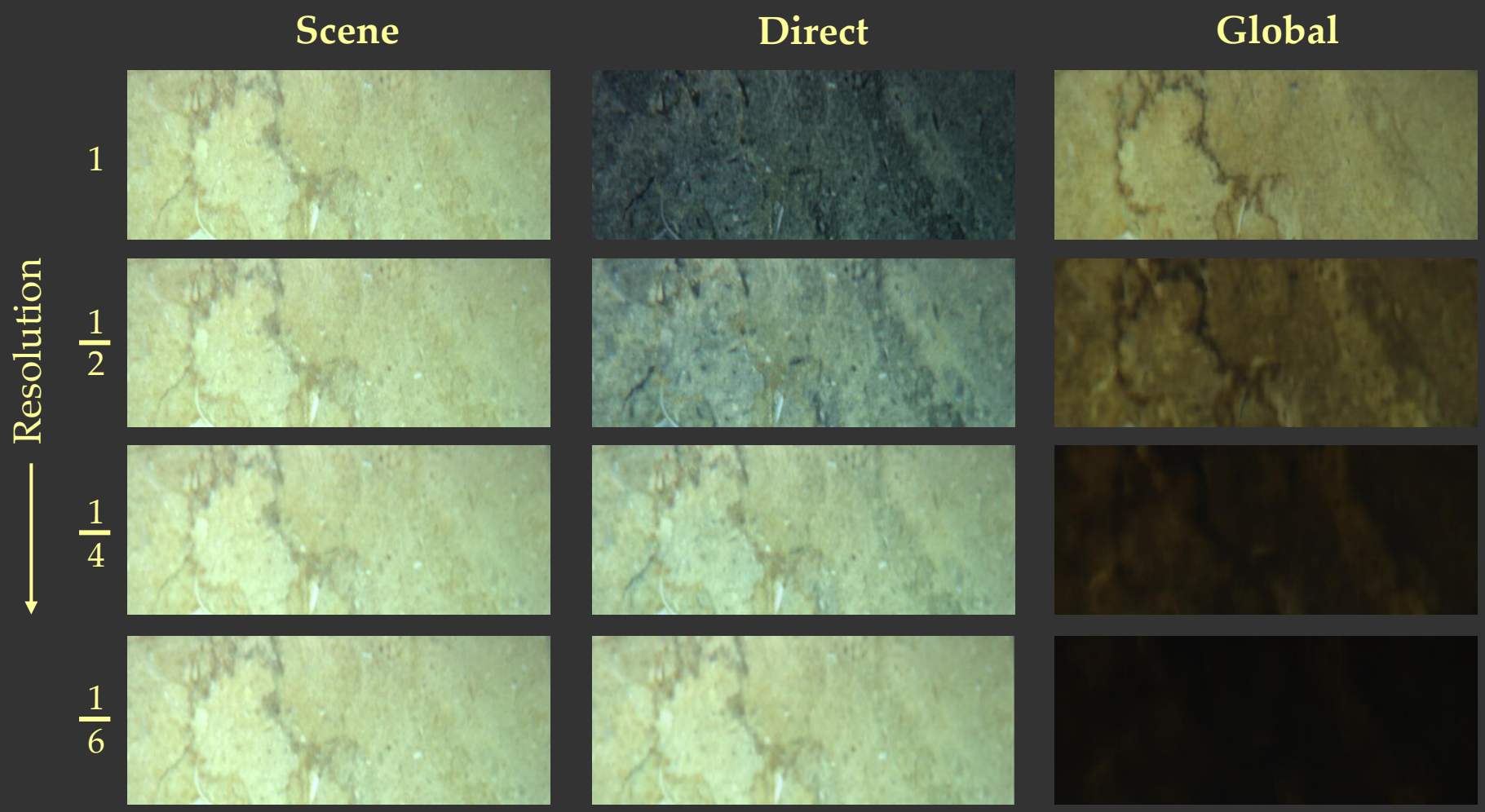
Translucent Rubber Balls

Direct



Global

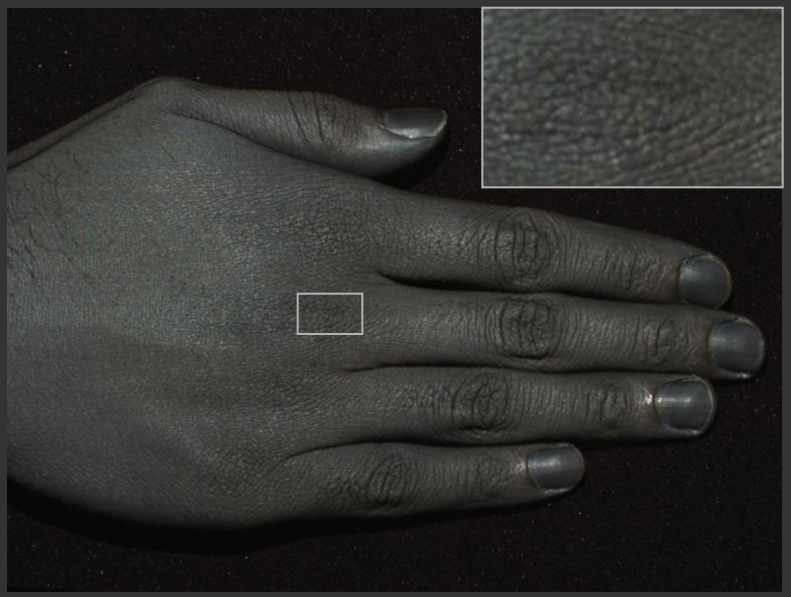
Marble: When BSSRDF becomes BRDF



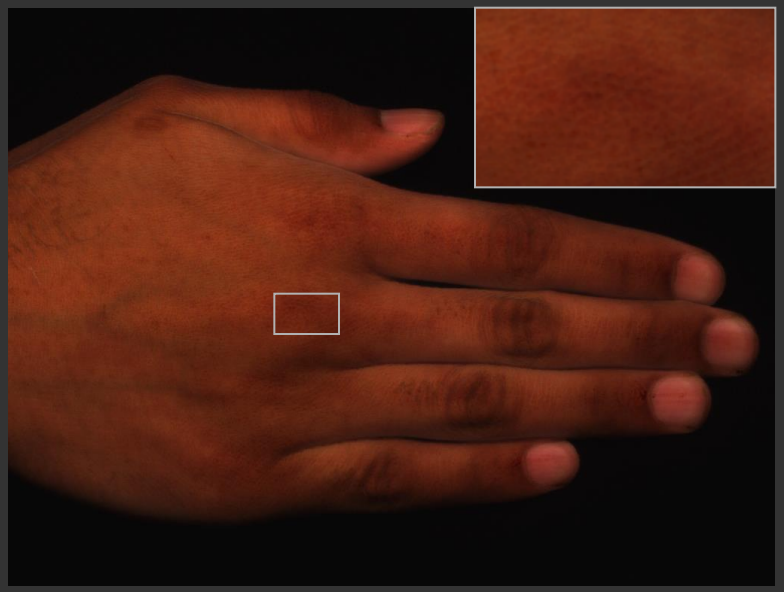
Subsurface Measurements:
Jensen et al. 01, Goesele et al. 04

Hand

Skin: Hanrahan and Krueger 93, Uchida 96, Haro 01, Jensen et al. 01, Igarashi et al. 05, Weyrich et al. 05



