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

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- **Previous Work in Inverse Rendering using global illumination and a full 3D scene**
  - Estimation of perfectly diffuse reflectances
    - Single image: Fournier93 [14], Gagalowicz94 [28], Drettakis97 [11]
    - Multiple images: Loscos99 [23], Loscos00 [24]

      ⮡ Limited to perfectly diffuse surfaces
  - Full BRDF estimation (anisotropy)
    - Set of images: Yu99 [41]

      ⮡ 150 images

      ⮡ Scene captures under specific viewpoints to compute BRDFs

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- **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 → Image Synthesis imitating the original one (multiple possible applications)

General overview of our method

- Minimizing the error computed from the difference between the real and the synthetic image
- Choosing an hypothesis regarding reflectances

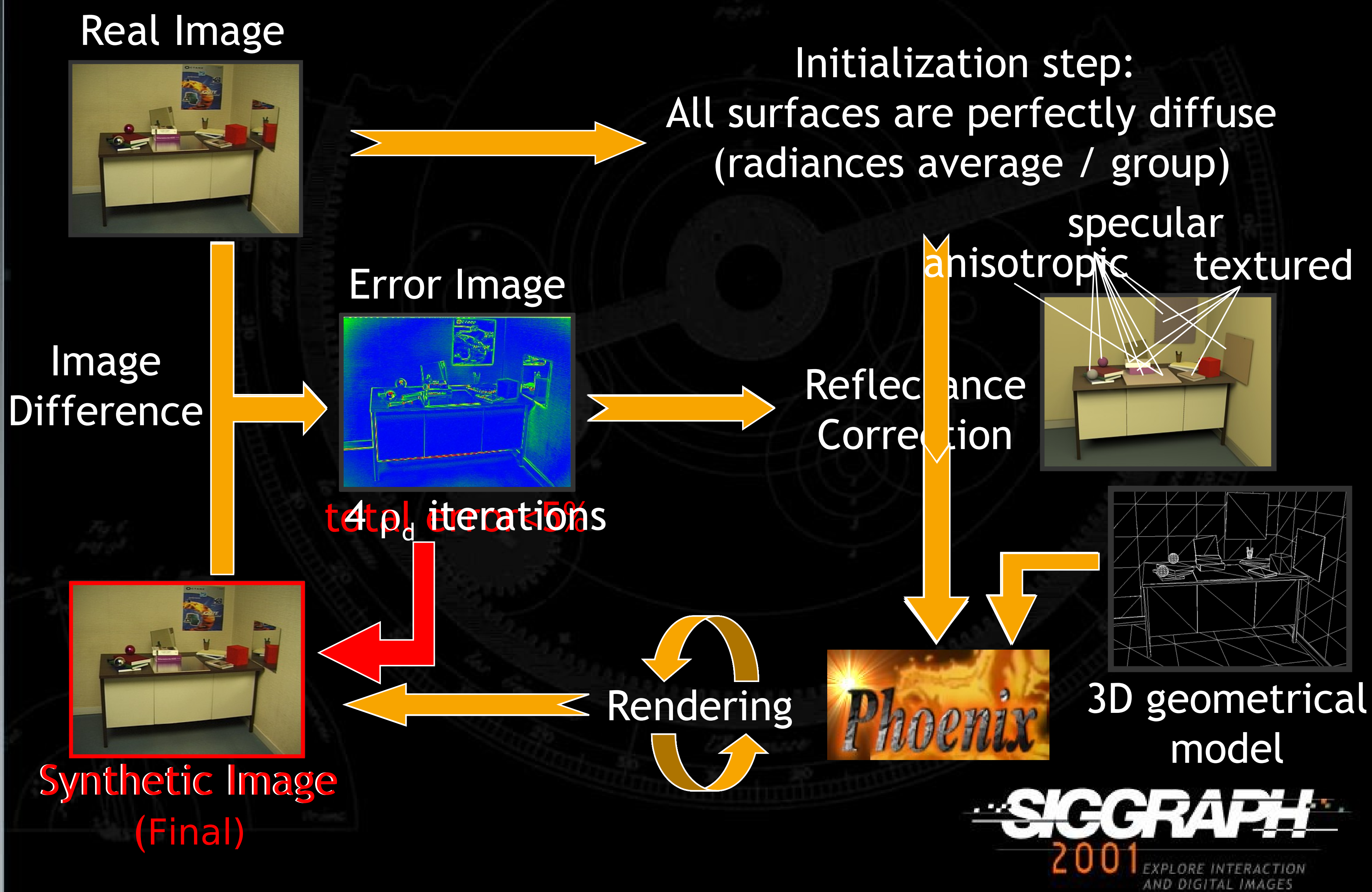
Enhancing as much as possible this hypothesis (maximal reduction of computed error)

