



Image-Based 3D Photography Using Opacity Hulls

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The Goal: To Capture Reality

- Fully-automated 3D models creation of real objects.
- Faithful representation of appearance for these objects.



2

Contributions

- A system to acquire complex 3D objects.
- Opacity Hull - a new shape representation.
- Algorithm for rendering 3D models with textured surface from arbitrary viewpoints under arbitrary illuminations.



3

Outline

- Background
- System overview
- Opacity Hulls and Surface Light Fields
- Surface Reflectance Fields
- Future Work and Conclusions

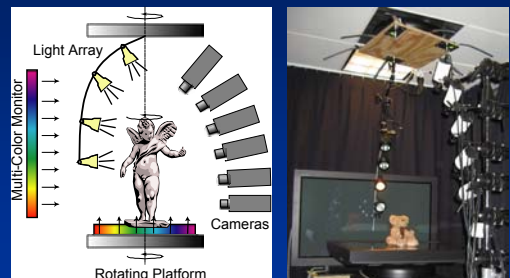
4

Previous Work

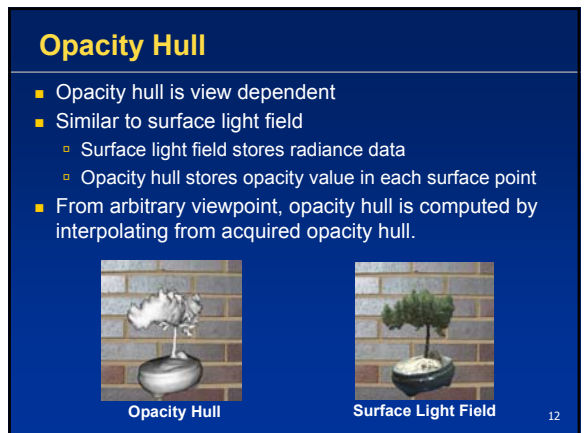
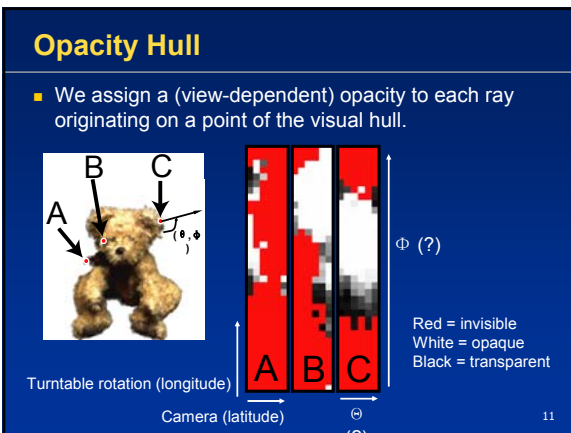
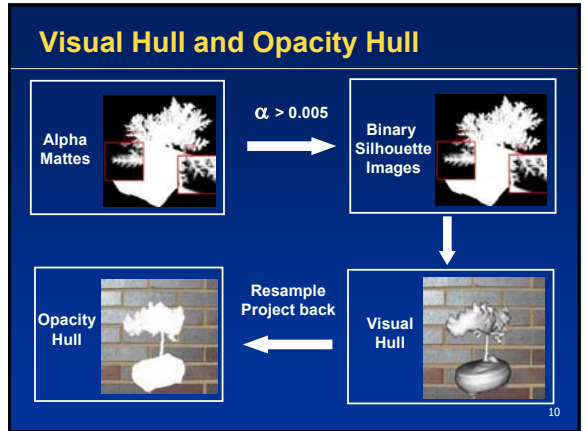
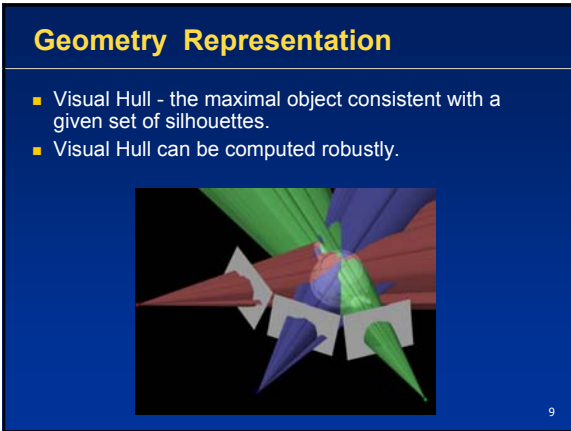
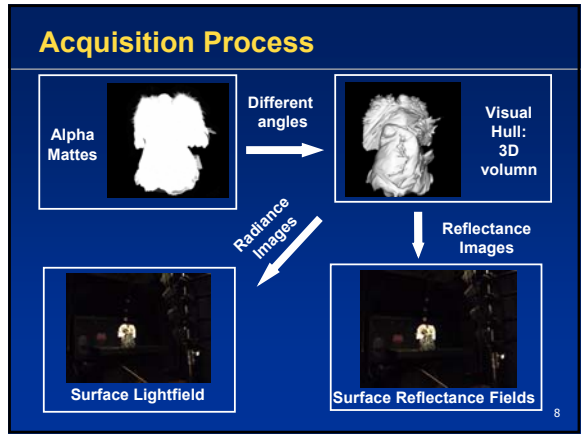
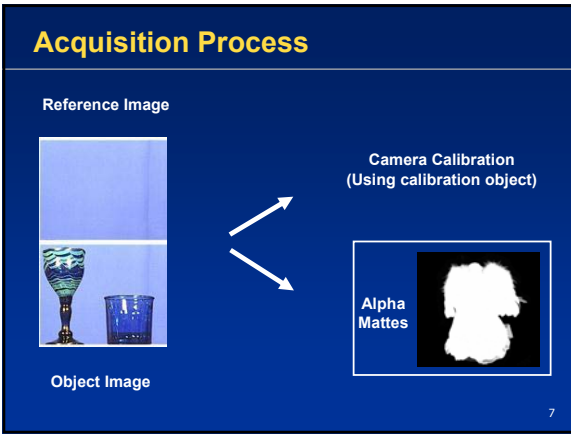
- Acquisition of 3D shape of real objects.
 - Contact digitizers – intensive manual labor, Lambertian surface only.
 - Active light imaging systems – restrict types of scanned materials.
 - **Our approach: Opacity Hull – a variation of visual hull**
- Capture of surface reflectance property
 - Parameter fitting to BRDF models – fails for complex objects and optical effects.
 - Image based modeling and rendering – lack of 3D model, static illumination, limited viewpoints.
 - **Our approach: Surface Reflectance Field**

