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Surface Light Field Rendering for Virtual Product Design

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Current VR Visualization

- Simple Materials
  - Phong
- Simple Lighting
  - Directional or point light sources
  - Radiosity

- Application Areas
  - Shape Reviews
  - Functionality Reviews

Lack of Quality

- Hard to judge
  - Shape
  - Appearance
- Unsuitable for design reviews

Interior of Mercedes C class
(textures, point and directional light source)

Realistic Materials

- Measured Materials (BRDF, BTF)
- More realistic appearance
- Hard shadows

Interior of Mercedes C class
(measured BTFs, point and directional light source)

Global Illumination

- Realistic Light Simulation
- Very realistic results
- Suitable for design reviews

Interior of Mercedes C class
(measured BTFs, environmental lighting)

Real-time Raytracing

- Good performance
- Global illumination + complex materials too much effort

Interior of Mercedes C class rendered with OpenRT engine

Precomputed Radiance Transfer

- Global illumination + complex materials
- Tradeoff
  - All-frequency lighting and
  - Geometric complexity vs.
  - Real-time rendering

Interior of Mercedes C class
(PRT solution for front seats)

Surface Light Fields

- Rendering of existing or virtual objects

real and virtual objects
Chen et al. 2002

left: photograph, right: SLF
Wood et al. 2000

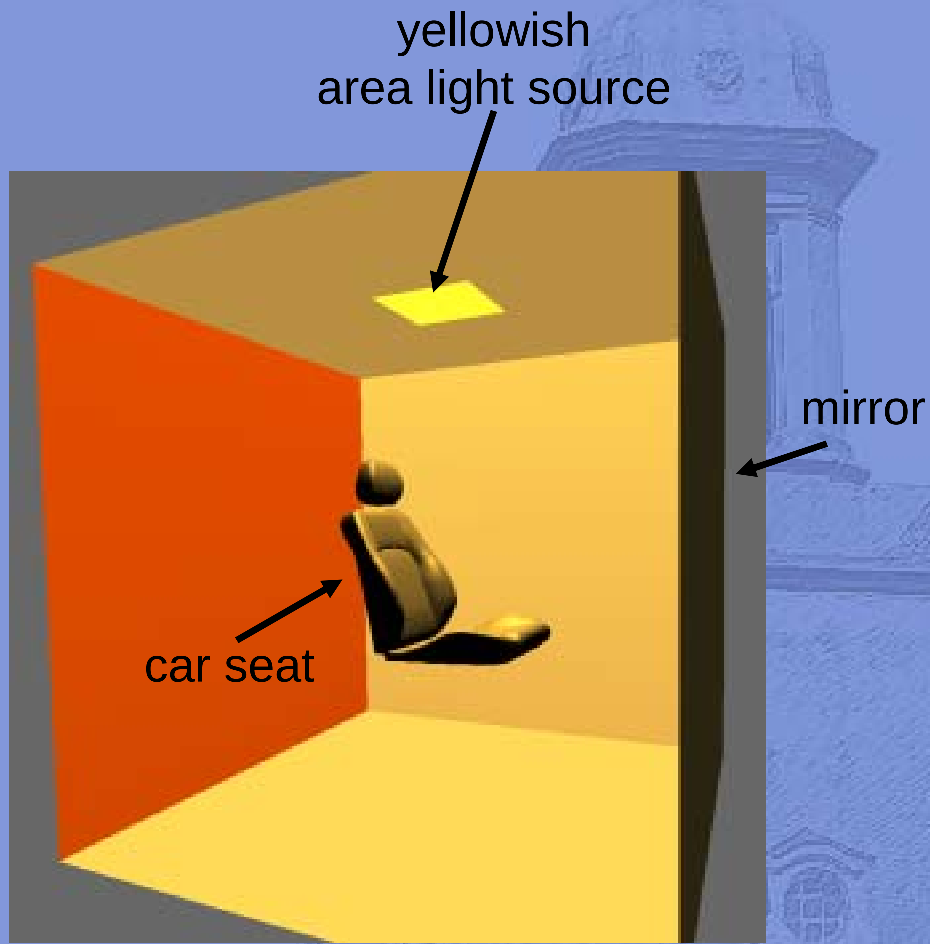
Surface Light Fields

- 4D function
  - Outgoing radiance
  - Fixed lighting
  - Fixed material
  - Fixed geometry

$$SLF(x,v) = \int_{\Omega_i} \overbrace{\rho(x,l,v)}^{\text{material}} \overbrace{L_i(x,l)}^{\text{incoming light}} \overbrace{\left(n(x)\cdot l\right)}^{\text{orientation}} dl$$

