Filling Holes in Complex Surfaces using Volumetric Diffusion

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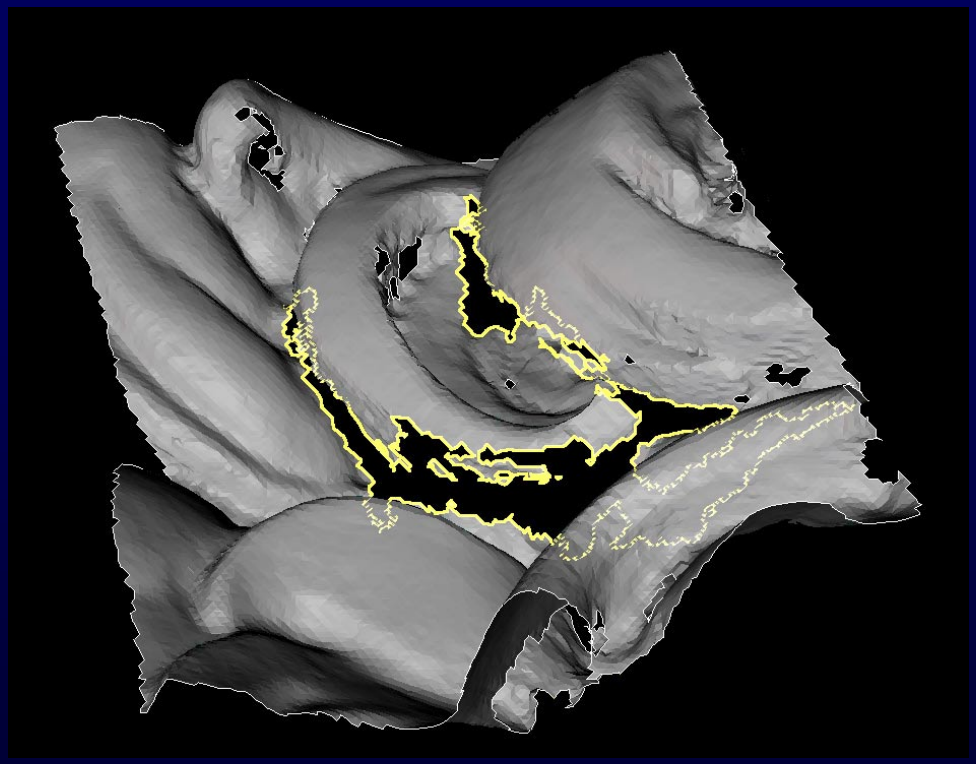
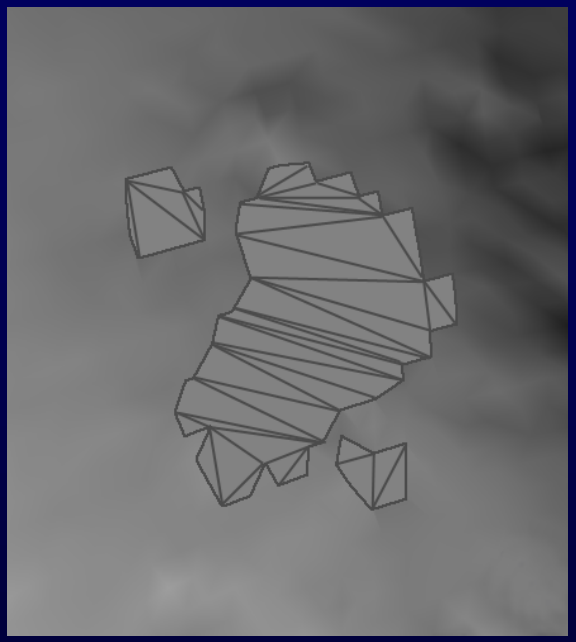
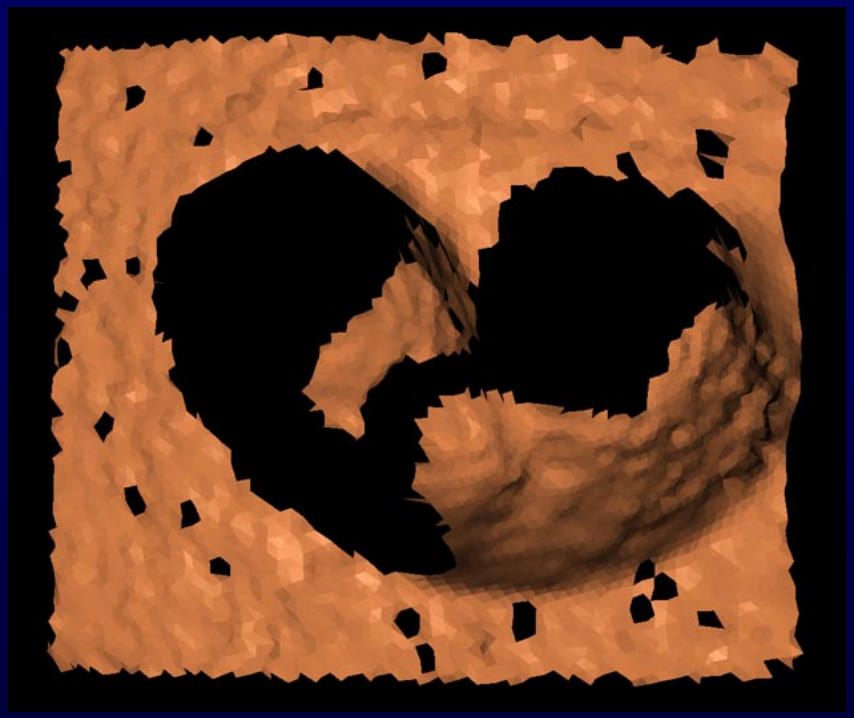
Scanned geometry often has complex holes

