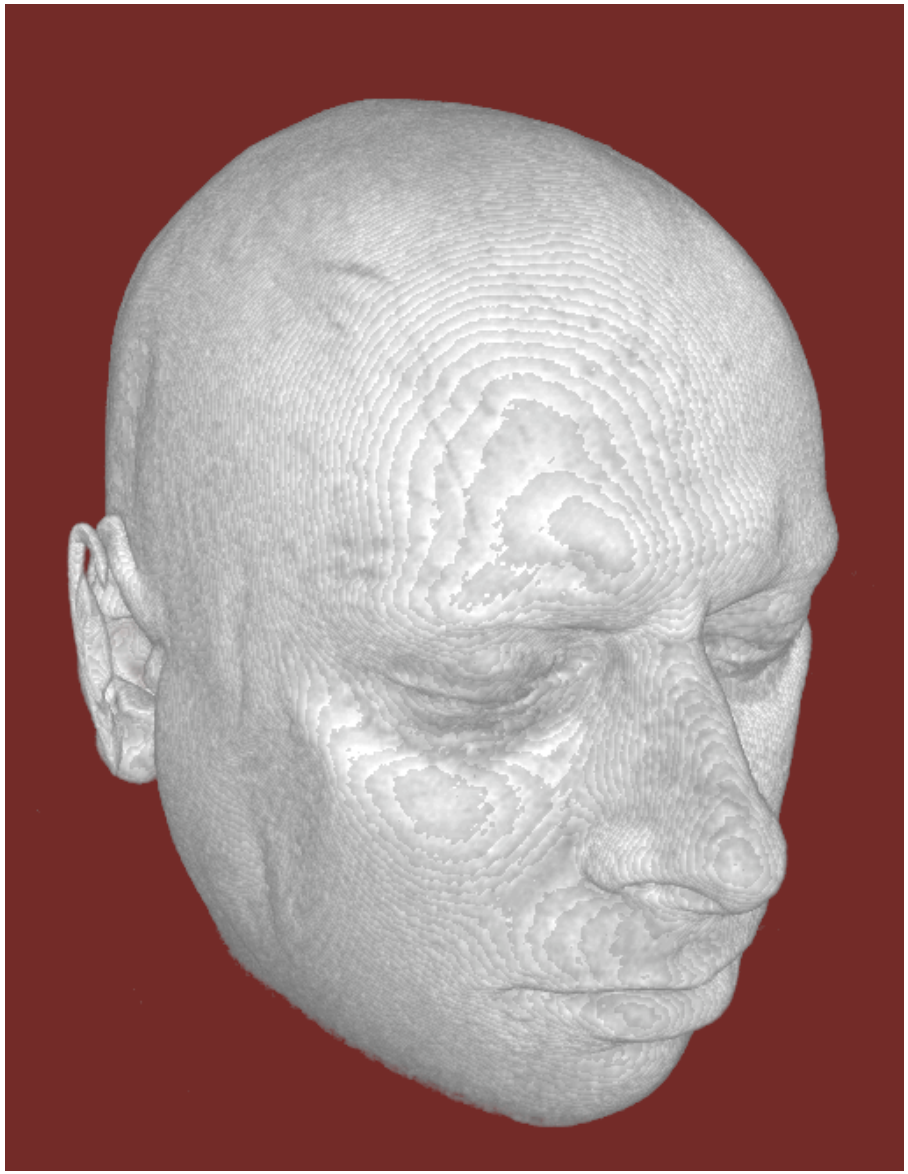
Selected Recent Research in Computer Graphics at IMM

Andreas Bærentzen, IMM

- Volume Visualization & Manipulation
  - Texture Based Volume Visualization
  - The 3DMed Project
- Shape Representation and Manipulation
  - The angle weighted normal
  - GPU assisted mesh to volume conversion
- Global Illumination
  - Near Real-time Global Illumination