Iterative Principle

If the error is too big then changing the hypothesis

Hierarchical Principle

• Description of the full inverse rendering process



- **The case of perfectly diffuse surfaces ($\rho_d \neq 0$)**

  - Average of the radiances covered by the projection of the group in the original image
  - Iterative correction of the diffuse reflectance ρ_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 ($\rho_s = 1$, $\rho_d = 0$)**
  - The simplest case because ρ_d and ρ_s are constant
  - Computation of the error between the real and the synthetic image

    ➔ if error > threshold then group is non-perfectly specular

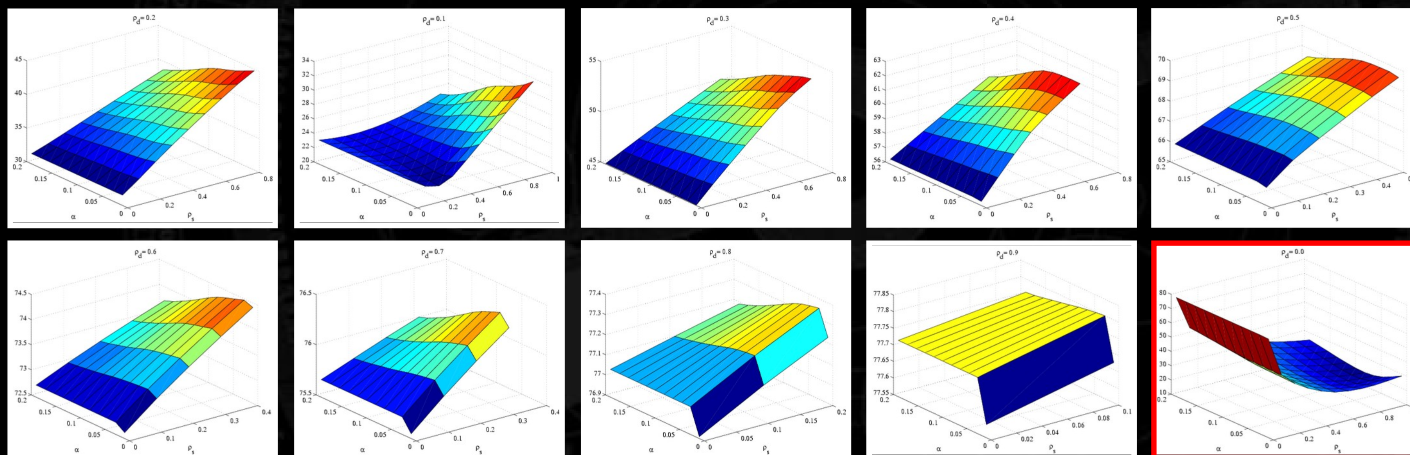
- **The case of non-perfectly specular surfaces ($\rho_s \neq 1, \rho_d = 0$)**
  - Iterative correction of ρ_s minimizing the error between the real and the synthetic image
  - Computation of the error between the real and the synthetic image

Experimental Heuristic:

→ if error > threshold then group is anisotropic

→ if error > 50% then group is textured

- **The case of isotropic surfaces (ρ_d, $\rho_s \neq 0$, α)**
  - Direct minimization with ρ_d, ρ_s and α with $\rho_s = 1$ computed separately



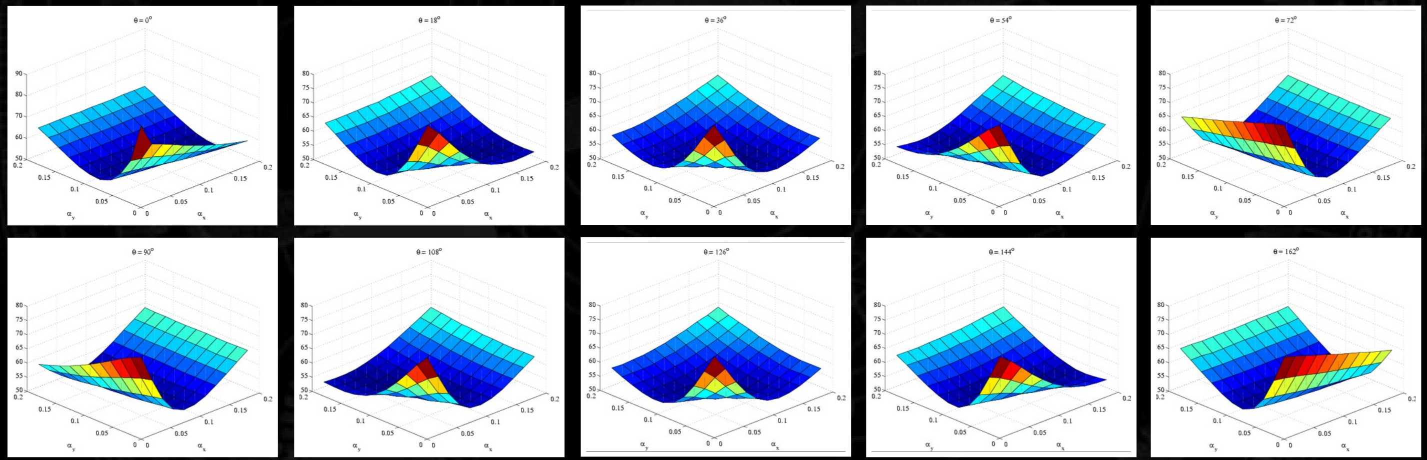
  - Computation of the error between the real and the synthetic image