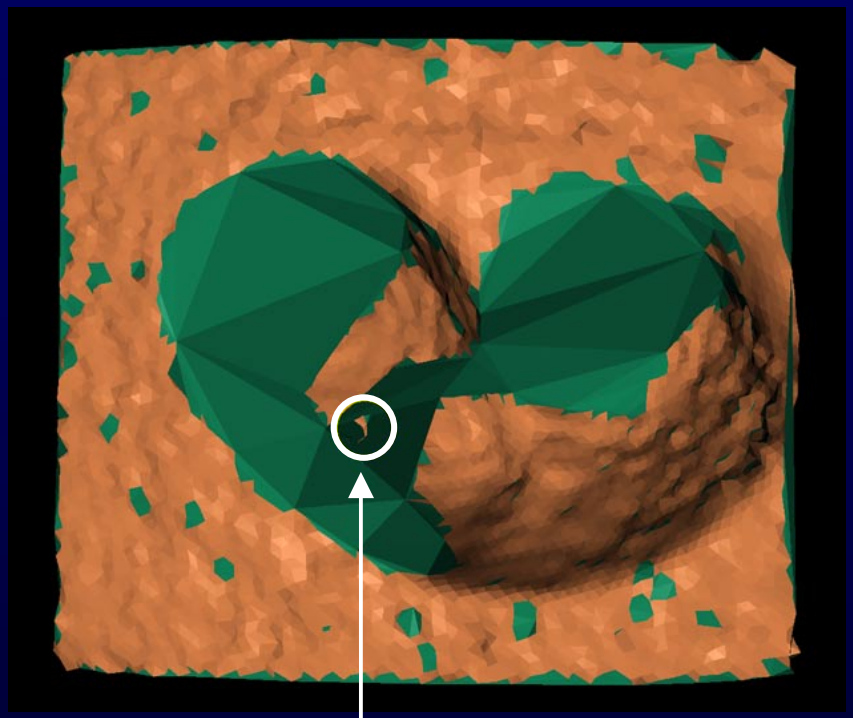


Locate hole boundaries and triangulate?



