Environment Matting and
BRDF’s

Topics in Image-Based Modeling and Rendering
CSE291 J00
Lecture 11

Environment Matting & Compositing

• D. Zonker, D.M. Werner, B. Curles and D.H. Salesin
  Environment Matting and Compositing ,  SIGGRAPH 1999, pp. 205-214

• Yung-Yu Chuang, Douglas E. Zongker, Joel Hindorff, Brian Curless, David H. Salesin, Richard Szeliski,
  Environment matting extensions: towards higher accuracy and real-time capture, SIGGRAPAPH 2000, pp. 121 - 130
Environment Matting

- Capture way light rays from background interact with foreground object – e.g. transparent/specular object

- Imagine if foreground object is a magnifying glass.

Environment Matte

Basic Assumption: Single ray into object, single ray out.
Environment Matting Equation

\[ C = F + (1 - \alpha)B + \Phi \]

- \( C \): Rendered color
- \( F \): Foreground color
- \( B \): Background color
- \( \alpha \): Only masking: \{0,1\}
- \( \Phi \): Contribution of light from the environment that reflects from or refracts through the object.

Background Textures
Explanation of $\Phi$

$$\Phi = \sum_{i=1}^{m} R_i M(T_i, A_i)$$

$R_i$: Reflectance coefficient
$M$: Texture mapping operator for axis-aligned rectangle ($A_i$) of texture ($T_i$)
Sunflower/Hurricane Movie
Environment Matte Example

Alpha Matte  Environment Matte  Photograph

Environment Matte Example

Alpha Matte  Environment Matte  Photograph
Environment Matte Example

Alpha Matte          Environment Matte          Photograph

Environment Matte Example

Alpha Matte          Environment Matte          Photograph
Movies

Glass block movie

Goblet movie

Morphing

Extensions

1. How might you do this right?

2. Higher accuracy – O(k) backgrounds

3. Real time
Compositing to match lighting


Image Acquisition
A Dataset from onesphere

Video Compositing of Real Objects

Video Footage

Radiance Map
Compositing: Computing Pixel Values

$$\begin{array}{c}
\text{Shadows and Interreflections} \\
\text{Radiance Scale Factor, } m
\end{array}$$
Compositing: Computing Pixel Values

A composited object
Compositing Real Objects in Video

Compositing Real Objects in Video
from Image Based Modeling and Rendering of Surfaces with Arbitrary BRDFs

BRDF
Reflectance vs. Texture

- Reflectance: How light is scattered at a single point on the surface
- Texture: Characteristic variation in reflectance and visible geometry across the surface.
- Distinction depends on scale

How to characterize reflectance properties?

- Reflectance is defined for a small surface patch.
- Reflectance is an intrinsic surface property, independent of illumination.
**BRDF**

- Bi-directional Reflectance Distribution Function
  \[ \rho(\theta_{\text{in}}, \phi_{\text{in}}; \theta_{\text{out}}, \phi_{\text{out}}) \]

- Function of
  - Incoming light direction: \( \theta_{\text{in}}, \phi_{\text{in}} \)
  - Outgoing light direction: \( \theta_{\text{out}}, \phi_{\text{out}} \)

- Ratio of incident irradiance to emitted radiance

**Surface Reflectance Models**

**Common Models**

- Lambertian
- Phong
- Physics-based
  - Specular
    - [Blinn 1977], [Cook-Torrance 1982], [Ward 1992]
  - Diffuse
    - [Hanrahan, Kreuger 1993]
  - Generalized Lambertian
    - [Oren, Nayar 1995]
  - Thoroughly Pitted Surfaces
    - [Koenderink et al 1999]
- Phenomenological
  - [Koenderink, Van Doorn 1996]

**Arbitrary Reflectance**

- Non-parametric model
- Anisotropic
- Non-uniform over surface
- BRDF Measurement
  - [Dana et al. 1999]
Physically-based models

- Example: He-Torrance-Sillion-Greenberg model

Model Parameters: spectral sensitivity function; complex index of refraction; surface height RMS deviation and autocorrelation length.

A couple 2-D slices of the 4-D BRDF

Cook-Torrance-Sparrow BRDF

\( \theta_s = 10^\circ \)

\( \theta_s = 20^\circ \)

\( \theta_s = 40^\circ \)
BRDF

\[ f_r(p, \theta_i, \phi_i, \theta_e, \phi_e) \]

Bidirectional Subsurface Scattering Reflectance Distribution Function

BSSRDF

\[ S(p_i, \theta_i, \phi_i, p_e, \theta_e, \phi_e) \]

Bidirectional Subsurface Scattering Reflectance Distribution Function
Isotropic BRDF
BRDF is constant over rotation about surface normal
Isotropic BRDF has 3-DOF

Off Specular Reflection

Adapted from Steve Marschner
Backscatter

Adapted from Steve Marschner