    if error > threshold then group is anisotropic

- # The case of anisotropic surfaces

  # $(\rho_d, \rho_s \neq 0, \alpha_x, \alpha_y, \overrightarrow{x})$

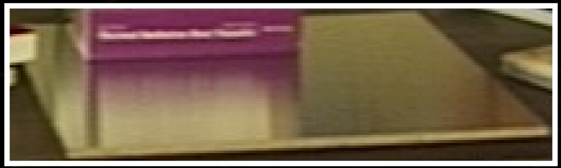
  - Minimization with α_x, α_y, $\overrightarrow{x}$



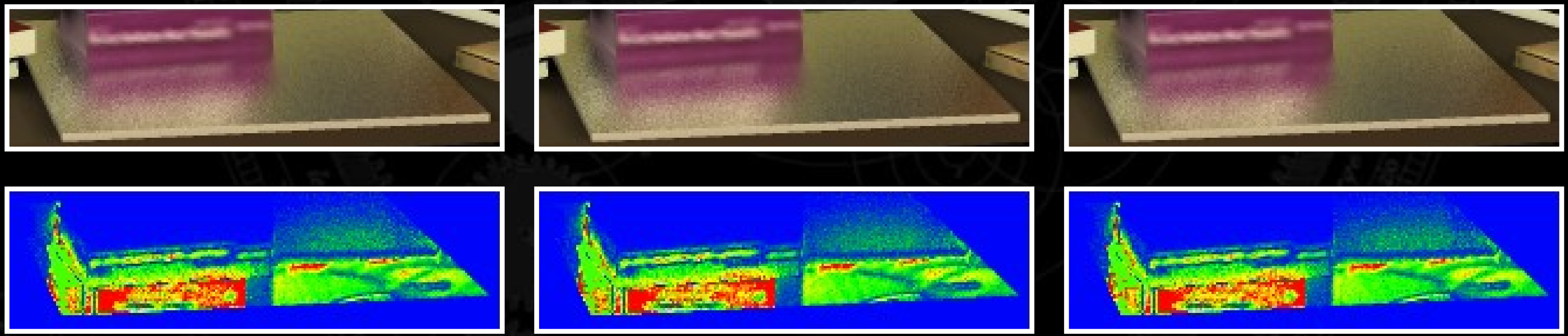
  - Several minima

    ↳ What are the resulting images ?