Triangulating boundaries sometimes fails



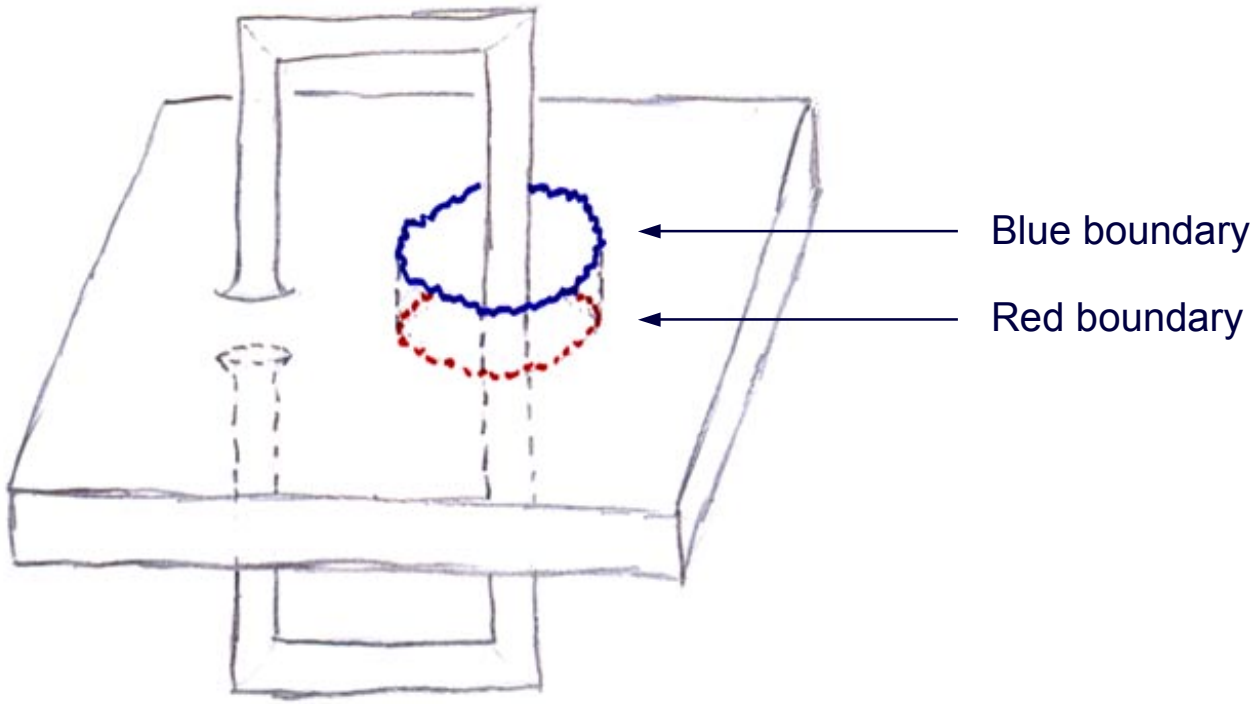


Self intersecting surface

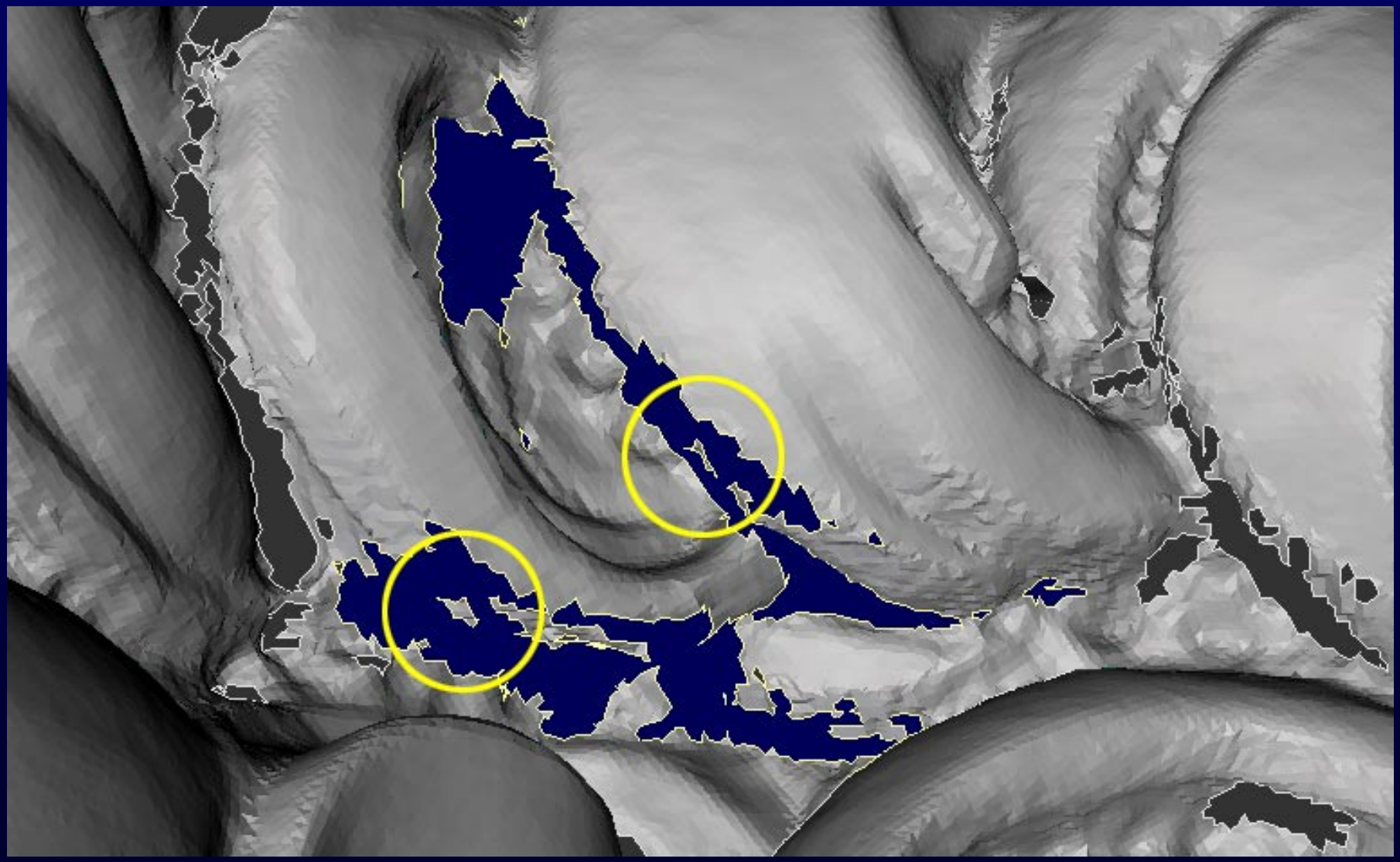
Hole boundaries must be correctly connected

Fill hole on blue boundary - no solution possible

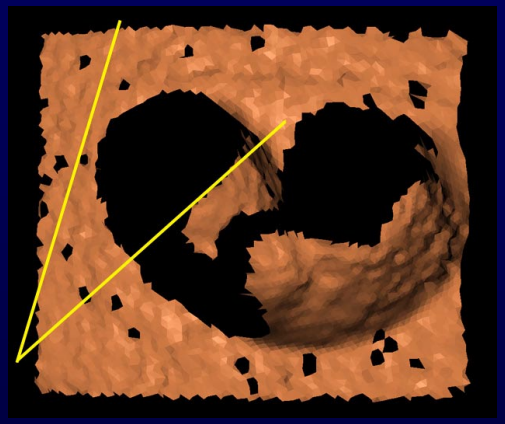
Fill hole *between* blue and red boundary - solution possible

