Daisuke Miyazaki, Robby T. Tan, Kenji Hara, Katsushi Ikeuchi,
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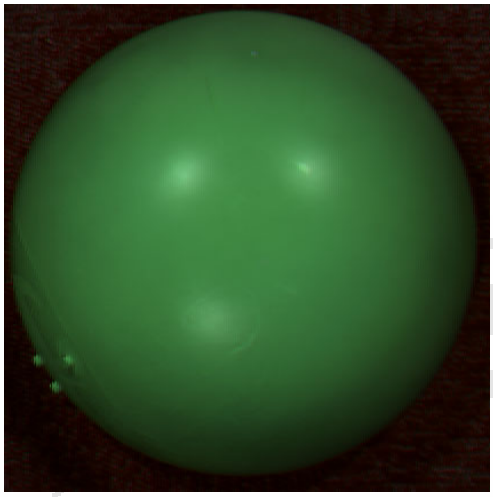
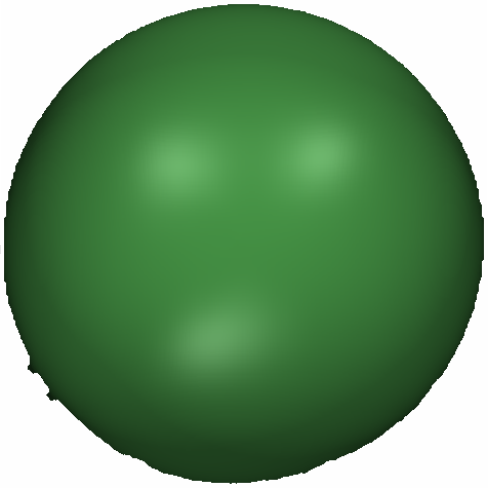
Polarization-based Inverse Rendering from a Single View

Daisuke Miyazaki, Robby T. Tan, Kenji Hara, Katsushi Ikeuchi

ICCV proceeding pp.982-987



Real Image



Synthesized Image

◆Abstract

By observing the polarization state of the object from a single view, we estimated the 3D shape of the object, reflection parameters of the object such as albedo and surface roughness, and also estimated the illumination distribution.

◆Method

1. Separate input images into specular component image and diffuse component image.
2. Calculate the polarization data from diffuse component images.
3. Estimate the surface shape from the polarization data.
4. Estimate the direction of light sources from specular component image.
5. Estimate diffuse albedo, specular albedo, and surface roughness.

Inverse Rendering Methods

	Shape	Diffuse Reflection Parameter	Specular Reflection Parameters	Illumination Distribution
Unten & Ikeuchi 2003	⊘	✓	⊘	✓
Du et al. 2003	⊘	✓	⊘	✓
Rahmann 1999	✓	⊘	⊘	✓
Pentland 1990	✓	✓	⊘	✓
Zheng & Chellapa 1991	✓	✓	⊘	✓
Nayar et al. 1996	✓	✓	⊘	✓
Kim et al. 1998	✓	✓	⊘	✓
Yilmaz & Shah 2002	✓	✓	⊘	✓
Weber et al. 2002	✓	✓	⊘	✓
Nayar et al. 1990	✓	✓	✓	⊘
Kiuchi & Ikeuchi 1993	✓	✓	✓	⊘
Sato & Ikeuchi 1994	✓	✓	✓	⊘
Solomon & Ikeuchi 1996	✓	✓	✓	⊘
Tominaga & Tanaka 2000	✓	✓	✓	⊘
Ikeuchi & Sato 1991	⊘	✓	✓	✓
Sato et al. 1999	⊘	✓	✓	✓
Ramamoorthi & Hanrahan 2001	⊘	✓	✓	✓
Nishino et al. 2002	⊘	✓	✓	✓
Hara et al. 2003 [yesterdayís poster #19]	⊘	✓	✓	✓
Our method [Miyazaki et al. 2003]	✓	✓	✓	✓