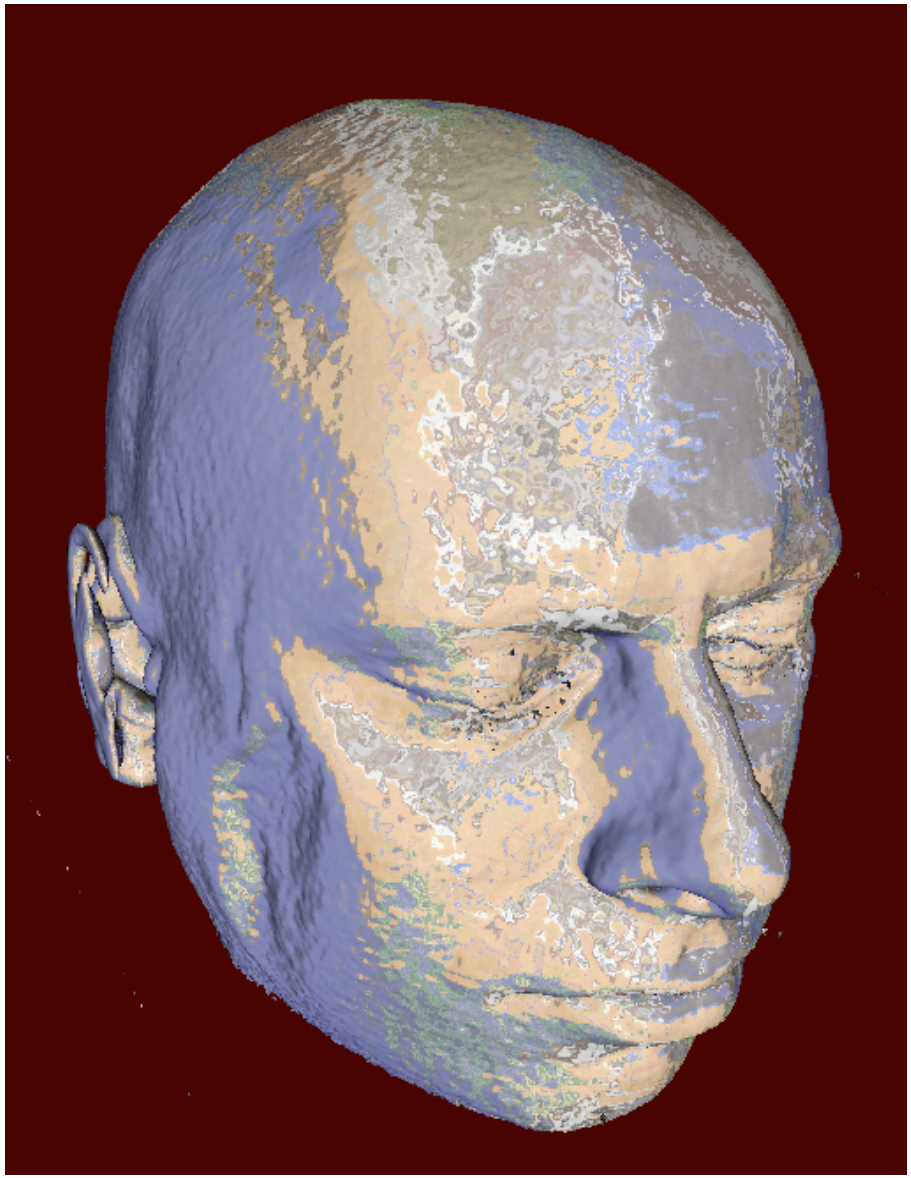
Volume Visualization

Volume Visualization
using 3D textures



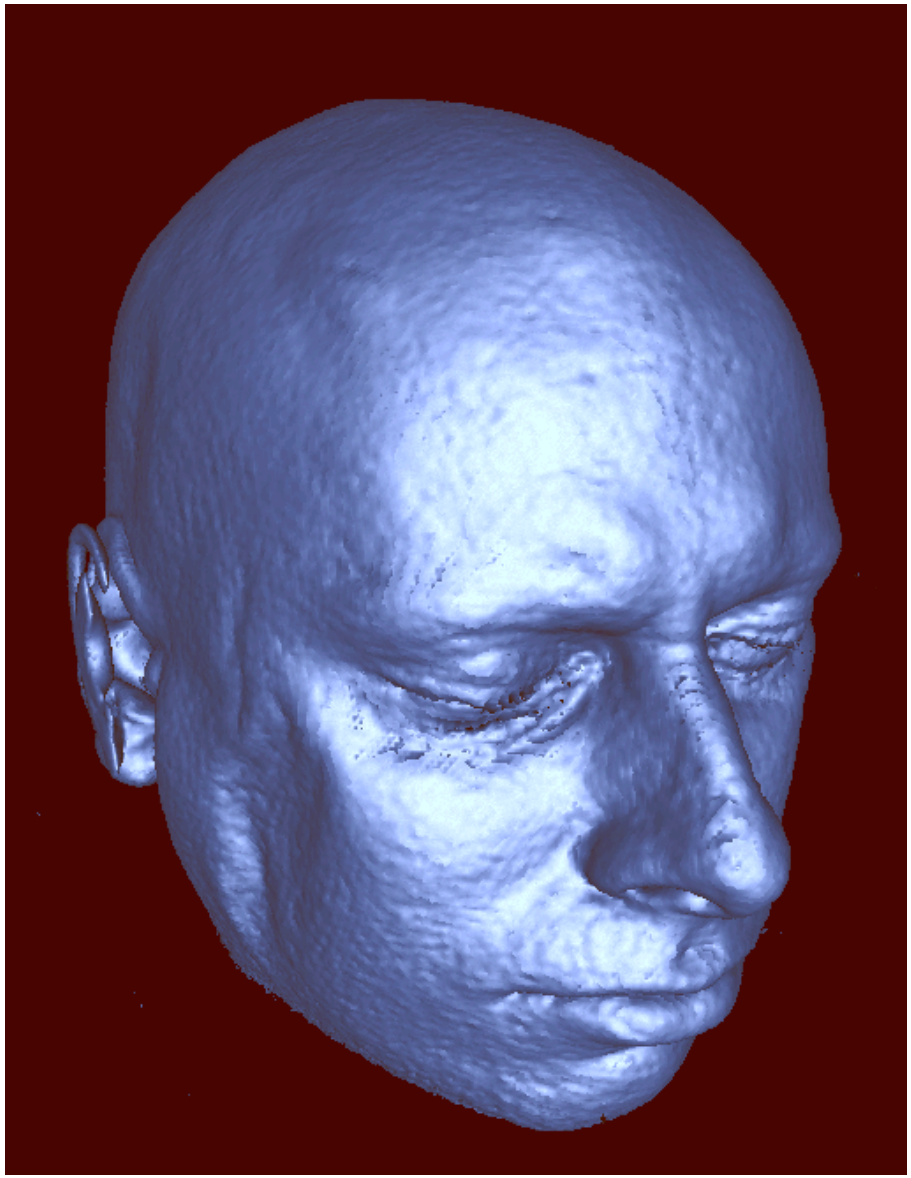
Volume Visualization

Volume Visualization using normals stored in 3D textures and cube mapping



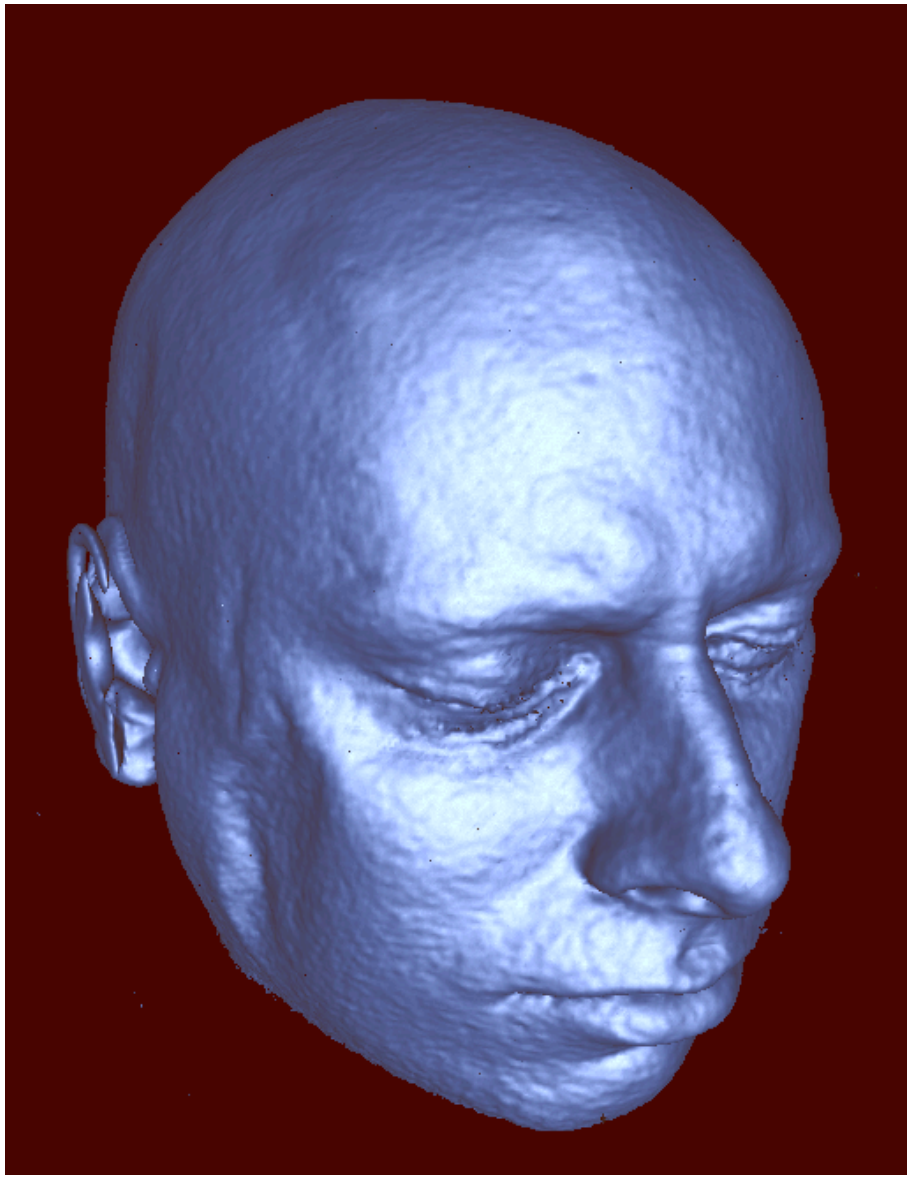
Volume Visualization

Volume Visualization using 3D textures and fragment programs to compute Phong shading