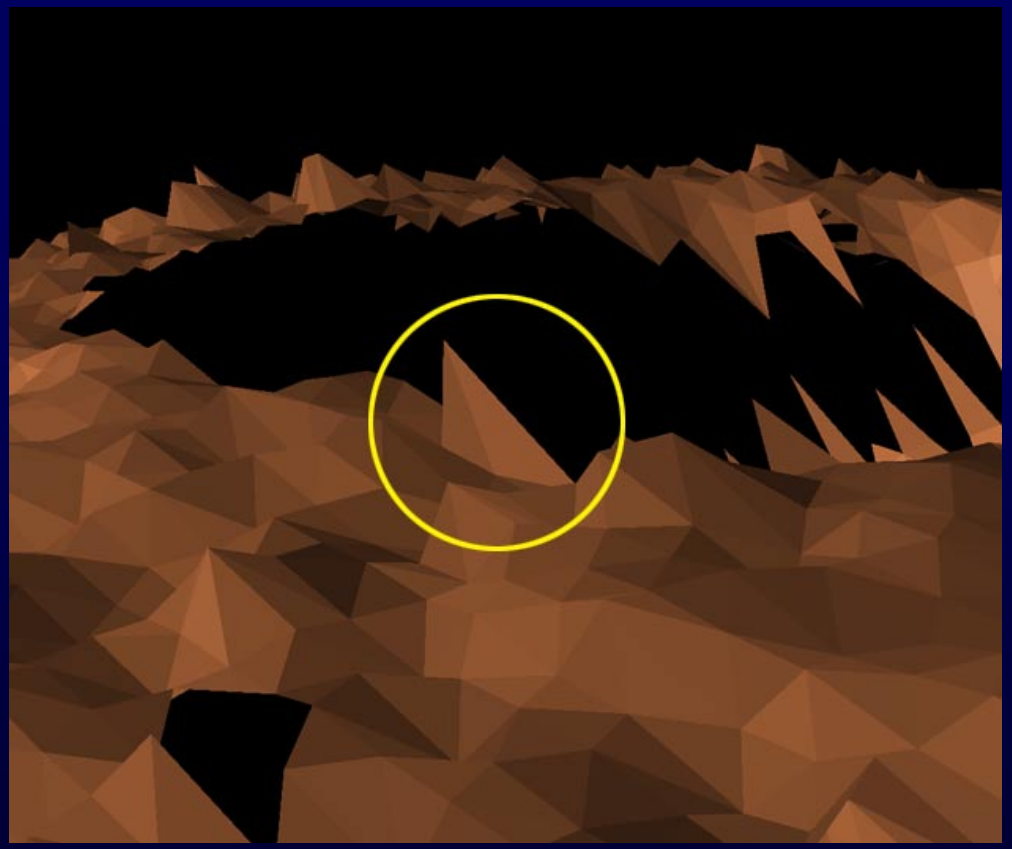


Topological complexity



Geometric complexity





Noise at the micro scale insures complex geometry

Desirable hole filling attributes

- Manifold non-self-intersecting surfaces
- Topological flexibility
- Use of all available information
- Efficiency

Related work

Simple boundary triangulation

[Berg, et. al. 97]

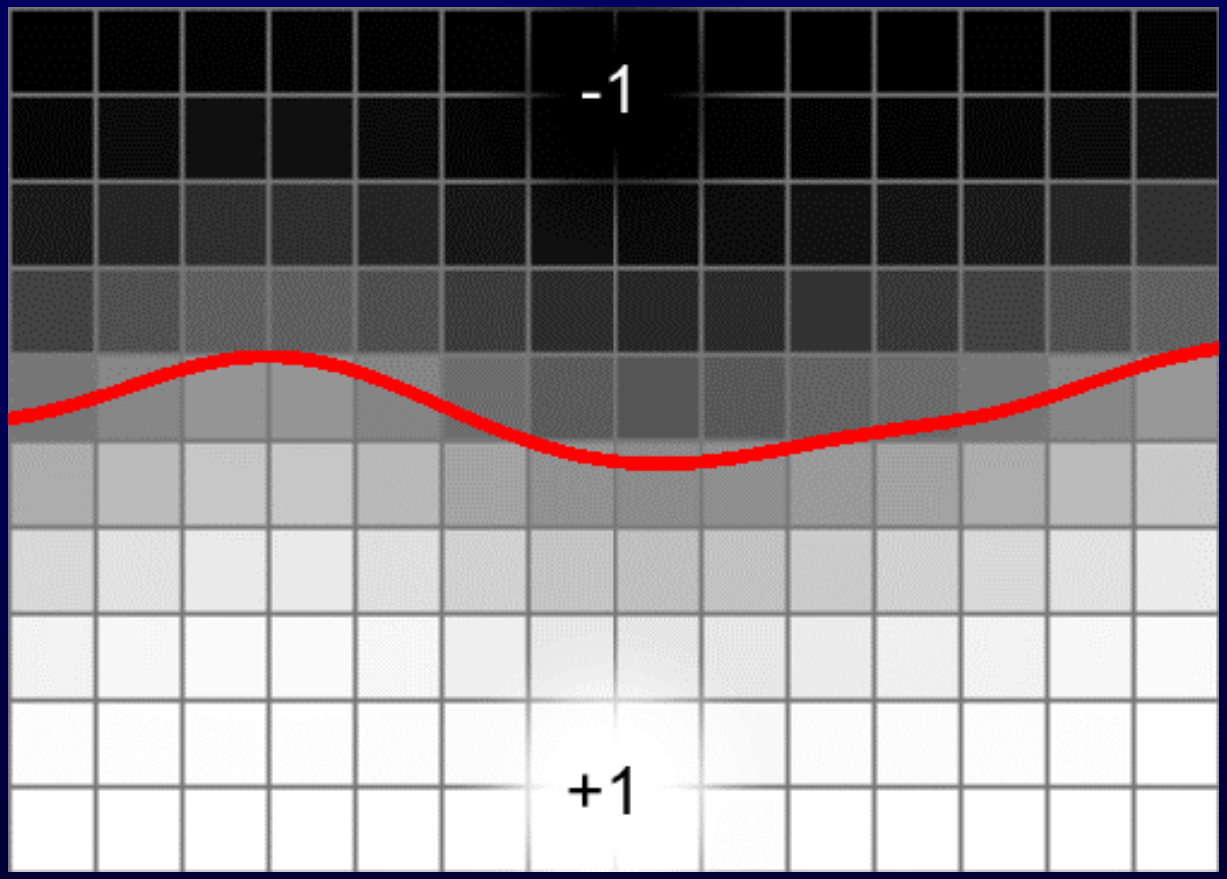
Mesh based surface reconstruction

[Turk94] [Curless96] [Wheeler98]