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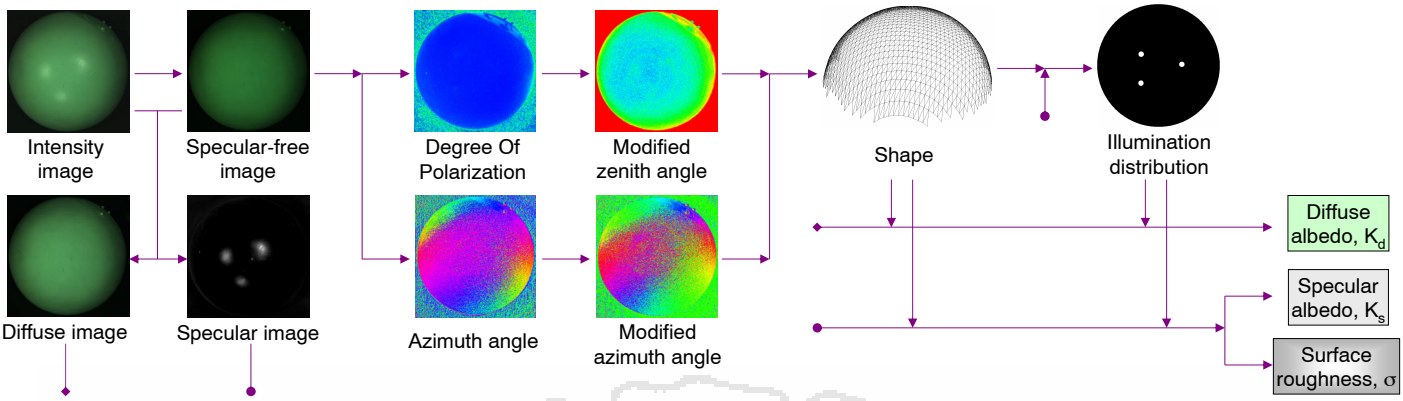
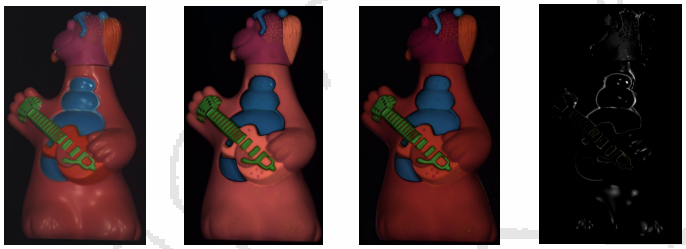
Outline