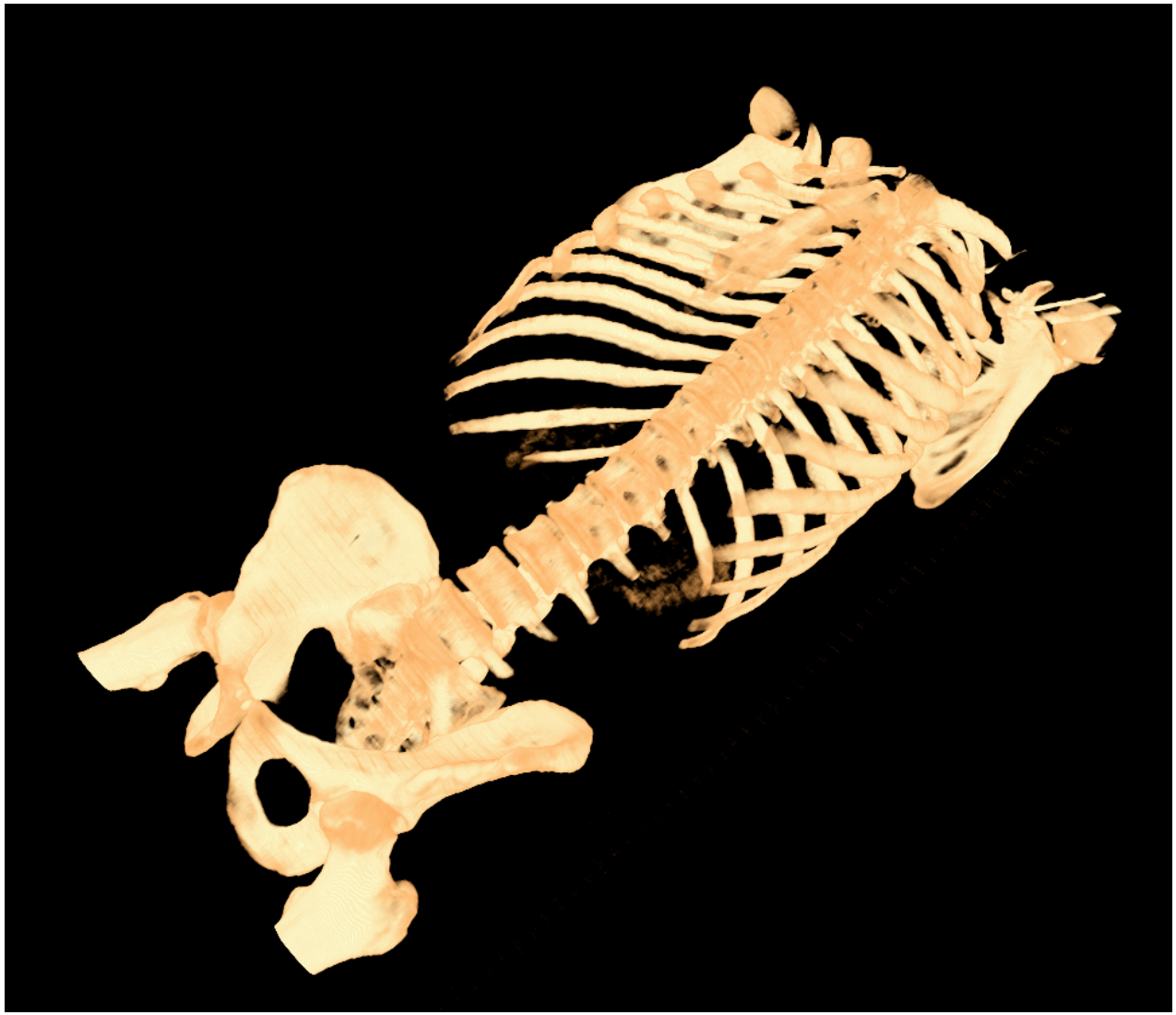
Volume Visualization

Volume Visualization using 3D textures and preintegrated slabs.



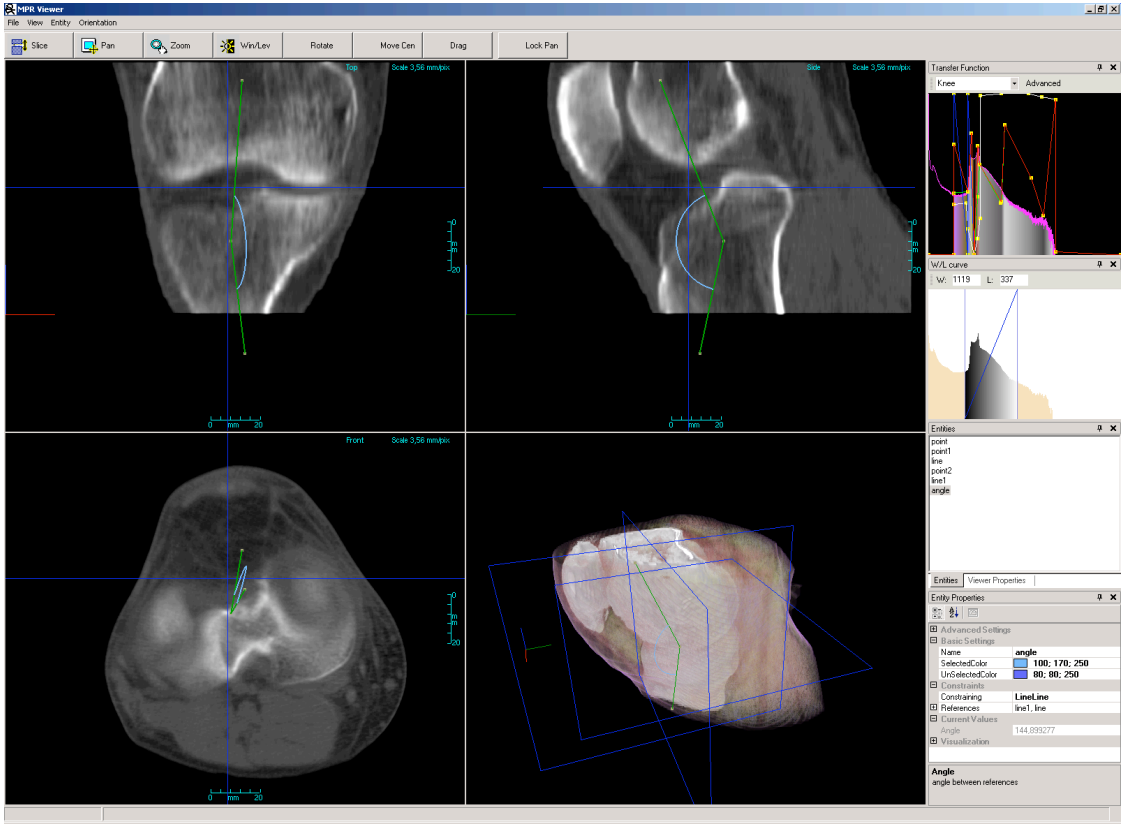
Volume Visualization

Volume Visualization of large volumes using bricking



The 3DMed Project

Surgery planning application delveloped in collaboration with DIKU, 3D Lab, and ImageHouse.

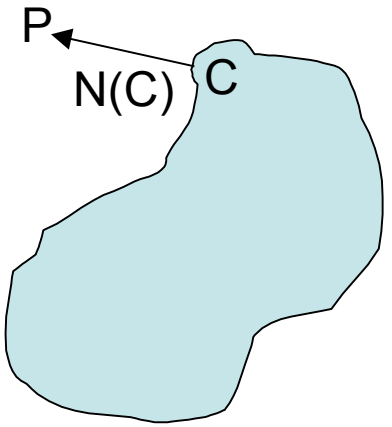


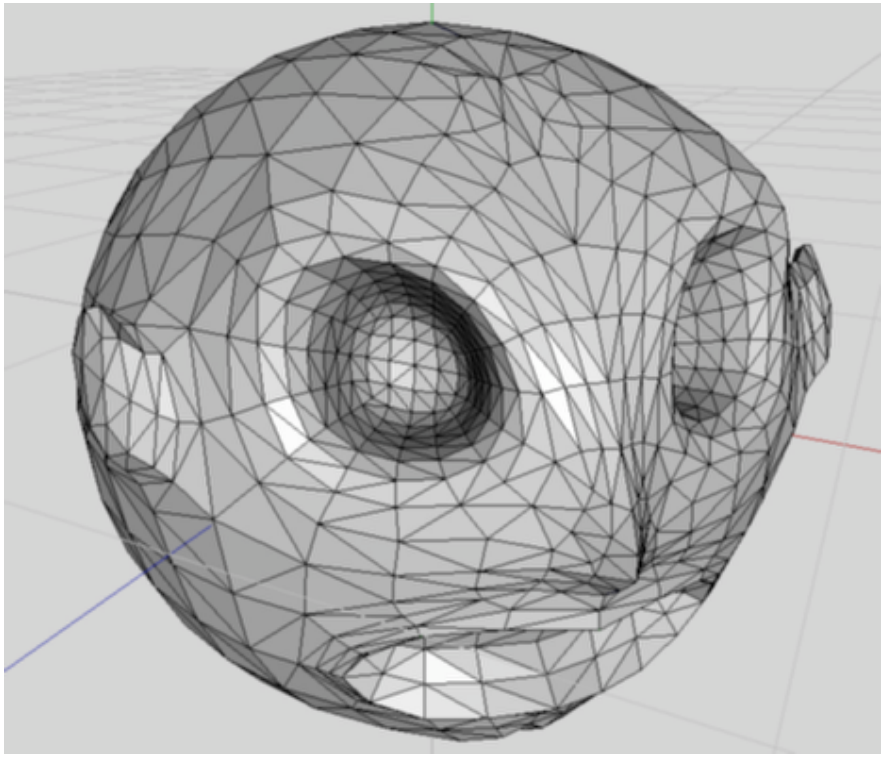
Visualization and manipulation of volume data