Point cloud interpolation

[Edelsbrunner92] [Hoppe92] [Bajaj95] [Chen95] [Amenta98]
[Whitaker98] [Bernardini99] [Dey01] [Zhao01] [Dinh01] [Carr01]

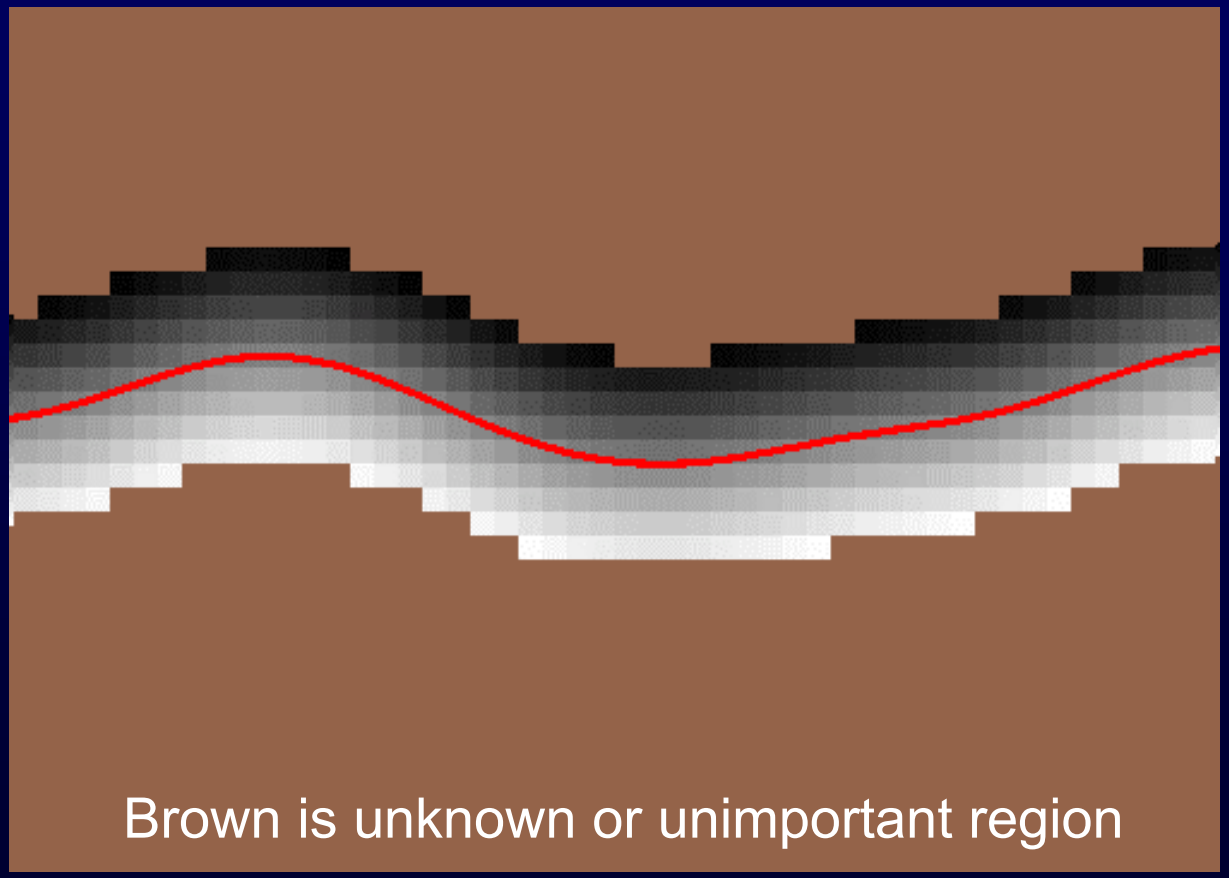
Volumetric surface representation



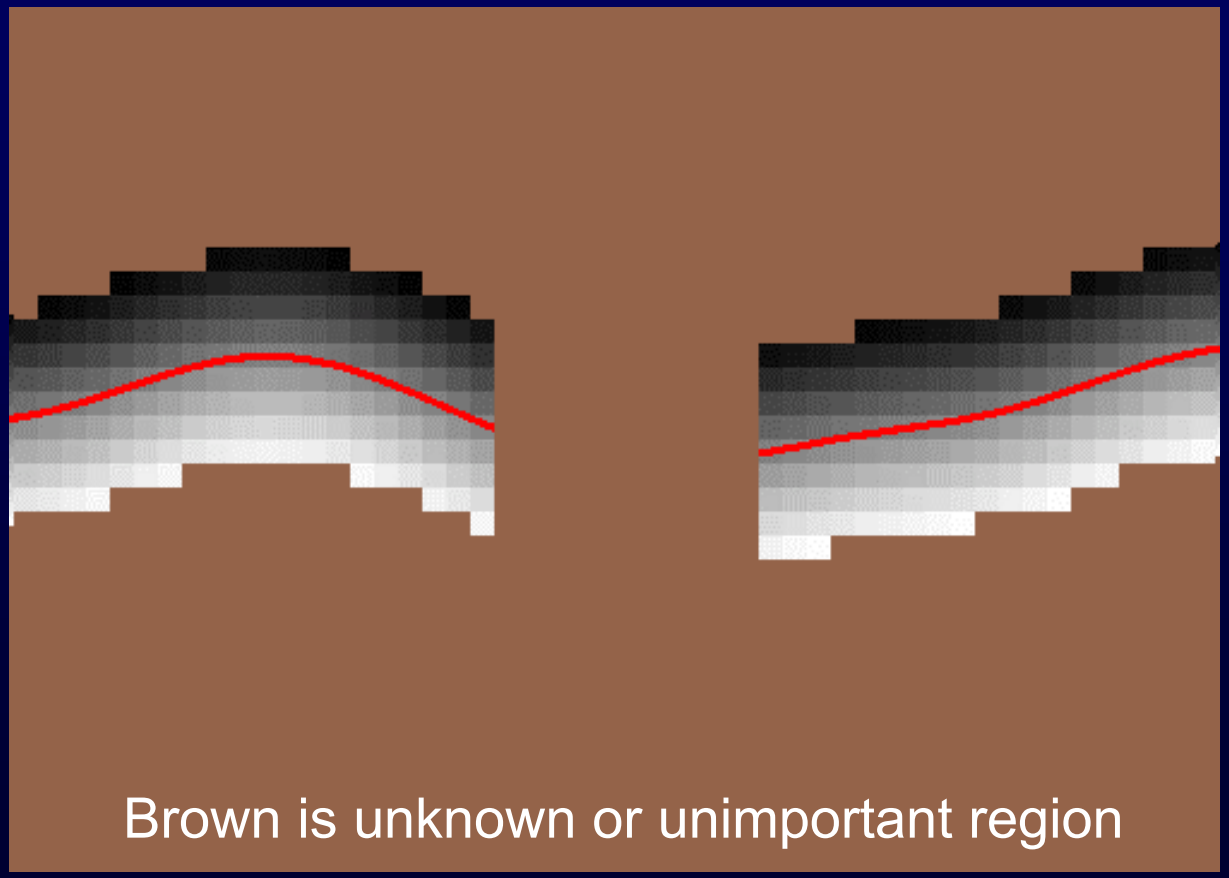
