Image-Based Photometric Reconstruction for Mixed Reality

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Traditional illumination process

INPUT

- Geometric data
- Material data
- Lighting data

Global illumination algorithm

Photorealistic synthetic images

OUTPUT
So what is photometric reconstruction?

INPUT

Photographs of real environment

Geometric data

Photometric reconstruction

Material data

Lighting data

OUTPUT
Application: mixed reality

Aim: increase the quality of mixed / augmented reality

Use reconstructed data to:
- Improve shading quality
- Render shadows
- …
Previous work (inverse illumination)

Loscos et al. (EGWR’99 / TVCG’00)
  – Diffuse lights/surfaces

Yu et al. (SIGGRAPH’99)

Boivin and Gagalowicz (SIGGRAPH’01)
  – Known direct illumination

Sato et al. (ICCV’99)
  – Hemispherical distribution (lights at infinity)
Benefits of our approach

1. Incomplete geometric data:
   – Incomplete object geometry
   – Unknown light-source geometry

2. Any mixture of lighting:
   – Interior illumination
   – Natural illumination (sun/skylight)

3. Non-diffuse (Phong) reflectance, texture surfaces
Outline of method

1. Capture high dynamic-range (HDR) images
2. Reconstruct geometry from images
3. Reconstruct photometric data
4. Use data for mixed-reality rendering
HDR image construction
(Debevec and Malik, SIGGRAPH’97)
Geometry reconstruction
Material groups

User groups geometric objects into sets with approximately the same material properties
Photometric reconstruction

Automatically position *virtual light-sources* around reconstructed geometry.
Photometric reconstruction

We want to work out how the virtual light-sources should illuminate our geometry, so surface radiances match the HDR images.
Interreflections

Surfaces already receive illumination from other reconstructed surfaces (Virtual light sources ‘fill in’ the missing light)
Reflectance initialisation

Initialise surface reflectance using *colour-constancy* algorithm (assume all surfaces are diffuse)
Iterative solution method

1. Estimate virtual light-source emission, to match HDR image radiances
2. Re-estimate diffuse / Phong surface reflectance, using new VLS emissions
3. Converged?
   - No
   - Yes: Extract surface detail textures
Interior lighting results

HDR reference image

Synthetic: after 5 iterations

Synthetic: 5 iterations + texture
Interior & natural lighting results

HDR reference image

Synthetic: after 5 iterations

Synthetic: 5 iterations + texture
Synthetic rendering from different view
Synthetic rendering with artificial lights
Synthetic rendering with artificial objects
Augmented HDR animation
Synthetic animation
Synthetic animation
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