- Measurements
- Visualization
- Editing
- Segmentation

Angle Weighted Pseudo-Normal

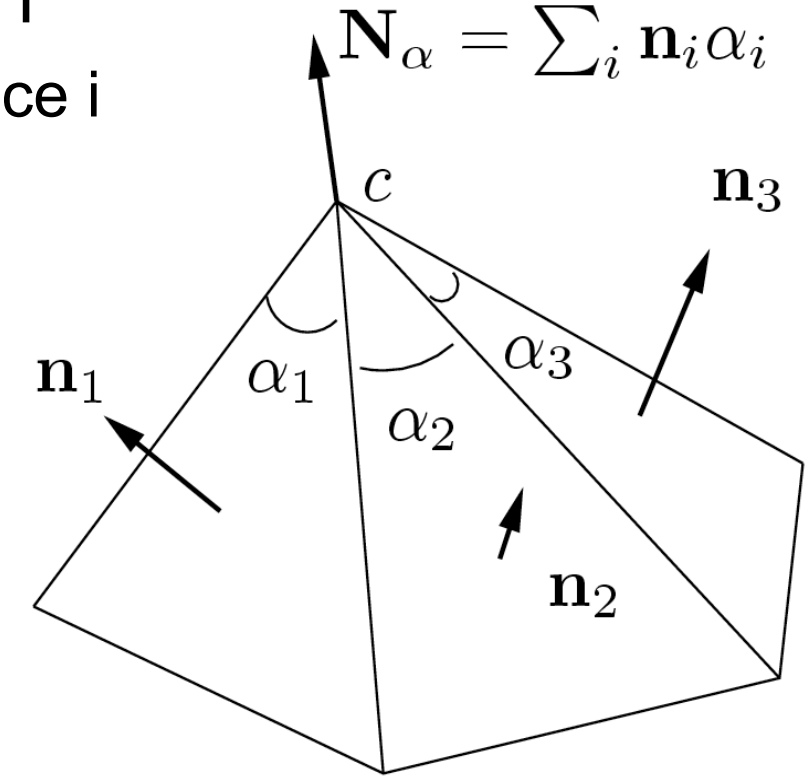
- Given a point P and the closest point C on a smooth surface, the normal N(C) tells us whether P is inside.
- Problem: A triangle mesh has no normals at vertices and edges
- Solution: Use *angle weighted normals* at vertices and edges



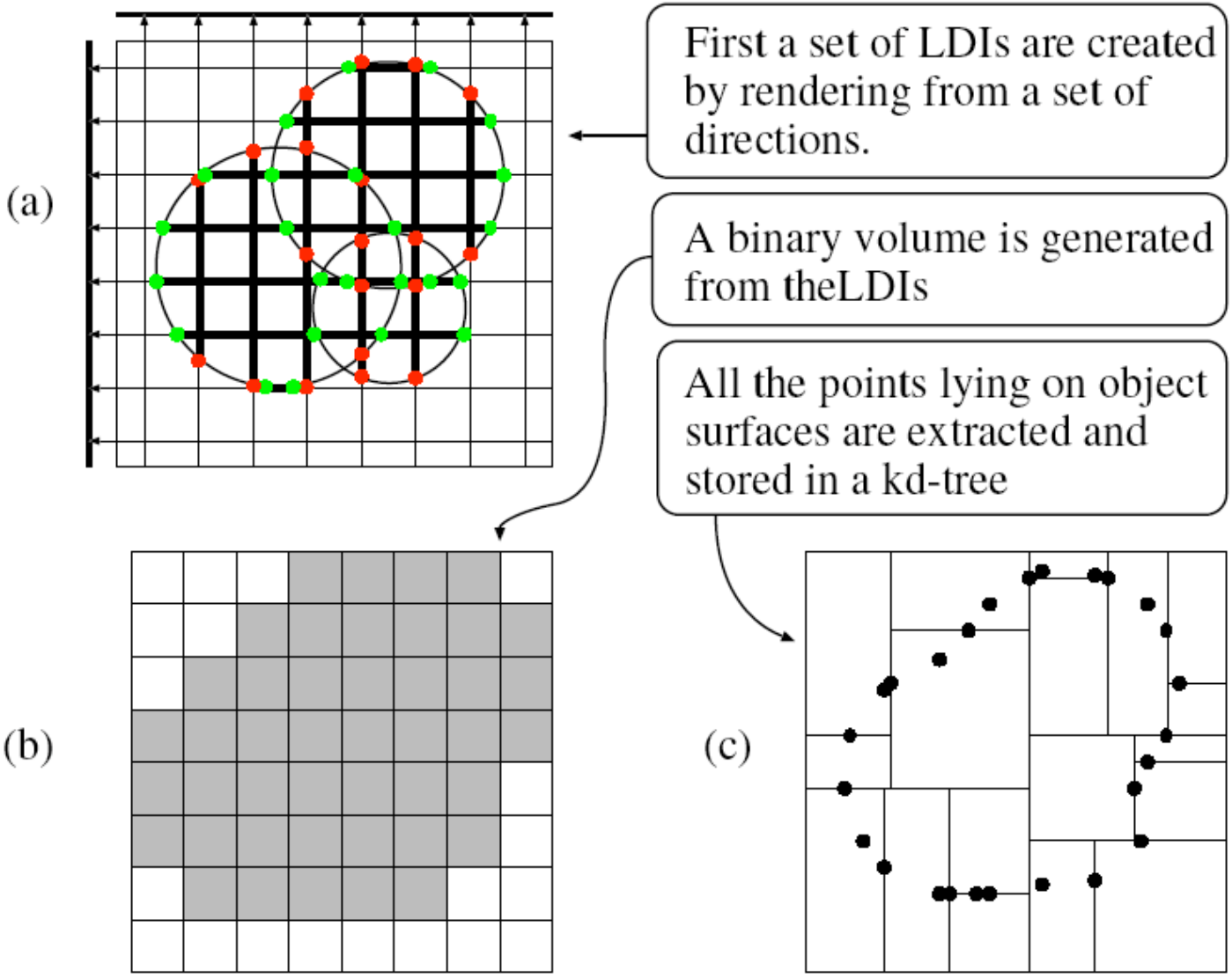


Angle Weighted Pseudo-Normal

- Definition of *angle weighted pseudo normal* at a vertex *c*:
  - For each incident face i
    - Compute normal n_i of face i
    - Compute angle α_i
    - N_α += $\alpha_i n_i$
  - Normalize N_α