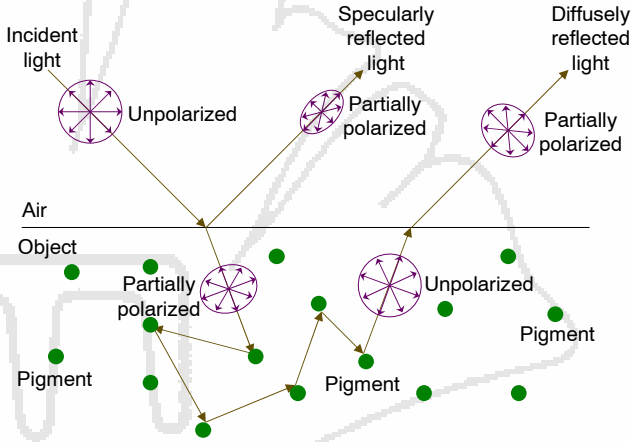


Separating Reflection Components

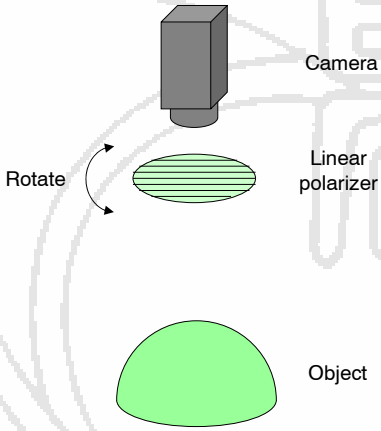


See todayís poster #7 [Tan & Ikeuchi] for more detail

Diffuse Light and Polarization

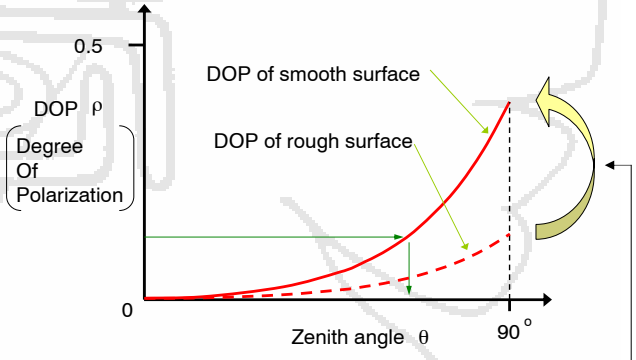


Acquisition System



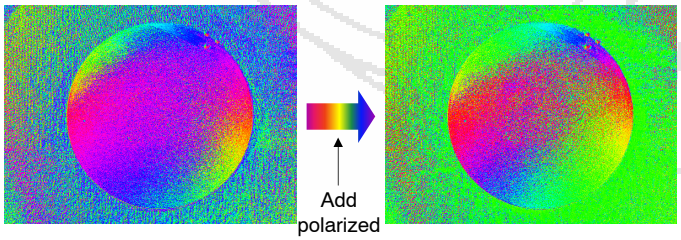
DOP (Degree Of Polarization)

$$\rho = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{(n - 1/n)^2 \sin^2\theta}{2 + 2n^2 - (n + 1/n)^2 \sin^2\theta + 4\cos\theta\sqrt{n^2 - \sin^2\theta}}$$



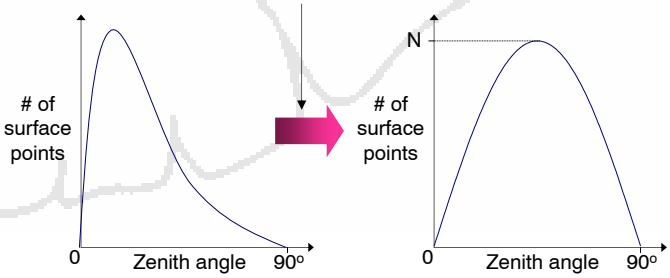
Raise DOP by histogram modification

Unpolarized World Algorithm



Azimuth angle image calculated from input polarization image

Azimuth angle image modified under unpolarized-world assumption



Assumption
histogram of θ of object = histogram of θ of hemisphere

Affected by surrounding ambient light

Ambient light is canceled out by assuming the ambient light as a polarized light

◆Errata in proceedings p.985

- **✧ì 4.3. Histogram Modificationî last paragraph, first sentence**
- **✧Wrong: Histogram of hemisphere will be 2Nsinθ**
- **✧Right: Histogram of hemisphere will be Nsin2θ**

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Reflection Parameter Estimation

Torrance-Sparrow model

$$I = K_d \int \cos\theta_i + K_s \frac{1}{\cos\theta_r} \int e^{-\frac{\alpha^2}{2\sigma^2}}$$