Direct



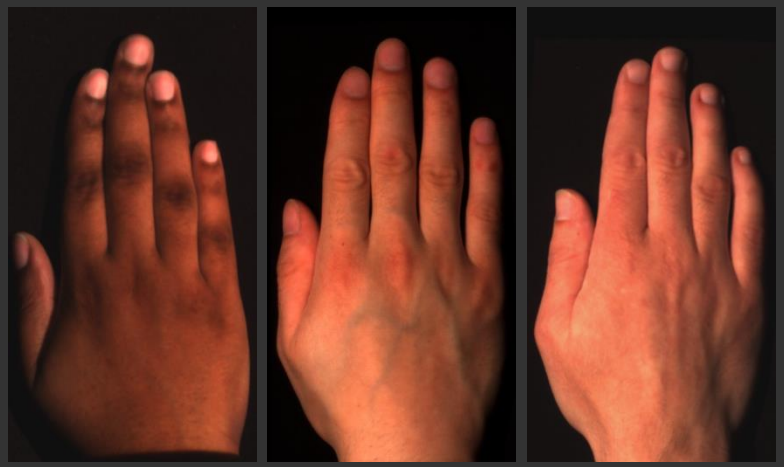
Global

Hands

Afric. Amer. Female | Chinese Male | Spanish Male

Afric. Amer. Female | Chinese Male | Spanish Male

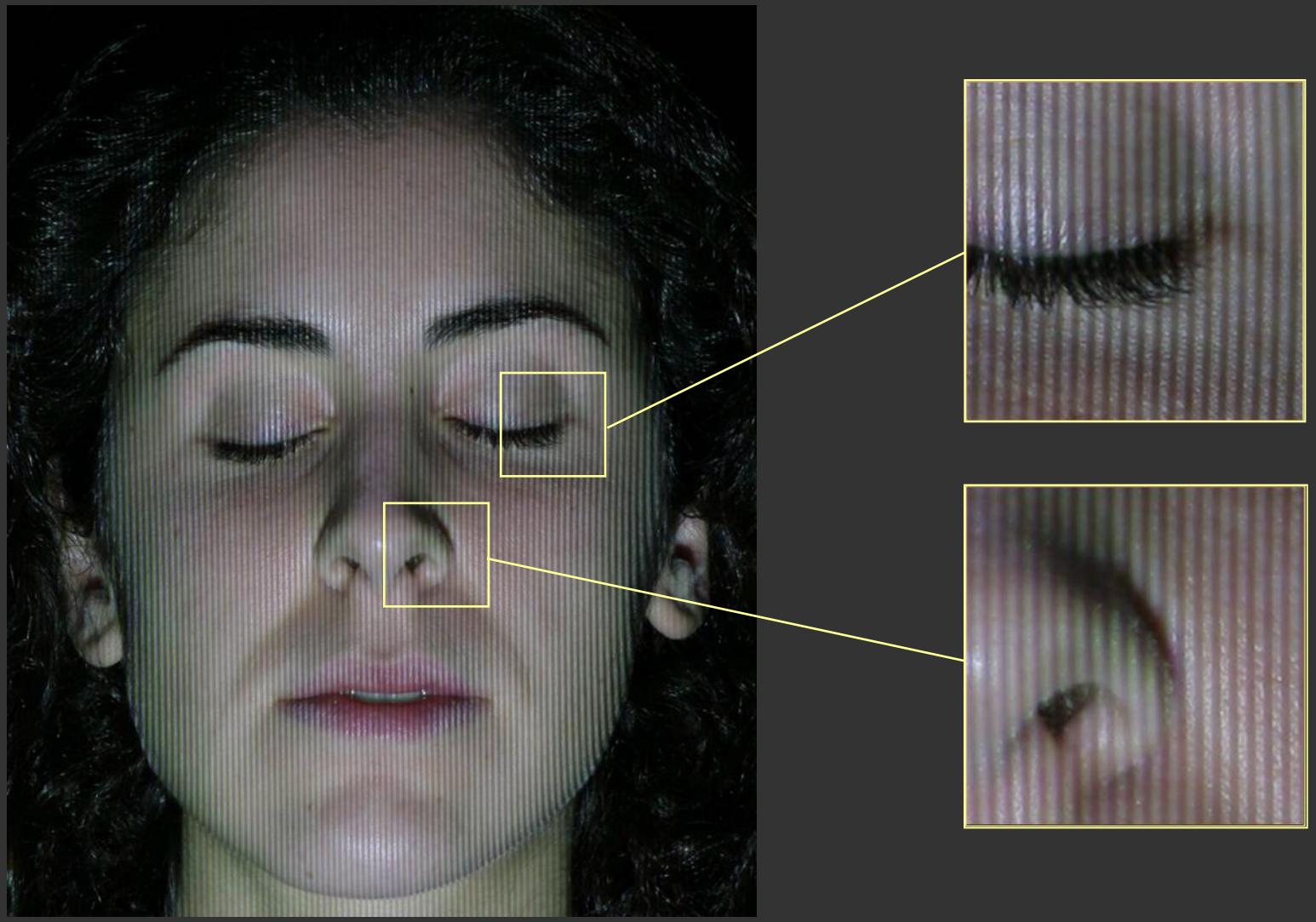
Direct