Original image



Synthetic images rendered using minima



→ unsatisfactory

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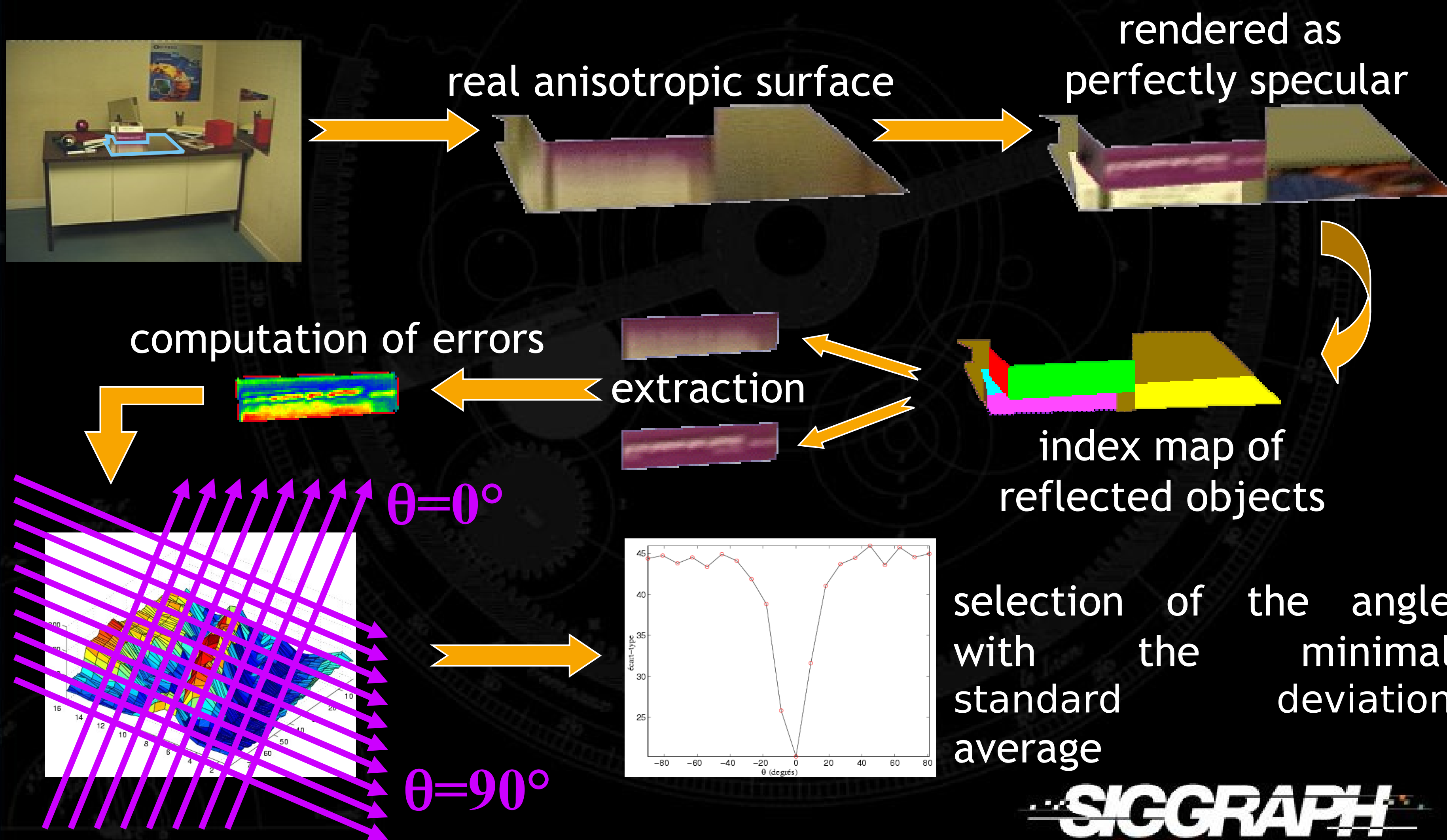
- Direct estimation of the anisotropic direction from the original image



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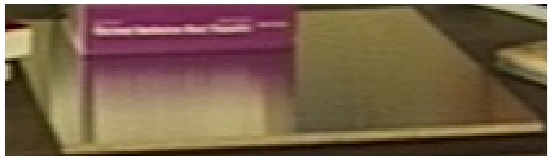
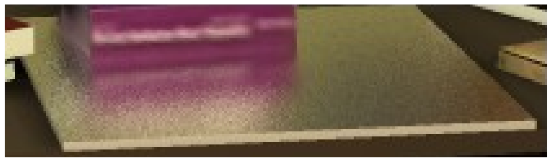
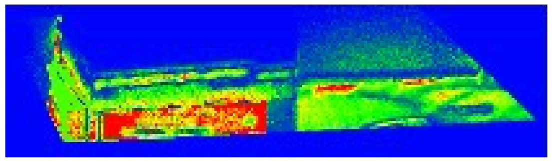
Original real image



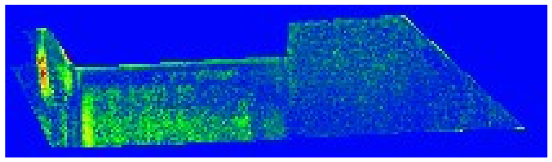
Synthetic image

without direct estimation of the anisotropic direction





with direct estimation of the anisotropic direction



- **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)

- Some inverse rendering results

~4B-4ini30tes

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- **Some applications in Augmented Reality**

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Conclusion

- New inverse rendering method

Advantages	Disadvantages
✓ One single image ✓ Various types of reflectances ✓ « Simple » to code ✓ Immediate extensions	▪ Textures are hard to take into account ▪ Particular cases (2 anisotropic surfaces)

Future Works (1/2)

- Testing other BRDF models (different from Ward)
- Finding a solution to the « texture problem » (2 images ?)
- Testing the algorithm using a scene under direct illumination conditions (specular highlights)
- Testing the method with multiple colored light sources

Future Works (2/2)

- Automatic positioning of mirrors and light sources
- Adaptive meshing of objects to enhance image matching
- Participating media (fire, smoke, …) using a new volume hierarchy (bounding volume)

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