Surface is the zero set of a filtered sidedness function
(or equivalently a clamped signed-distance function)

Limit the computational domain

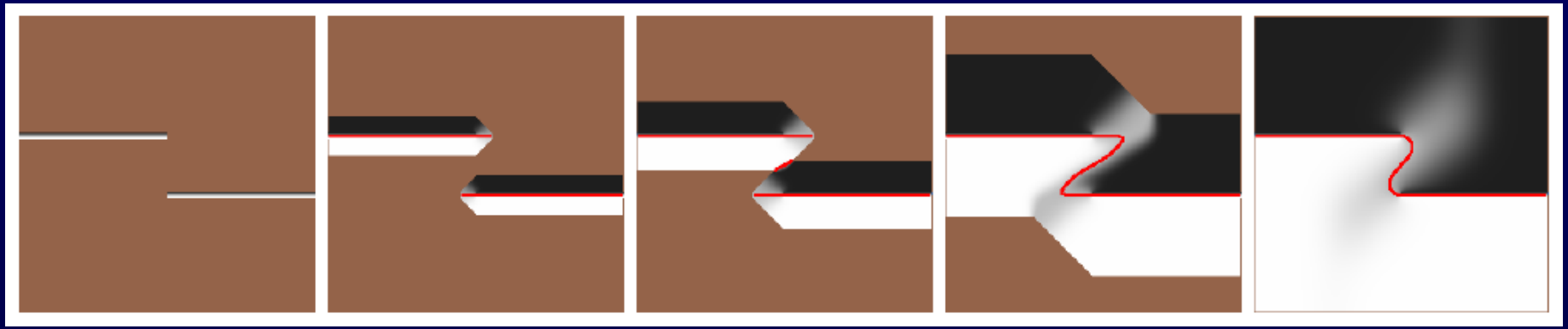
Volume represented only near the surface