Afric. Amer. Female | Chinese Male | Spanish Male

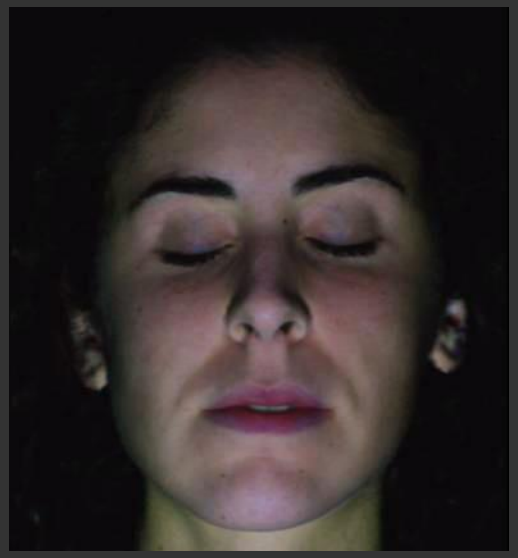
Global

Separation from a Single Image

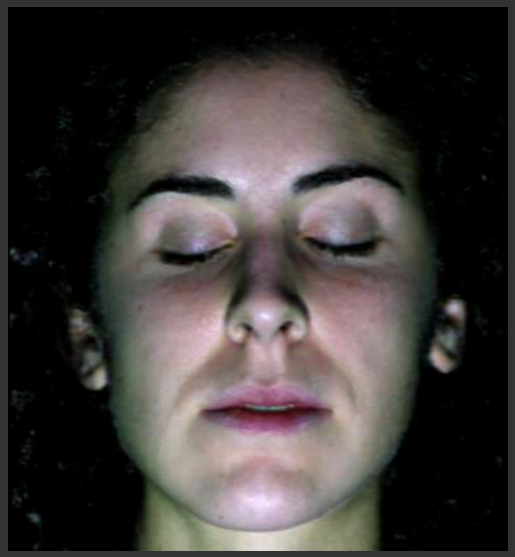


Face

Direct

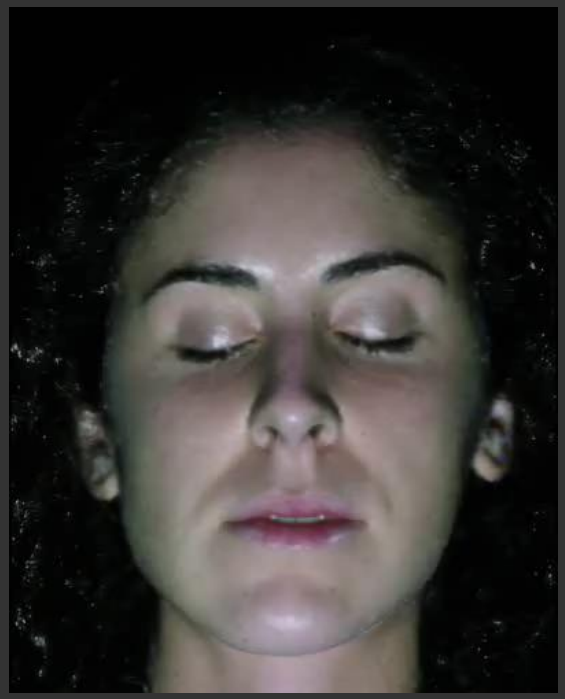