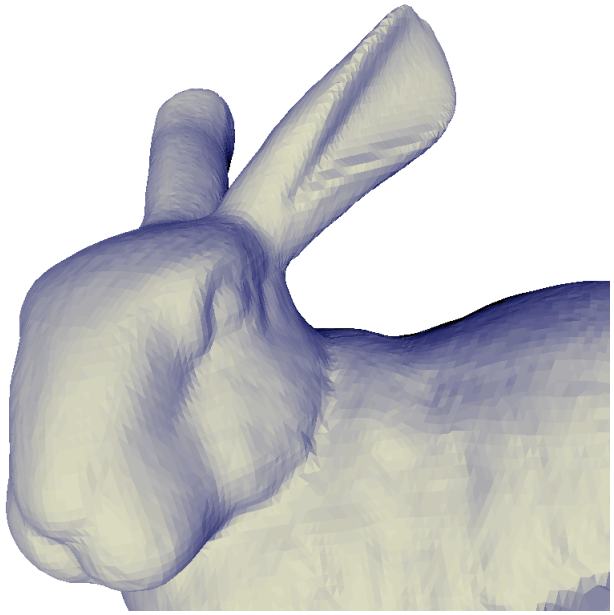
Voxelization using Depth Peeling



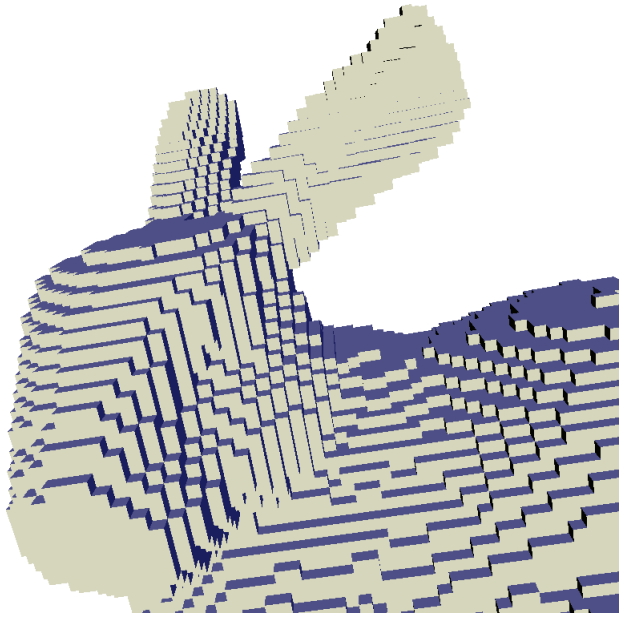
Getting a Mesh back

- Voxelization can be used for remeshing
- Applications: Fixing holes, boolean operations, topological simplification