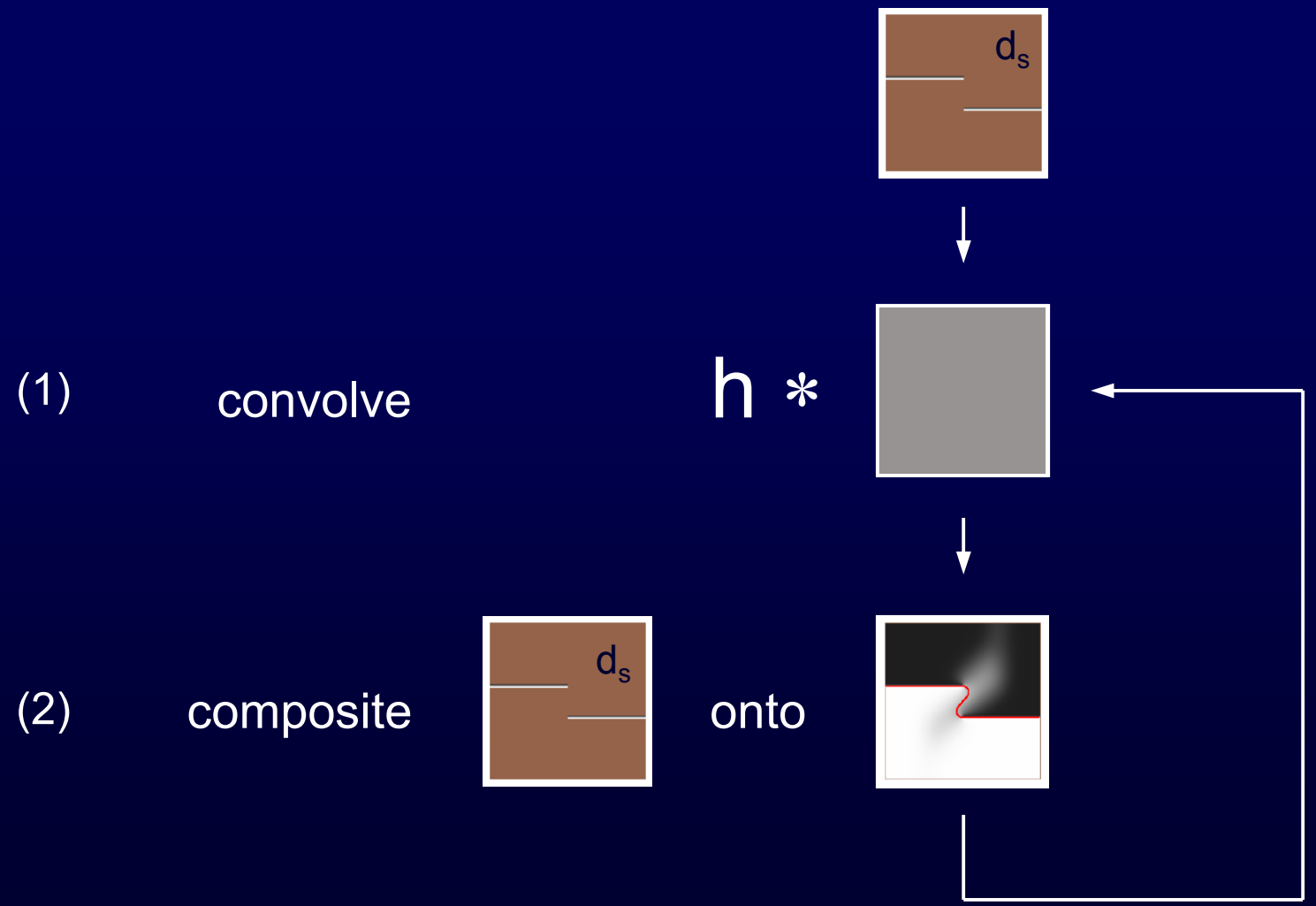
Surface holes are unknown regions



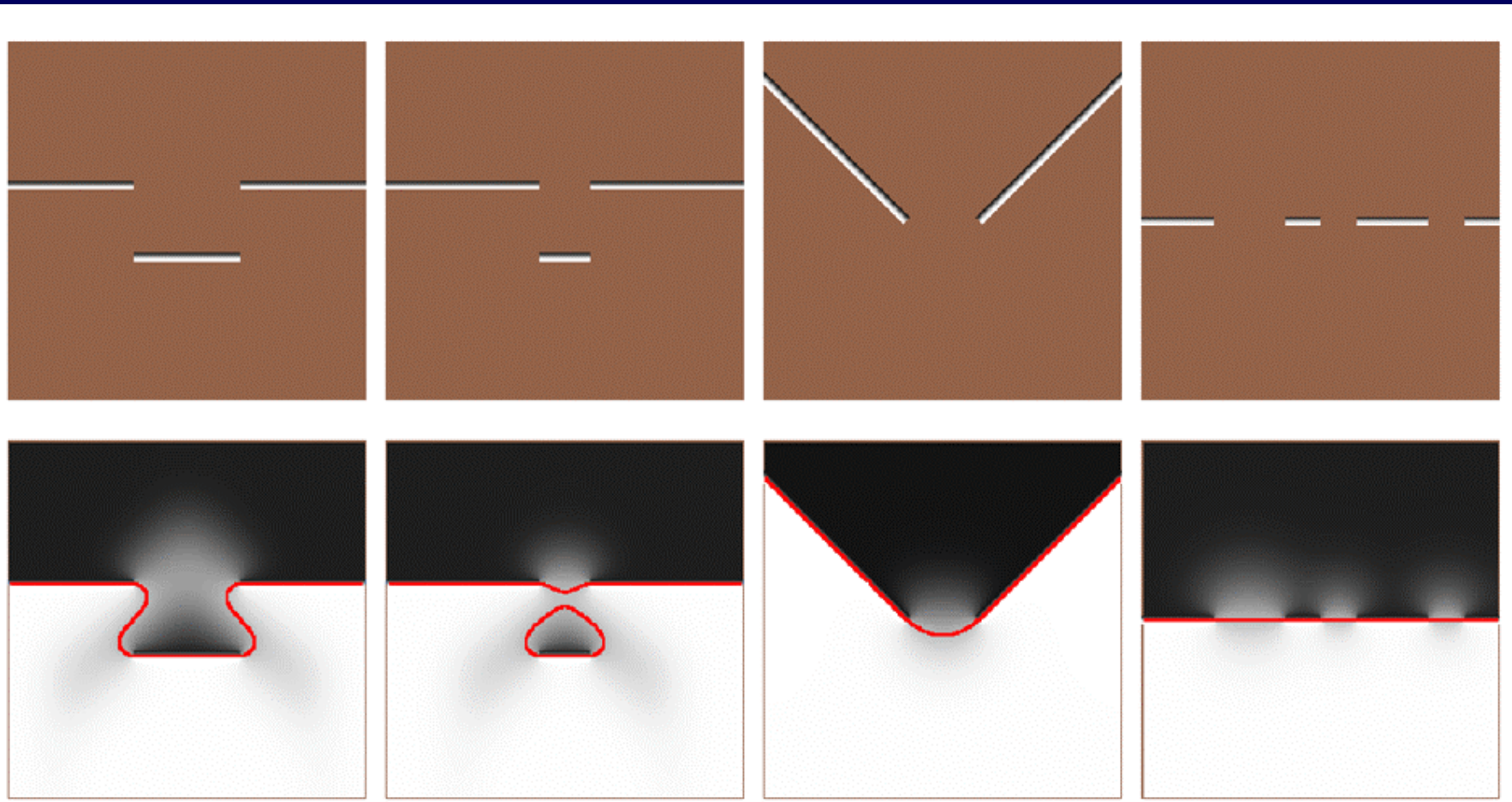
Diffuse to fill in missing volumetric regions