Global



Sum

Skin Tone Control

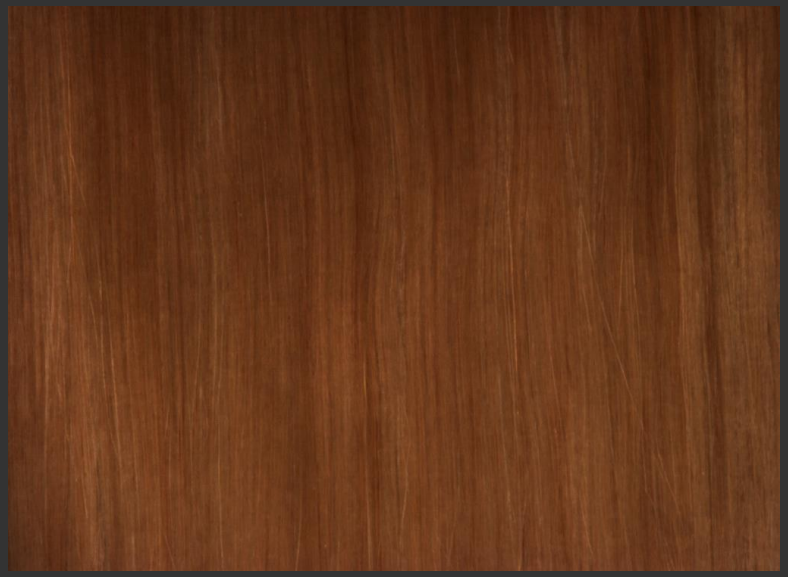


Skin Color and Lipids:
Tsumura et al. 03

Blonde Hair

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

Direct



Global