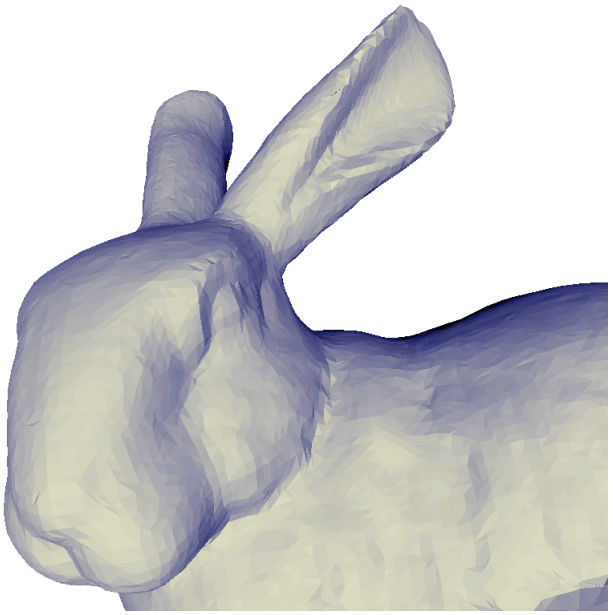
Original Stanford Bunny



surface of voxel model

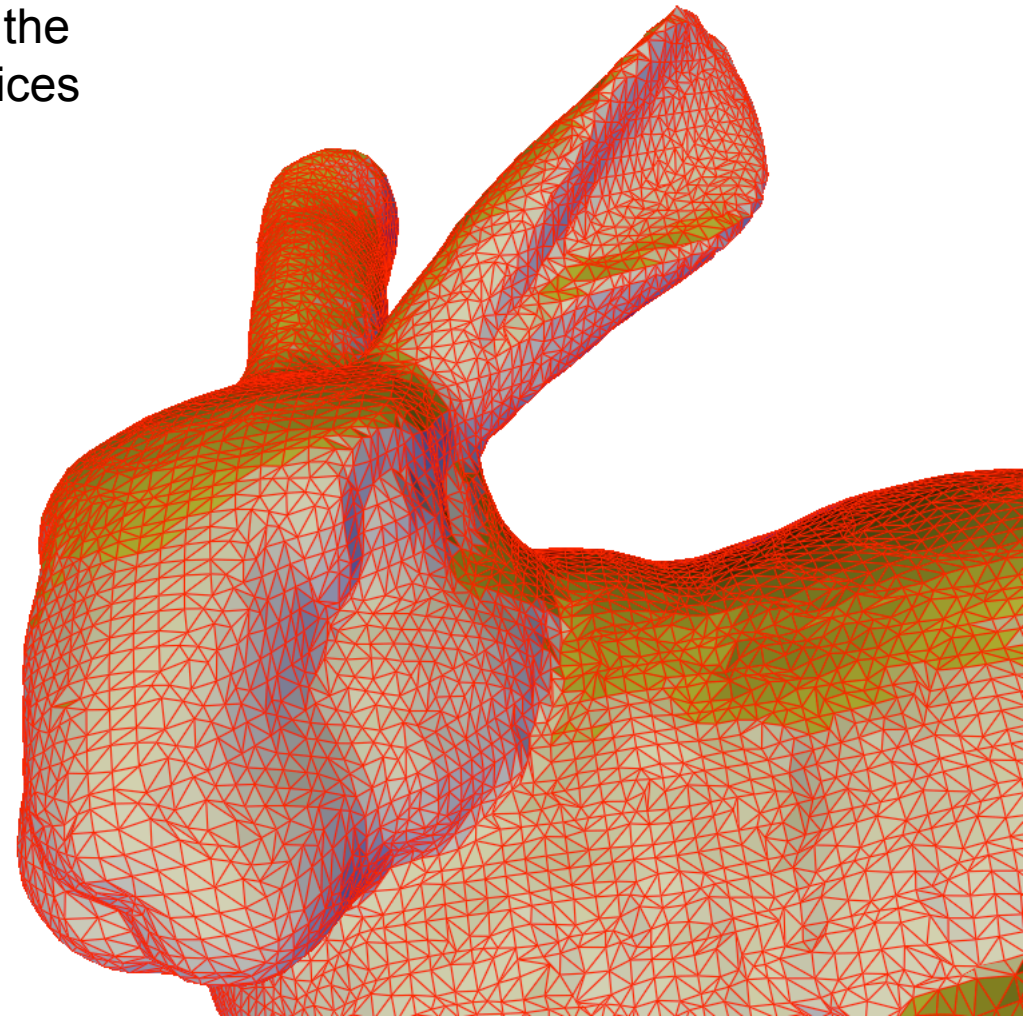


reconstructed mesh



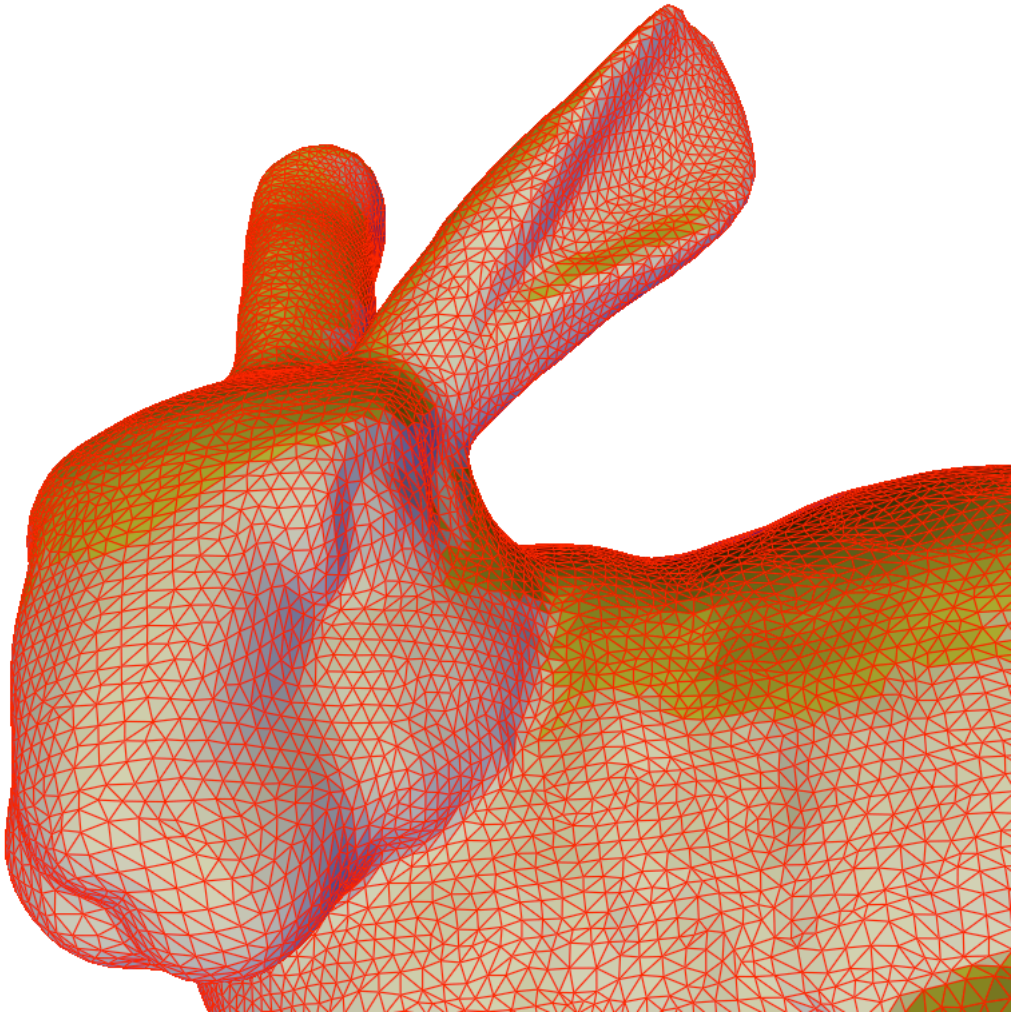
Before Smoothing

The reconstructed mesh is changed to improve the valencies of the vertices

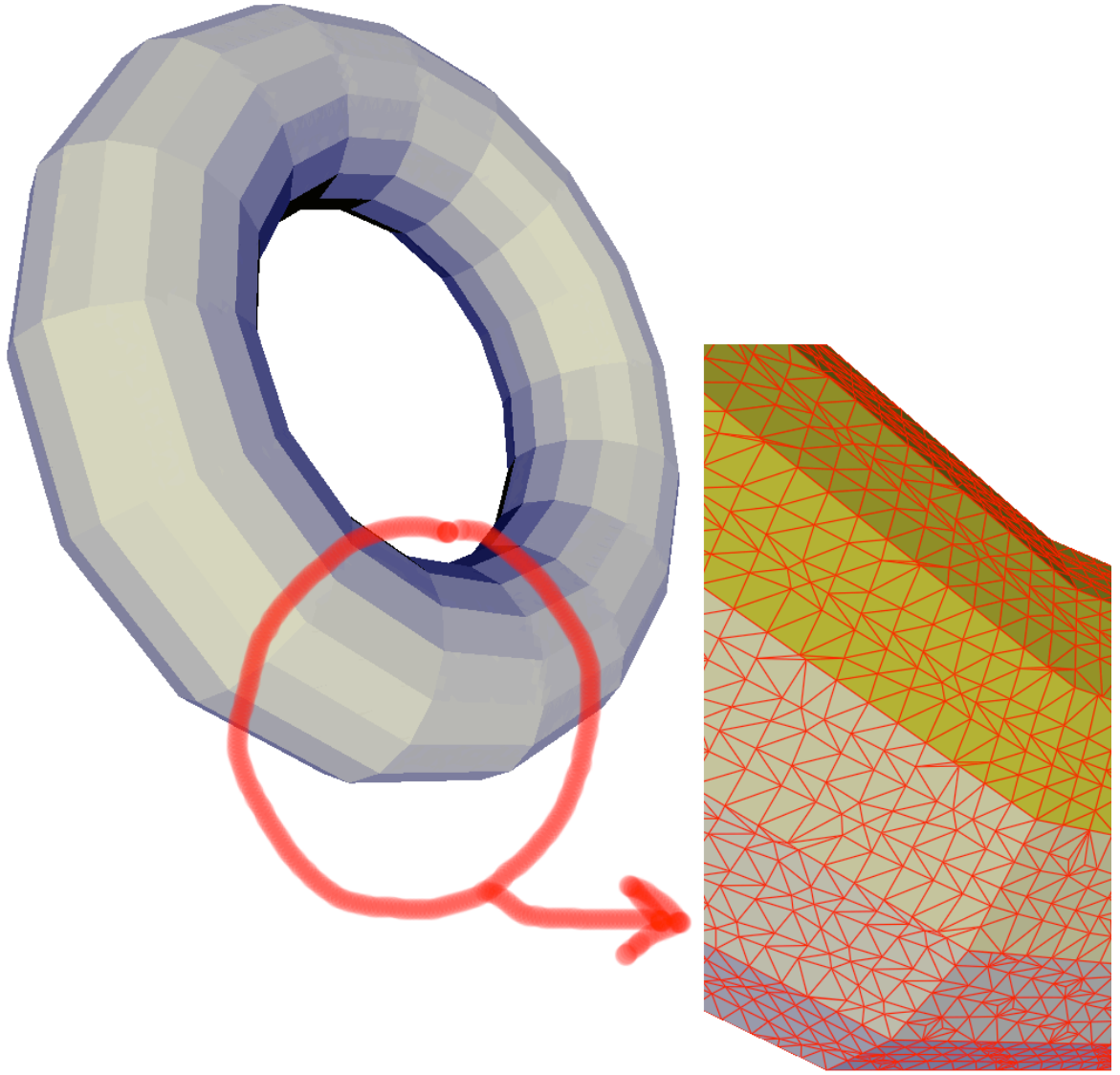