Test Setup

Leather BTF



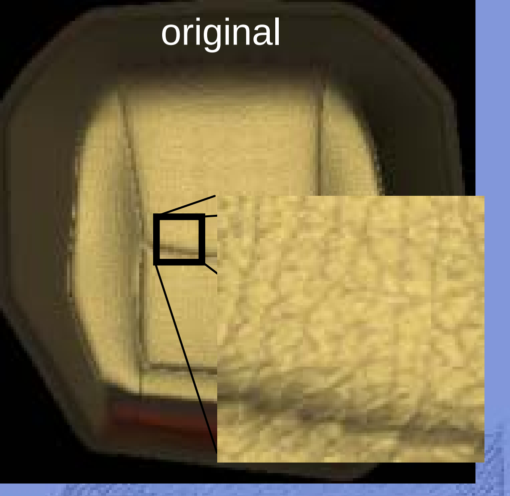
SLF Computation

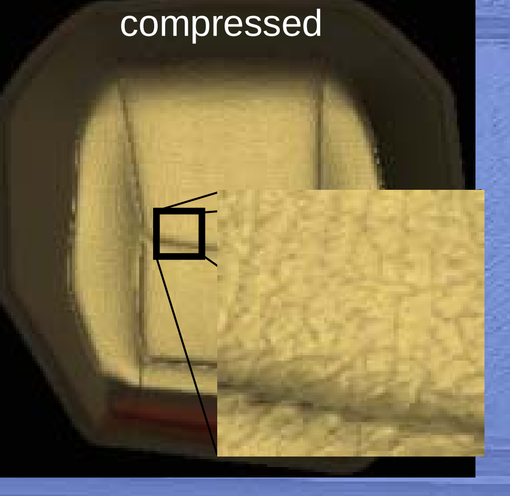
Five slices of the precomputed SLF

- About 220 MB (lossless EXR images)
- About 200 hours (single PC)

SLF Compression

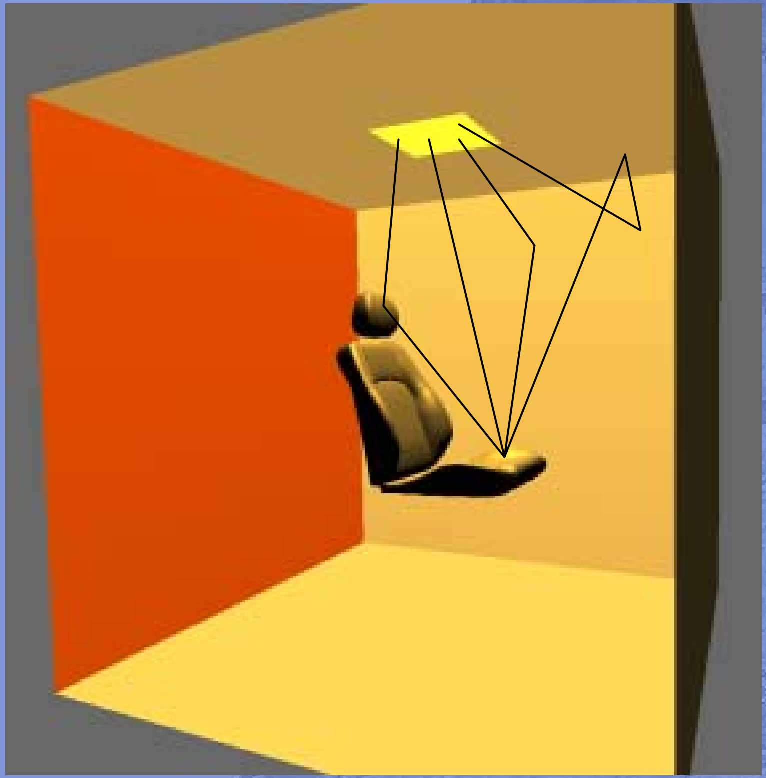
- Previous methods
  - Quantization [Wood et al. 2000]
  - Factorization [Chen et al. 2002]
- Here:
  - Clustered Factorization [Müller et al. 2003]
  - Compression ratio 1:24 (128 clusters, 4 components)