Hair: Bidirectional Texture Function

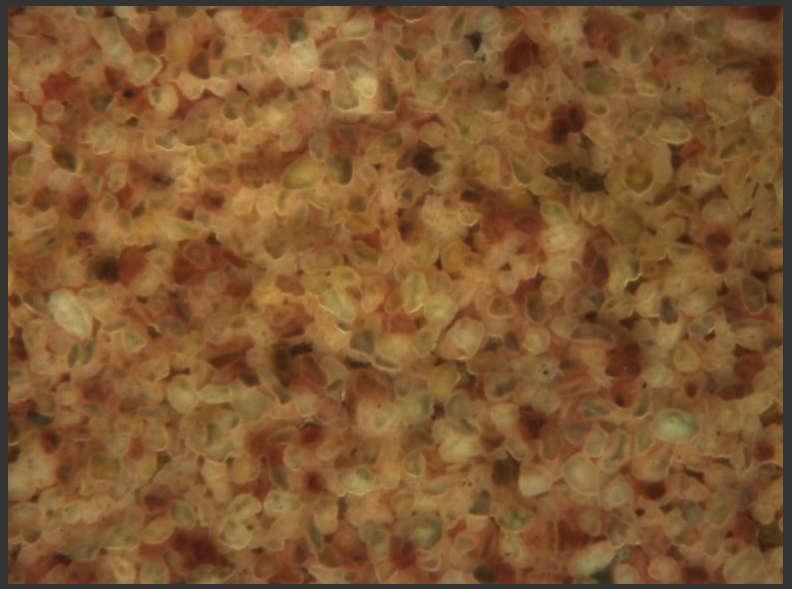
Hair

Direct

Global

Pebbles: 3D Texture

Direct



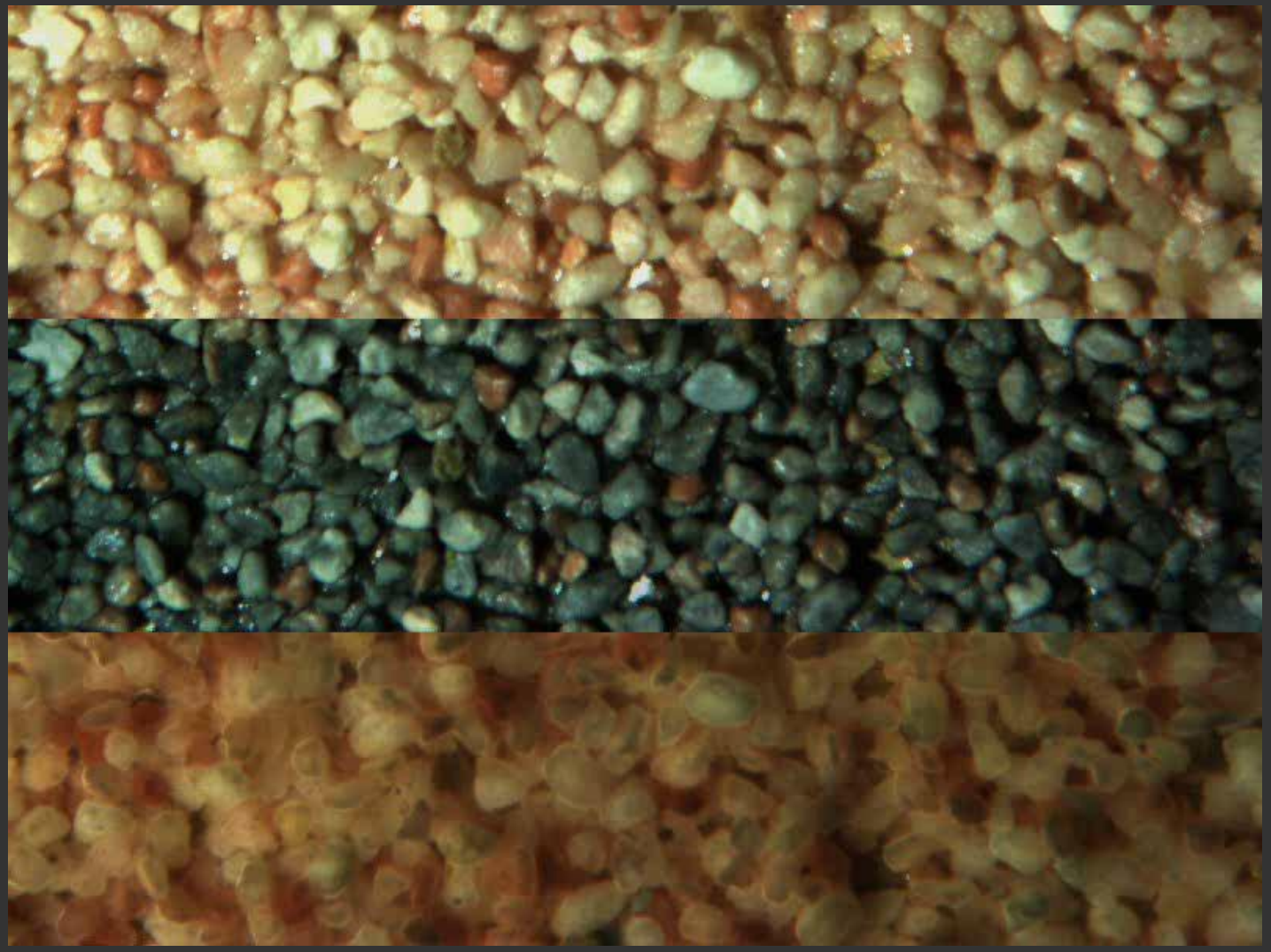
Global

Pebbles: Bidirectional Texture Function