After Smoothing

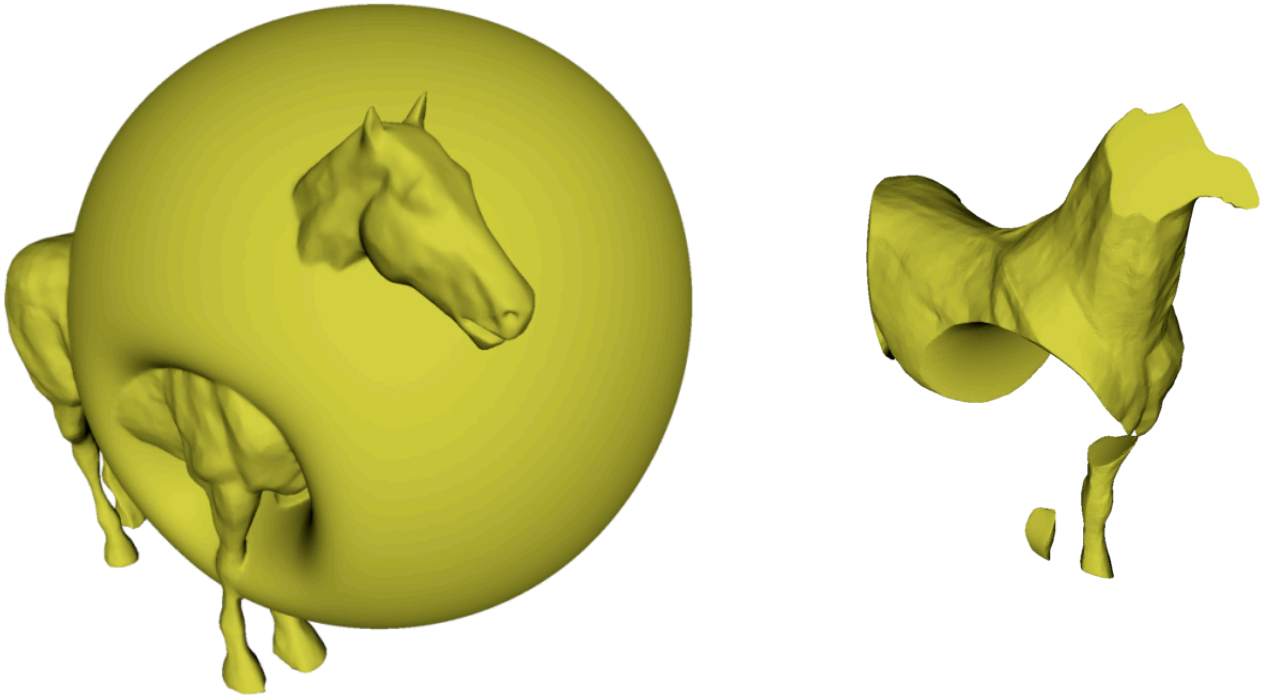
And then improved by smoothing



Sharp Edges



Boolean operations

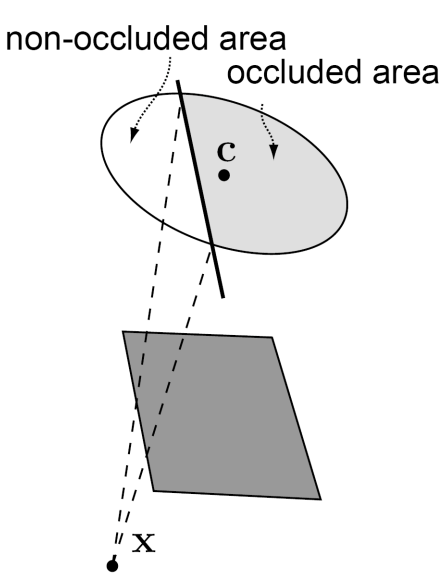


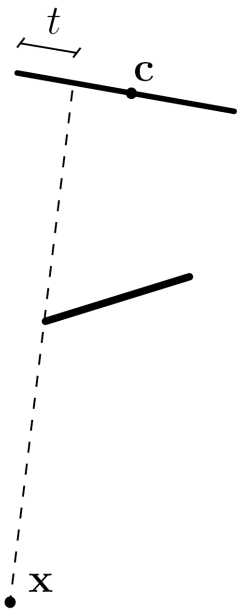
Global Illumination

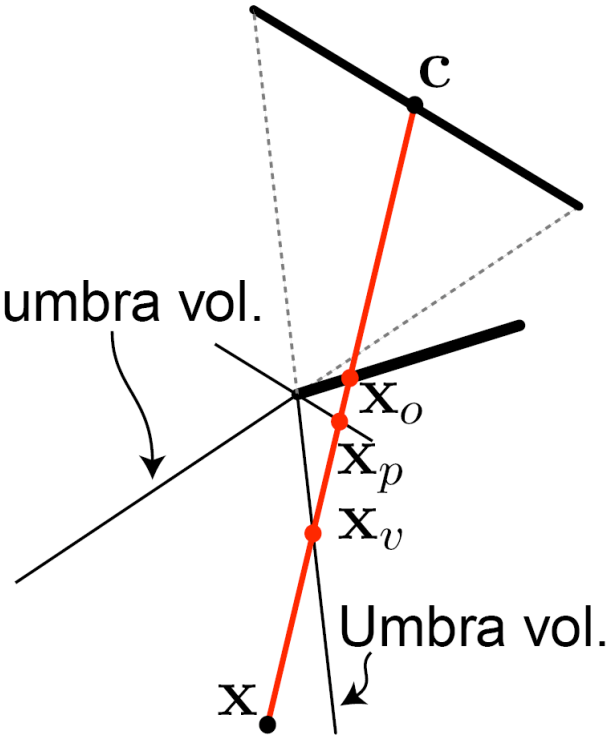
We want to do this real-time in Bents lifetime