Observed intensity

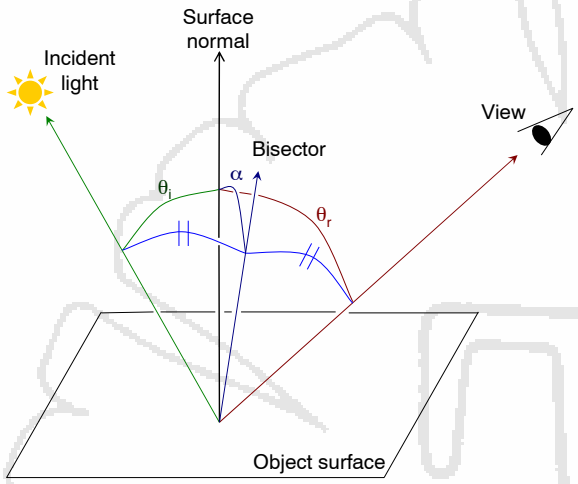
Diffuse reflection intensity

Specular reflection intensity

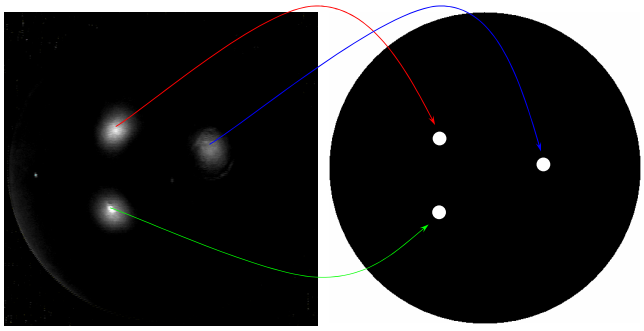
Diffuse albedo

Specular albedo

Surface roughness



Illumination Estimation

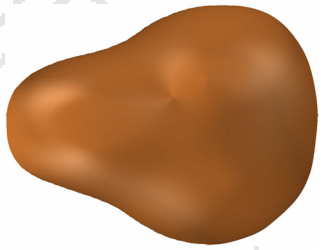


Specular reflection image

Illumination distribution

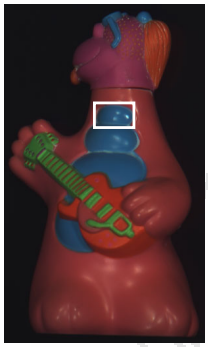
Result of Pear Object

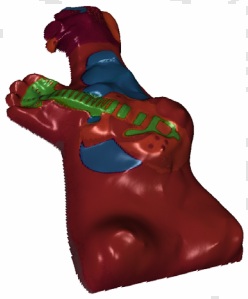
Real image



Rendered image

Result of Dinosaur Object

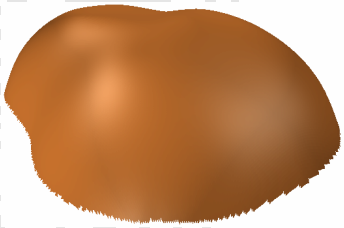




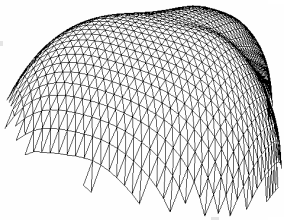
Real image

Estimated shape

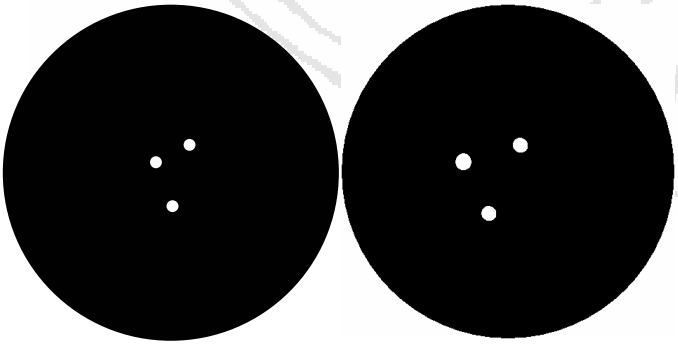
Rendered image



Rendered image



Estimated shape



Estimated illumination

True illumination

Future Work

- ◆**Evaluation of the precision**
- ◆**Improvement of the precision**
  - ✧**by using shading information**
  - ✧**by using multiple data taken under different illuminations**
  - ✧**by using multiple data taken from different views**
- ◆**Extend the method to**
  - ✧**model a whole indoor scene (by using multiple data taken from different views)**
  - ✧**render photorealistic image of complicated scenes from IBR(image-based rendering) approach with considering surface normal information (by using multiple data taken from different views)**
  - ✧**model 3D shape of translucent objects (by combining with Transparent Surface Modeling technique: see tomorrowís poster #21 [Miyazaki et al.])**