Pebbles

Direct

Global



Pink Carnation

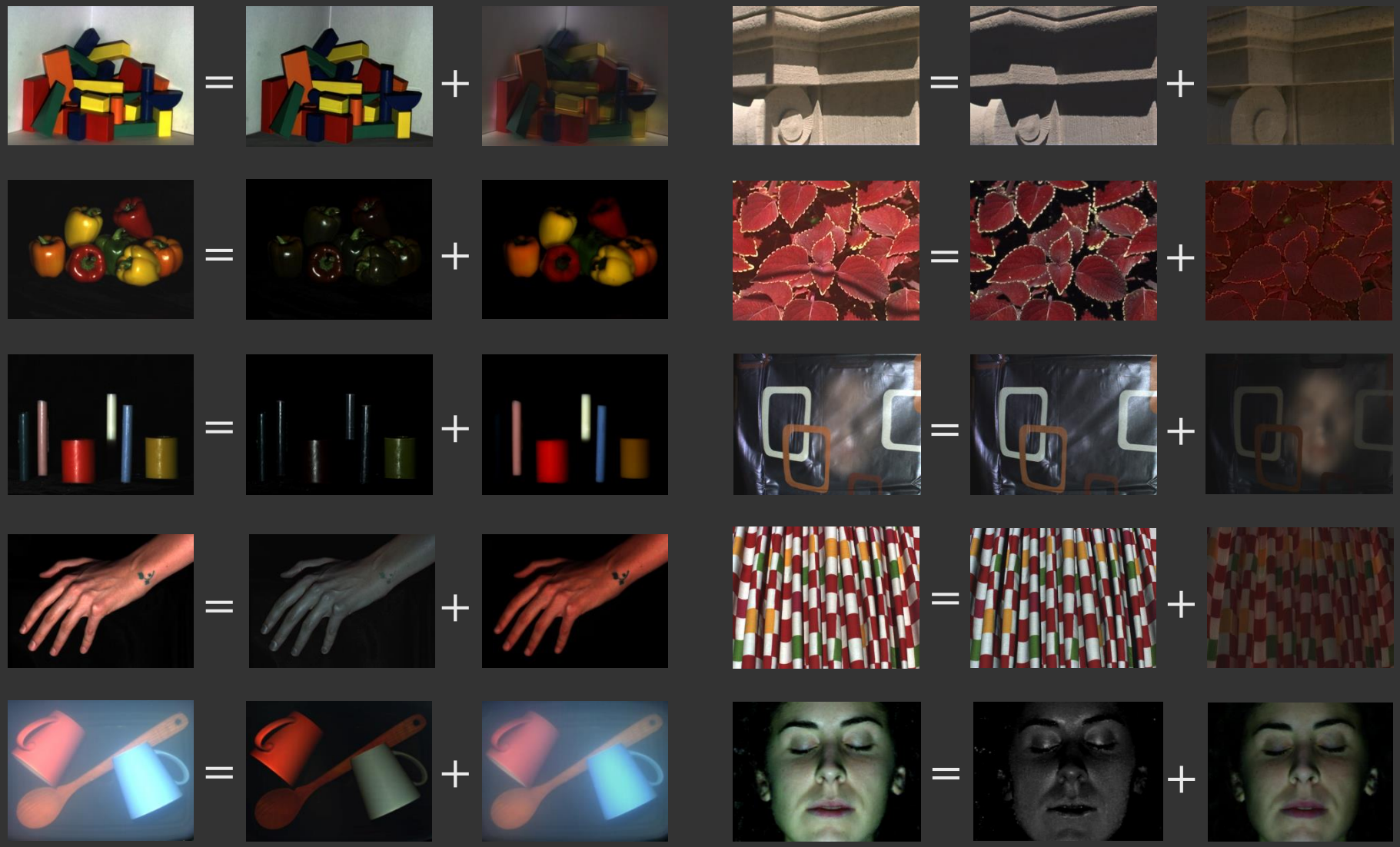
Spectral Bleeding: Funt et al. 91

Direct

Global

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



www.cs.columbia.edu/CAVE