5

Acquisition System

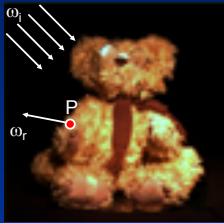


6



Surface Reflectance Field

- 6D function: $R(P, \omega_i, \omega_r) = R(u_r, v_r; \theta_i, \Phi; \theta_r, \Phi_r)$

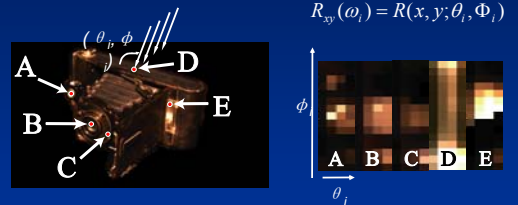


- Assumes directional illumination at infinity.

13

Reflectance Function

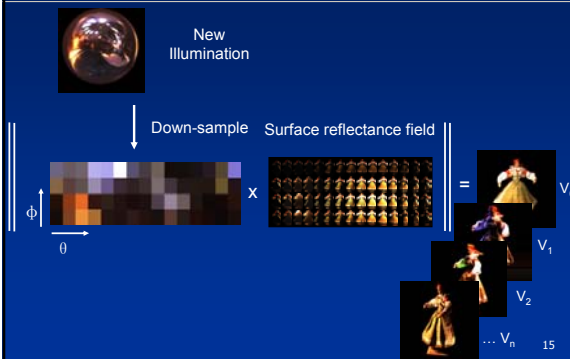
- 4D function at each viewpoint:



- We use multiple viewpoints and 3D geometry.

14

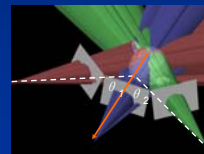
Step 1: Relighting from each viewpoint



15

Step 2: View Interpolation

- Interpolate opacity and radiance.
 - Unstructured lumigraph interpolation [Buehler et al., 01]
 - View-dependent texture mapping [Debevec 98].
- From new viewpoint, for each surface point, find four nearest acquired viewpoints.
- Weighted K-nearest neighbor interpolation.



16

Surface Reflectance Fields

- Work without accurate geometry.
- Surface normals are not necessary.
- Capture more than reflectance
 - Inter-reflections
 - Self-shadowing
 - Subsurface scattering
 - Refraction
 - Dispersion

17

Compression

- Subdivide images into 8 x 8 pixel blocks.
- Keep blocks containing object (avg. compression 1:7)
- PCA Compression (avg. compression 1:10)



18

Results



19

Results



20

Results



Rendered image



Results video ?

<http://graphics.lcs.mit.edu/~wojciech/videos.html>

21

Future Work

- Better compression
- Real-time rendering
- Refractive & transparent objects [Matusik et al., EGRW 2002]
- Rendering bigger objects



22

Conclusions

- Our system is able to capture and render any type of object.
- Opacity hulls combined with surface reflectance fields/lightfields provide realistic 3D graphics models rendered under varying illumination from novel viewpoints.
- Our models can be seamlessly inserted into new environments.

23

Acknowledgements

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24