Faster Precomputation I

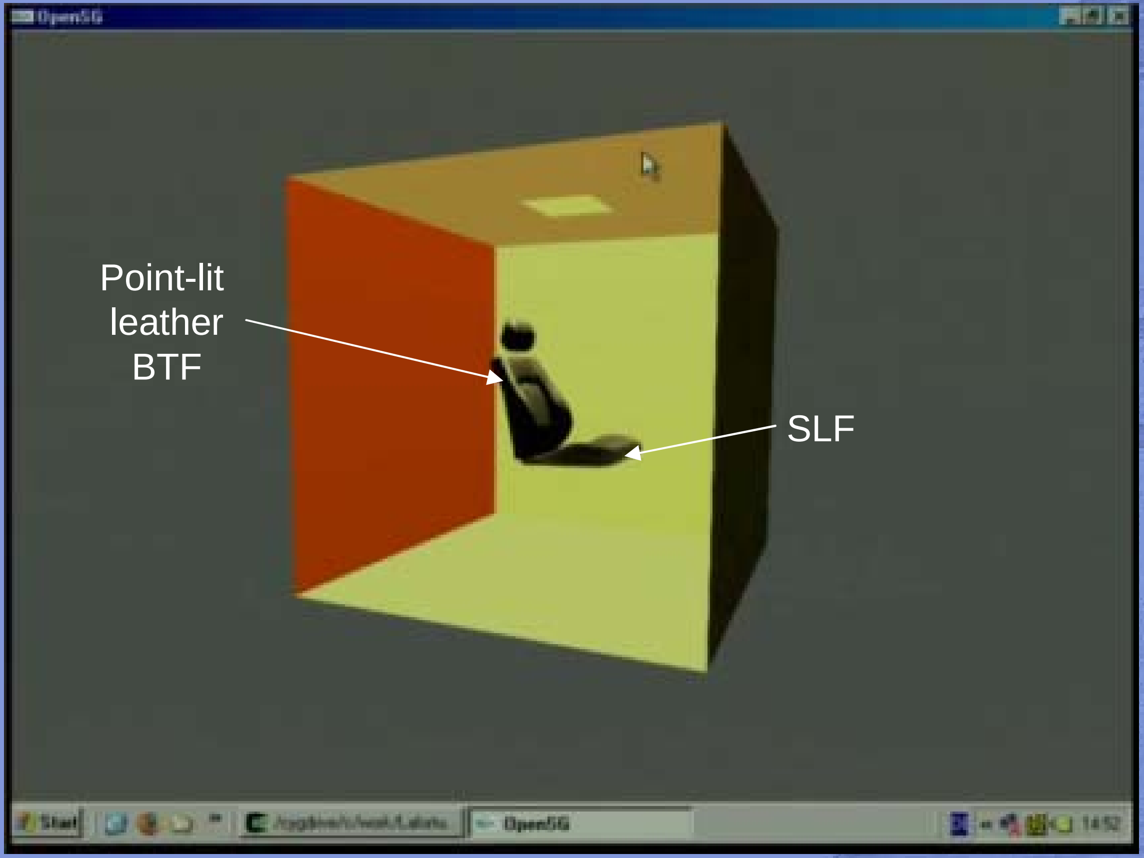
- Material variants
- Incoming SLF
  - Convolution with material on demand
- Improvement:
  - Reduction from 200 to 80 hours



Faster Precomputation II

- BTF clustering
- Approximation of BTF and incoming SLF
  - Linear (Spherical Harmonics) [Sloan et al. 2002]
  - Non-Linear (Haar Wavelets) [Ng et al. 2003]
- Improvement:
  - Speedup of factor 10-20

Results

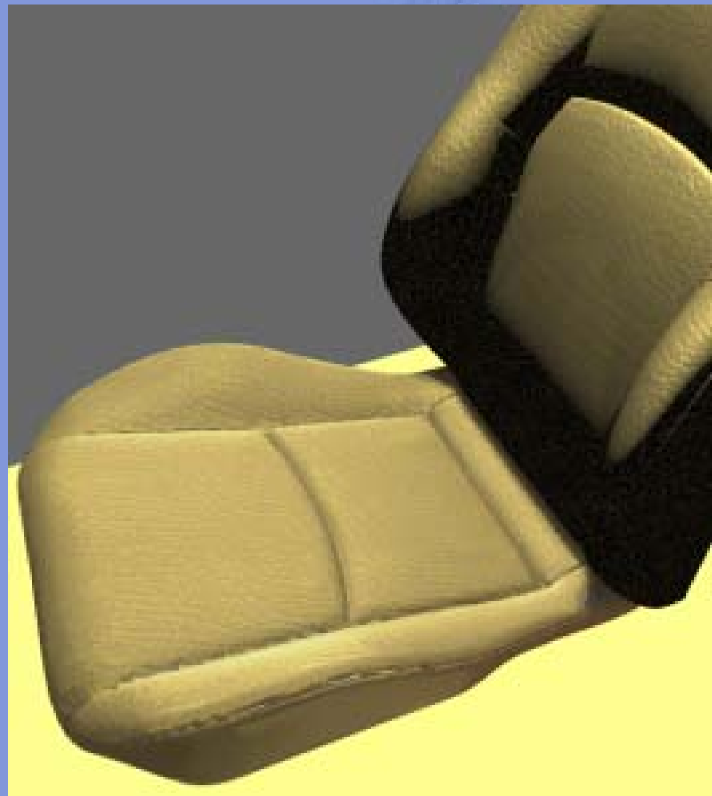


Results

- Performance:
  - 40 fps on GeForce 7800 GTX
  - Full-screen resolution
- Memory
  - 9 MB for seat cushion

Discussion

- ☺ High-quality visualization
  - All frequency lighting
  - Complex materials
  - Independent of geometric complexity
- ☺ Real-time performance



SLF of seat cushion

Discussion

- ☹ Memory requirements
  - – Small objects
  - – More suitable compression
- ☹ Flexibility
  - – Geometry and lighting fixed
  - – BUT: replacement of material rather fast

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