

Light-Image Collections

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IMPA

Outline

- Preliminaries
- General Framework
- Image-Based Relighting
- Flash / No-Flash
- Photometric Reconstruction

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Basic Setup

- ★ Variable Illumination
 - Fixed Camera Parameters
 - Fixed Scene
 - Static
 - Small Motion
- *Measure Illumination Effects through Camera*

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Model

- *Illumination Equation*

$$L_o(x, \omega_o) = L_e(x, \omega_o) + \int f_r(x, \omega_i^o) L_o(x', \omega_i) \cos \theta_i d\omega_i$$

- Elements:
 - Light
 - Object Reflectance
 - Camera

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Light and Color

Linear Model

- Vector Space
 - Add
 - Scalar Multiplication
 - Filters
 - Representation
 - Bases
- *Physical Systems (CIE)*

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Reflectance Function

- Ideal Case
 - Diffuse Materials
- Difficult Issues
 - Specularities
 - Shadows / Self-Shadows
 - Inter-Reflections

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Camera

- Lenses
 - Depth of Field
 - Color Aberration
 - Distortion
- Sensors
 - Non-Linear Response
 - Noise Model

➤ Camera Calibration

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Variations

- Same Light Type
 - Vary Position Only
- Different Light Types (e.g. Flash / No-Flash)
 - Intensity
 - Color
 - Position
- Sampling Rate (Photo / Video)
 - Synchronization

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Techniques

- Filter
 - Bilateral
- Blending
 - Poisson
- Segmentation
 - Edge
- Model
 - Dimensionality Reduction

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Applications

- Image-Based Relighting
- Appearance Enhancement
- Image Re-Styling (NPR)
- High Dynamic Range
- Photometric Reconstruction
- Etc...

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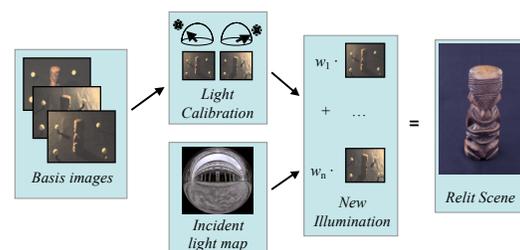
Image-Based Relighting

- Characteristics
 - Same Type of Illuminant
 - Many Images
 - Static Scenes (*)
- Incident Light Map (also an image)

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Overview



[from Masselus 2002]

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Types of Bases

- Spatial
 - Shannon / Haar
- Spectral
 - Spherical Harmonics
- Multi-resolution
 - Wavelets
- Interleaved

➤ *OBS: Parameterization*

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Capturing Image Basis

- Acquisition Mode
 - Structured
 - Unstructured
- Issues
 - Calibration (light directions)
 - Real-time (subject motion)
 - Completeness (sampling)
 - Compression (dimensionality reduction)

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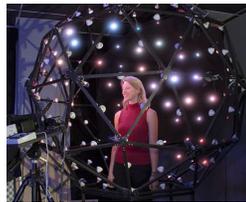
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Light Stage [Debevec]



• *Light Stage 1*



• *Light Stage 3*

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Structured Light Map

- Capturing Incident Illumination



Light Probe



Lat-Long Environment Map

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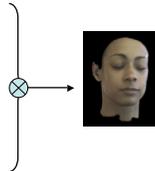
Relighting Computation



Image Basis



Illumination Coefficients

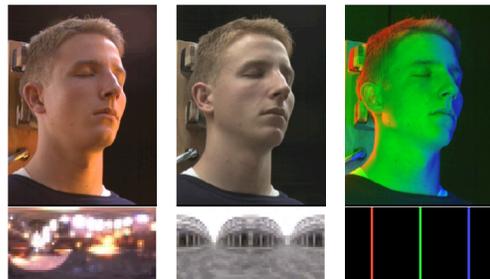


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Examples [Debevec]



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Application [Debevec]

- Mixed Reality



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User Interface [Mohan 2005]

- Painting with Light



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Flash / No Flash

- Characteristics
 - Different Illuminant Types
 - Color
 - Intensity
 - Few Images (e.g. ~ 2)
- Applications
 - Appearance Enhancement
 - Image Re-Styling (NPR)
 - High Dynamic Range

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Appearance Enhancement

- Main Techniques
 - Noise Removal
 - Color Improvement
 - Artifact Elimination

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Noise Removal / Color Improvement [Petschnigg et al. 2004]

- Best of both Worlds



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Artifact Elimination [Agrawal et al. 2005]

- Flash Reflections
- Techniques
 - Gradient Projection
 - Poisson Reconstruction



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Photometric Reconstruction

- Illumination Equation

$$I_{u,v} = \sum_i k_d N_{u,v} \cdot L_i$$

$$I_{u,v} = k_d (N_{u,v} L_0 + N_{u,v} L_1 + \dots)$$

- Stages

- Light Direction Estimation
- Computing the Normals
- Unshading
- Shape Reconstruction

References

- HDR Imaging and Image-Based Lighting

Paul Debevec

<http://www.debevec.org/>