Soft Shadow Method

Aim: To compute the visibility fraction *V*



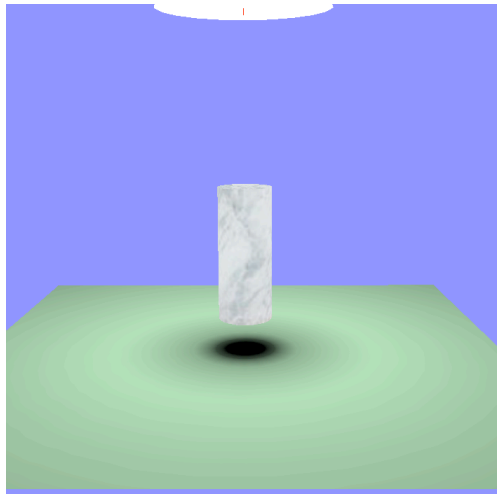


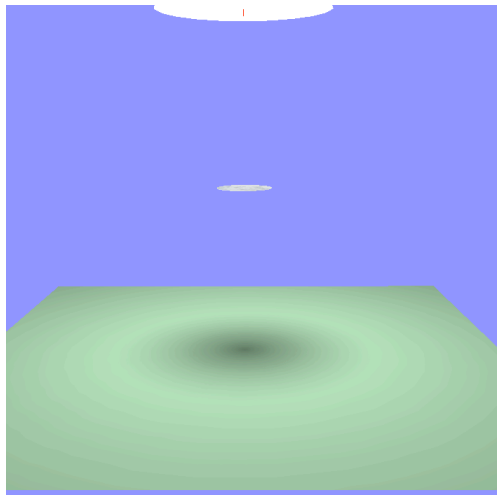


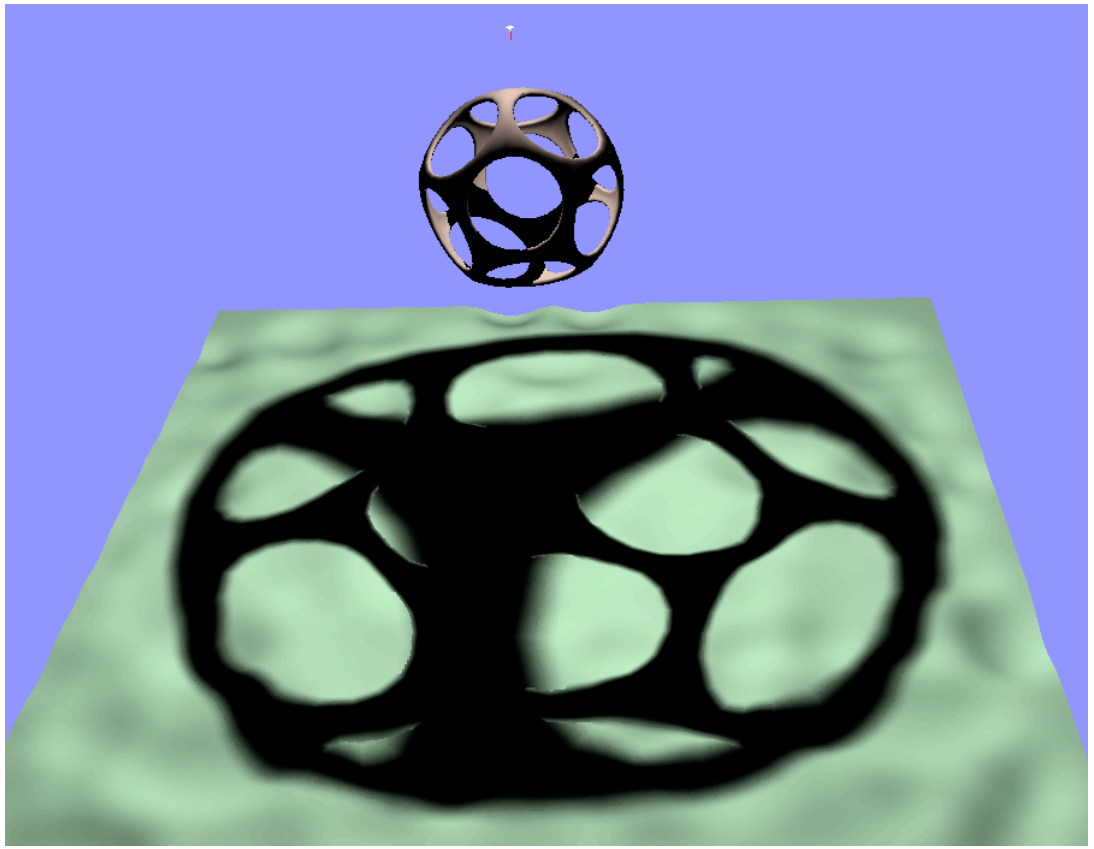
Circular light source divided by one straight line

V is calculated from $|\mathbf{cx}|$, $|\mathbf{cx}_o|$, $|\mathbf{cx}_v|$ and $|\mathbf{cx}_p|$)

Soft Shadow Results

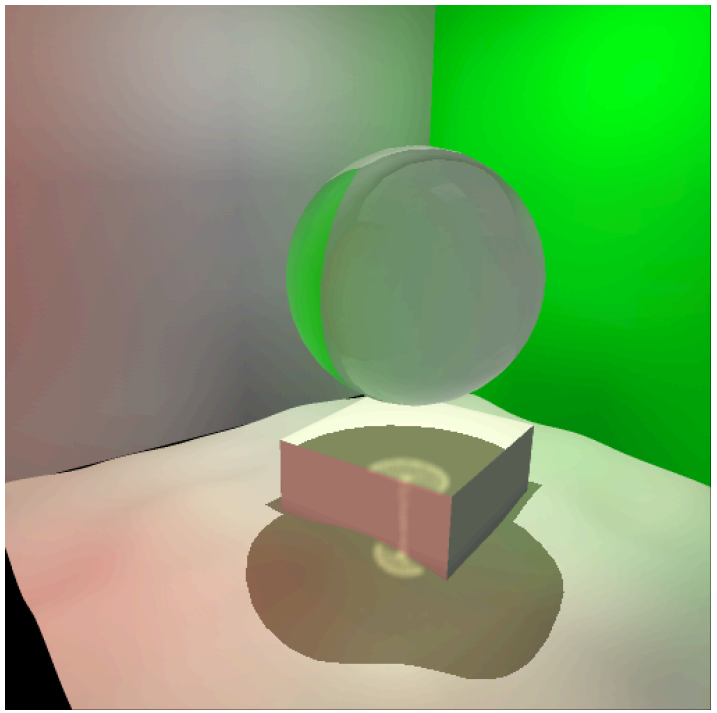




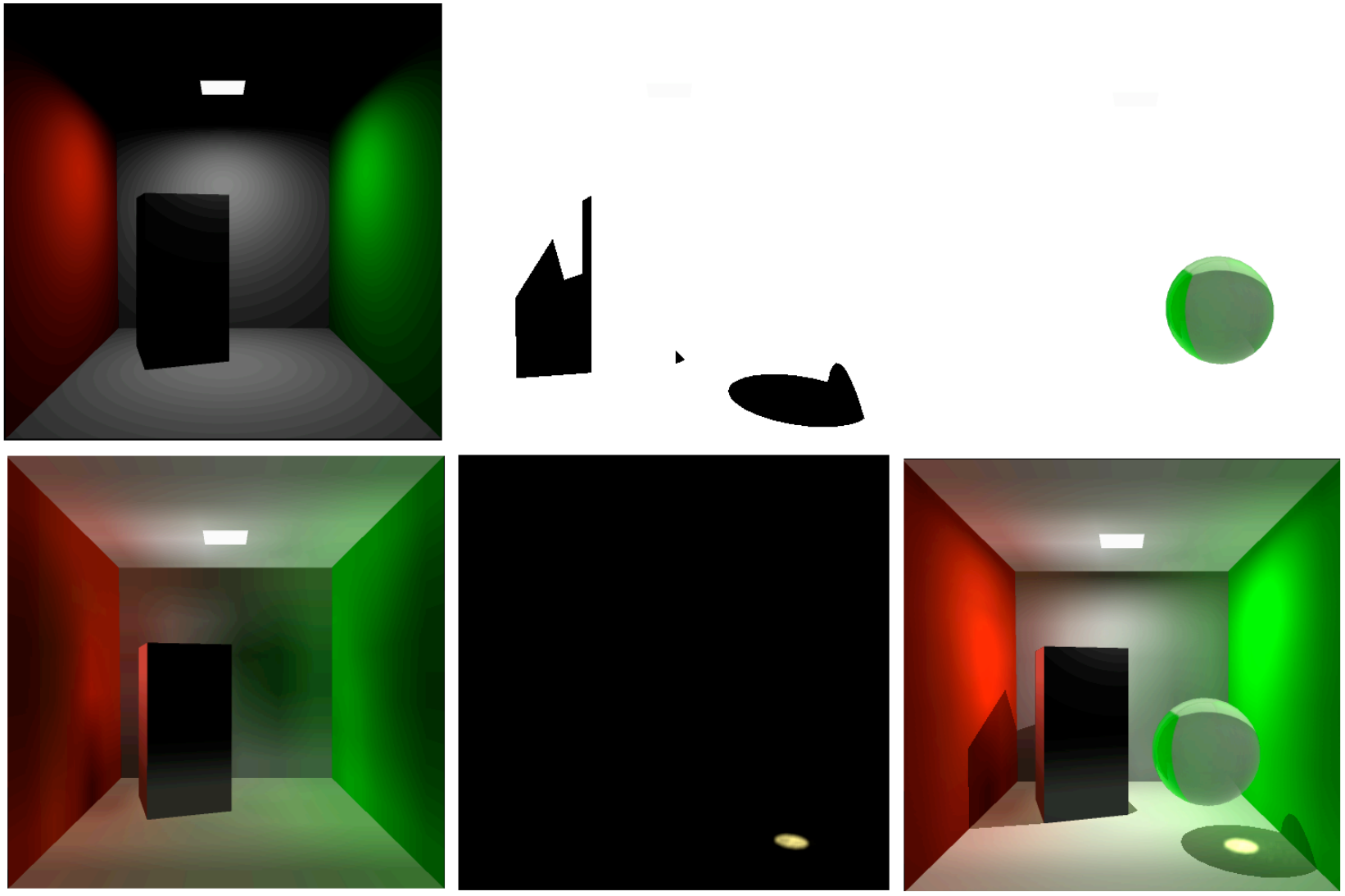


Photon Mapping for Real-time Applications I

- Photon Mapping is in general too slow for real-time applications
- We have carefully optimized the algorithm and introduced new methods for increased speed:
  - Selective retracing of photons on the CPU
  - Selective update of indirect illumination using the GPU
  - Progressive update of caustic photons on the CPU
  - Selective filtering in image space by using the GPU



Photon Mapping for Real-time Applications II



These slides represent the work of

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- Andreas Bærentzen
- Niels Jørgen Christensen