

Image-Based Rendering of Diffuse, Specular and Glossy Surfaces from a Single Image

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- **Main objectives of the paper**
 - Approximation of all reflectances using :
 - A single original image with no particular constraint for the viewpoint
 - A 3D geometrical model of the scene
 - Creation of a synthetic image keeping :
 - The real properties of the materials
 - The best visual approximation in comparison to the original image



- **Previous work in inverse rendering using global illumination and a full 3D scene (1/2)**
 - Estimation of perfectly diffuse reflectances
 - Single image :
 - Fournier et al., GI'93 [14]
 - Gagalowicz, Book 94 [28]
 - Drettakis et al., EGWR'97 [11]
 - Multiple images :
 - Debevec, SIGGRAPH 98 [7] (manually for non-diffuse)
 - Loscos et al., IEEE TVCG'00 [24]

Automatic reflectance recovery only for perfectly diffuse surfaces



- **Previous work in inverse rendering using global illumination and a full 3D scene (2/2)**
 - Full BRDF estimation (anisotropy)
 - Set of images:
 - Yu et al., SIGGRAPH 99 [41]
 - 150 original images
 - Scene captures under specific viewpoints to compute BRDFs (capture of highlights)
 - Single image:
 - None
 - This paper

- **Our method**
 - Data
 - 3D geometrical model of the scene
 - Objects are grouped by type of reflectance
 - One single image captured from the scene
 - First Result
 - Reflectance approximation for diffuse, specular (perfect and non-perfect), isotropic, anisotropic, textured surfaces
 - Second Result
 - Synthetic Image imitating the original one (multiple possible applications)

- **General overview of our technique**
 - Minimizing the error computed from the difference between the real and the synthetic image
 - Choosing an hypothesis regarding reflectances

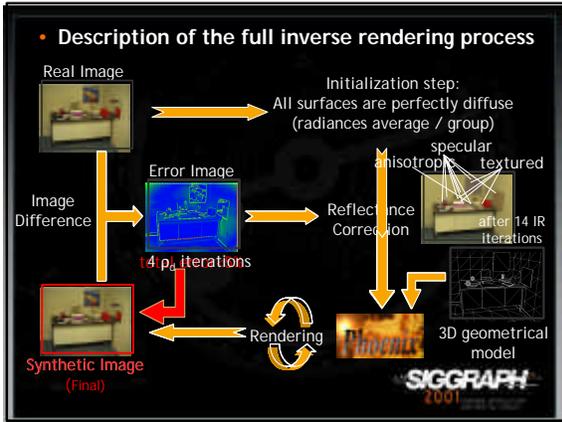
Enhancing as much as possible this hypothesis (maximal reduction of computed error)

Iterative Principle

If the error is too big then change the hypothesis

Hierarchical Principle





• **The case of perfectly diffuse surfaces ($r_d = 1, r_s = 0$)**

- Average of the radiances covered by the projection of the group in the original image
- Iterative correction of the diffuse reflectance p_d using this average value
 - ↳ Computation of the error between the real and the synthetic image
 - ↳ if error > threshold then group is perfectly specular

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• **The case of perfectly specular surfaces ($r_s = 1, r_d = 0$)**

- The simplest case because p_d and p_s are constant
- Computation of the error between the real and the synthetic image
 - ↳ if error > threshold then group is non-perfectly specular

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• **The case of non-perfectly specular surfaces ($r_s = 1, r_d = 0$)**

- Iterative correction of p_s minimizing the error between the real and the synthetic image
- Computation of the error between the real and the synthetic image
 - ↳ if error > threshold then group is diffuse and specular
 - ↳ if error > 50% then group is textured

Experimental Heuristic

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• **The case of both diffuse and specular surfaces ($r_s = 1, r_d = 0$, no roughness)**

- Minimized error is a function of two parameters (direct analytical solution)
- Computation of the error between the real and the synthetic image
 - ↳ if error > threshold then group is isotropic

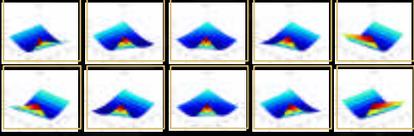
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• **The case of isotropic surfaces ($r_d, r_s = 0, a$)**

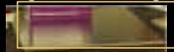
- Direct minimization with p_d, p_s and α with $p_s = 1$ computed separately

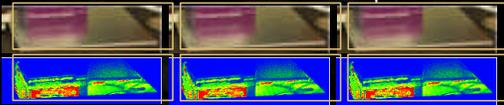
- Computation of the error between the real and the synthetic image
 - ↳ if error > threshold then group is anisotropic

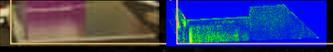
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- The case of anisotropic surfaces
 $(r_d, r_s^{-1} \mathbf{0}, a_x, a_y, \vec{x})$
 - Minimization with $\alpha_x, \alpha_y, \vec{x}$
 - Several minima
 What are the resulting images ?

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Original real image


Synthetic images without direct estimation of the anisotropic direction


unsatisfactory
 with direct estimation of the anisotropic direction


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- The case of textured surfaces
 - « Simple » because too few elements
 - Impossible to separate specular reflection and/or shadows from texture itself
 - Computation of an intermediate texture which balances the extracted texture (to take into account illumination)

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- Some inverse rendering results

~32 minutes



100% Material, 100% Specular, 100% Shadow

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- Some applications in Augmented Reality



Illumination control
 + Geometry control

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- Conclusion
 - New inverse rendering method

| Advantages | Disadvantages |
|--|---|
| <ul style="list-style-type: none"> ✓ One single image ✓ Various types of reflectances ✓ « Simple » idea ✓ Immediate extensions | <ul style="list-style-type: none"> • Textures are hard to take into account • Particular cases (2 anisotropic surfaces) |

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• Future Work

- Testing other BRDF models
- Solving the « texture problem » (2 images ?)
- Testing the algorithm using a scene under direct illumination conditions and/or with multiple colored light sources
- Automatic positioning of mirrors and light sources and adaptive meshing of objects
- Participating media (fire, smoke, ...) using a new volume hierarchy (bounding volume)

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