DISCO – Acquisition of Translucent Object

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Past Work – Acquisition

• BRDF Acquisition – cannot model subsurface scattering

• Image Acquisition – Captured with fixed viewpoints [Debevec 01], fixed lighting [Wood 00], or both [Levoy 96]

• [Jensen 01] allows arbitrary modeling of only homogenous materials
Past Work – Rendering

- Rendering with BSSRDFs
  - Expensive and slow
- Dipole Approximation
  - Physically correct for homogenous, infinite half-space
- Most methods not based on measured data
Goals

• Capture the exact behavior of real translucent objects
  – Heterogenous properties (eg. cracks, hollow objects, volumetric variations)

• Allow for modeling in arbitrary lighting with arbitrary viewpoints

• Integration into rendering systems ([Lensch 03])
DISCO method

• Digital Imaging of Subsurface sCattering Objects
• Want to measure $R_d(x_i; x_o)$ per color channel for all $x_i$ and $x_o$. 
DISCO (cont.)

\[ L^\rightarrow(x_o, \omega_o) = \int_A \int_{\Omega_+(x_i)} L^\leftarrow(x_i, \omega_i) S(x_i, \omega_i; x_o, \omega_o) d\omega_i dx_i. \]

\[ L^\rightarrow(x_o, \omega_o) = \frac{1}{\pi} F_{t,o}(\eta, \omega_o) \int_A R_d(x_i, x_o) \]
\[ \cdot \int_{\Omega_+(x_i)} L^\leftarrow(x_i, \omega_i) F_{t,i}(\eta, \omega_i) \langle N_i \cdot \omega_i \rangle d\omega_i dx_i. \]

- Illuminate at a single surface point \( x_i \) with known incident radiance \( L^\leftarrow(x_i; \omega_i) \), observe \( L^\rightarrow(x_o; \omega_o) \)
- Invert to find \( R_d(x_i; x_o) \)
DISCO (cont. again)

- Finite width beams that can enter at large angle of incidence $\omega_i$
  - Omit samples with $\omega_i$ larger than some threshold

```markdown
for all camera positions
for all turntable rotations
record silhouette image
for all laser colors
for all projector positions
record impulse response image
```
Data Storage and Access

- Raw data is several hundred gigabytes
- High sampling density around incident, more coarse sampling further away
  - Global response – matrix $F$ of throughput factors; interpolate vertices data does not fill
Throughput Interpolation

- Some vertices are never lit
- Case $F_{k,c}$, $k$ far from point of illumination $c$
  - Interpolate iteratively from neighboring vertices
- Case $F_{k,c}$, $k$ close to point of illumination $c$
  - Use distanced-weighted avg. response of neighbors
Interpolation (cont.)

Figure 6: Far and diagonal interpolation of throughput factor matrix $F$. The throughput factor shown in red is interpolated based on the neighboring factors shown in black.
Local Response

• Store filter kernals a la [Lenschch 03]
• Most laser peaks between discrete texels
  – Shift peak to all 4 neighboring texels weighted
    by $m(d) = c_1 \cdot e^{\alpha_1 d} + c_1 \cdot e^{\alpha_2 d}$, $d$ is distance to peak location
• Interpolate filter kernels with same method as throughput factors
Rendering

- Direct port into Lensch et al.'s approach
- Can substitute for dipole approximations, Monte Carlo/Photon Mapping evaluations
Pretty Pictures! (and results)

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Table 1: Some statistics about the acquired models.
Pretty Pictures! (and results, take 2)

Figure 9: The test objects under indoor illumination (top row) and illuminated by all three lasers (bottom row).
Pretty Pictures! (and results, take 3)
Conclusions

• Surface coverage limited by occlusion
• Additional imagery vs. Acquisition time
• Could try to plan acquisition images
  – Pre-determine lit surface positions