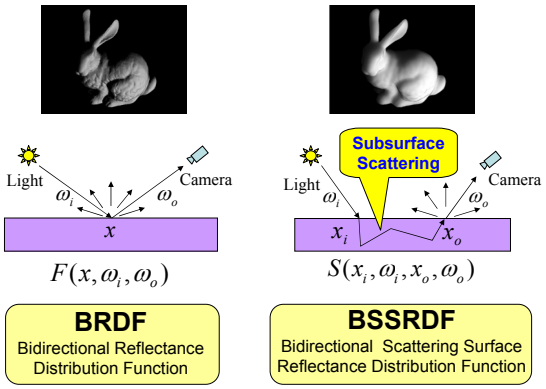
Analysis of Subsurface Scattering under Generic Illumination

Y.Mukaigawa, K.Suzuki, Y.Yagi (Osaka University, JAPAN)

Subsurface Scattering

Opaque object **Translucent object**



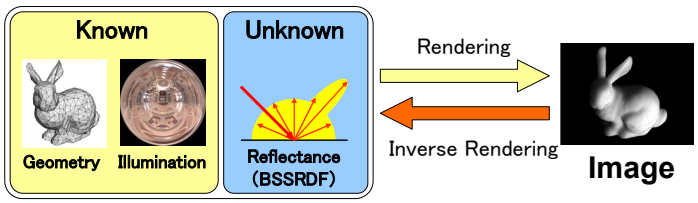
BRDF
Bidirectional Reflectance Distribution Function

BSSRDF
Bidirectional Scattering Surface Reflectance Distribution Function

Purpose

Input: single image, geometry, illumination

Output: parameters of BSSRDF model



Analysis of Subsurface Scattering

Dipole approximation for BSSRDF model [Jensen et al. 2001]

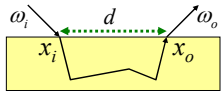
Fresnel function

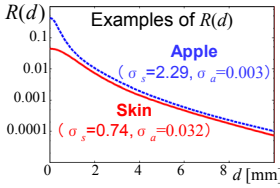
$$S(x_i,\omega_i,x_o,\omega_o) \approx F_{t,i}(\eta,\omega_i)\, R(d)\, F_{t,o}(\eta,\omega_o)$$

Diffuse subsurface reflectance

Diffuse subsurface reflectance: $R(d)$

- defined by inherent parameters of the material
  - * scattering coefficient σ_s
  - * absorption coefficient σ_a



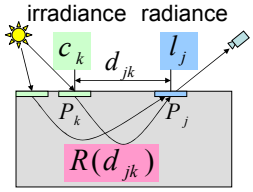


Estimation of $R(d)$

ill-posed problem

$$l_j = \sum_{k=1}^{m} R(d_{jk})\, c_k$$

(l_j: known; $R(d_{jk})$: unknown; c_k: known)



Quantization of distance d

d_{jk}, $R(d_{jk})$ → $d'_1, d'_2, \ldots, d'_n$; $R'_1, R'_2, \ldots, R'_n$

mxm unknowns → n unknowns

well-posed problem

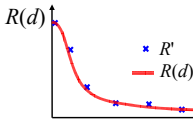
$$l_j = \sum_{i=1}^{n} R'_i\, c'_{ji}$$

(l_j: known; R'_i: unknown; c'_{ji}: known)

Model fitting to estimated R'_i

$$\arg\min_{\sigma_s,\sigma_a} \sum_{i=1}^{n} (R'_i - R(d'_i))^2$$

parameter estimation → σ_s, σ_a

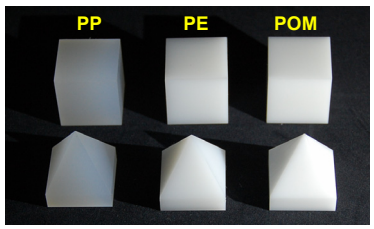


Experimental results

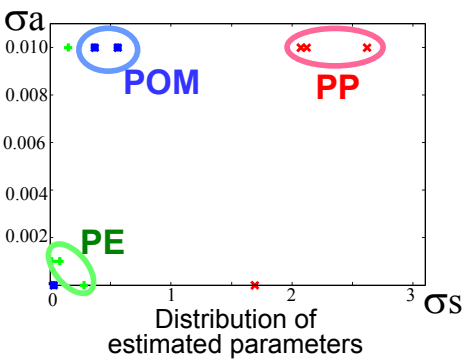
Target objects:

Three materials
- polypropylene (PP)
- polyethylene (PE)
- polyoxymethylene (POM)

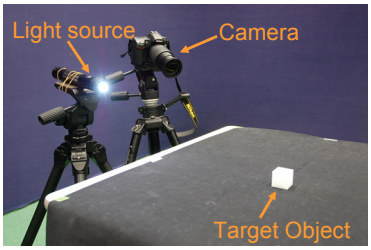
Two shapes
- cube
- pyramid



Target objects



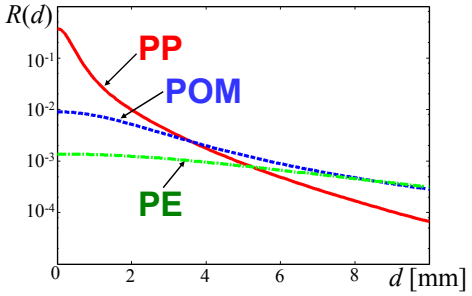
Distribution of estimated parameters



Experimental setup

		Cube		Pyramid		
		right	left	right	left	
PP						Average
	σs	2.62	1.69	2.07	2.12	2.13
	σa	0.010	0.000	0.010	0.010	0.008
PE						Average
	σs	0.01	0.08	0.28	0.15	0.13
	σa	0.001	0.001	0.000	0.010	0.003
POM						Average
	σs	0.03	0.37	0.56	0.37	0.33
	σa	0.000	0.010	0.010	0.010	0.08

Estimated parameters for each image



Diffuse subsurface reflectance