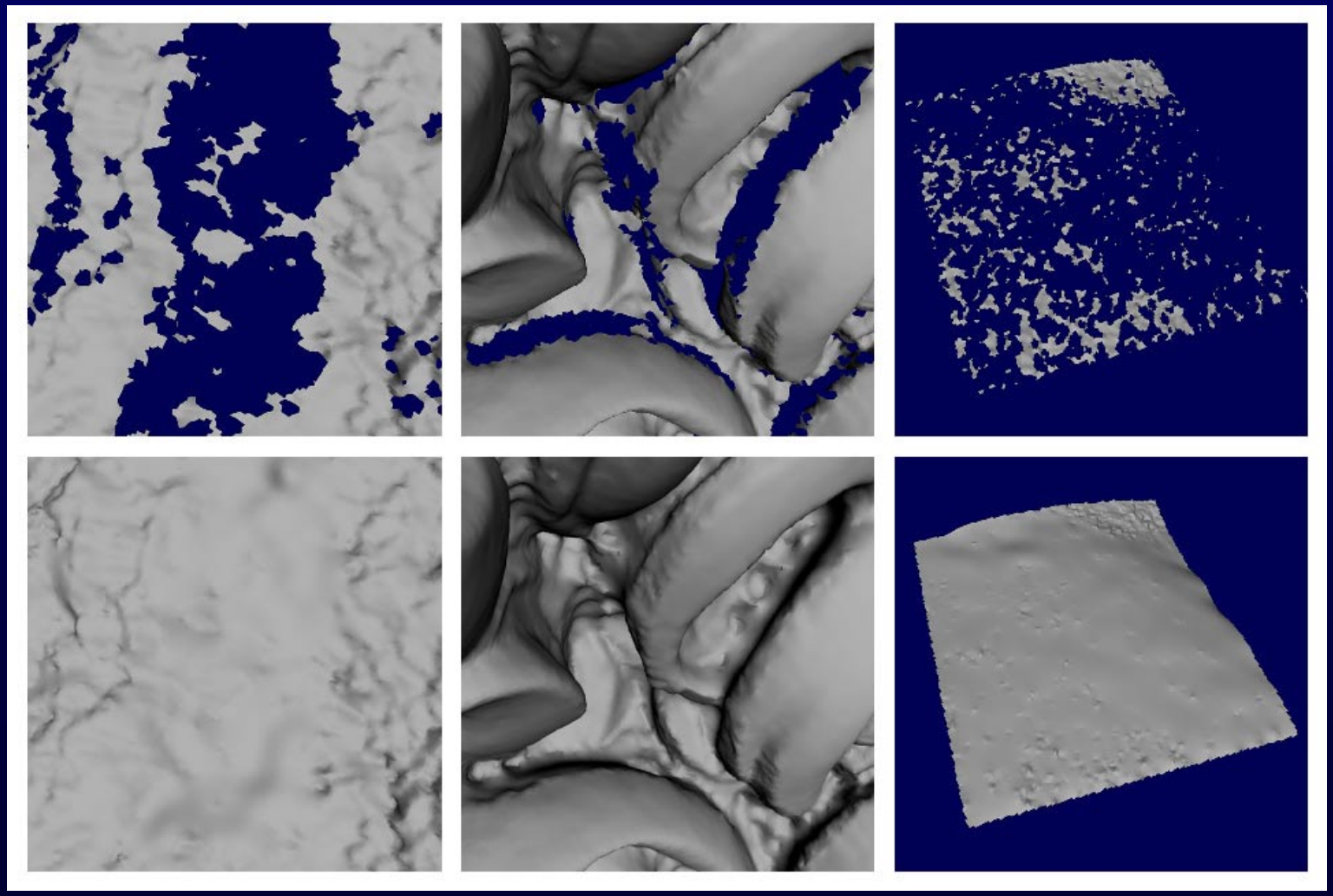
Simplified method description



Examples from synthetic holes

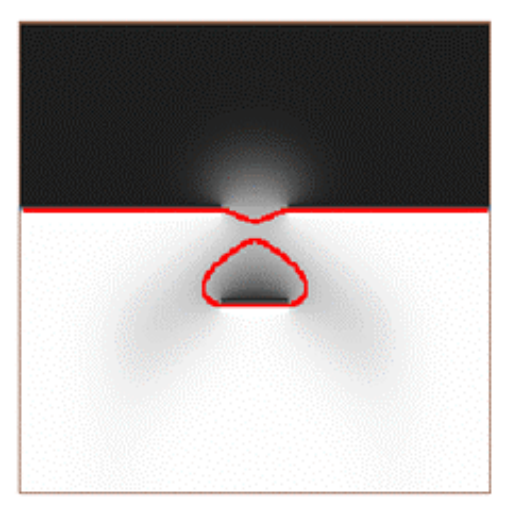


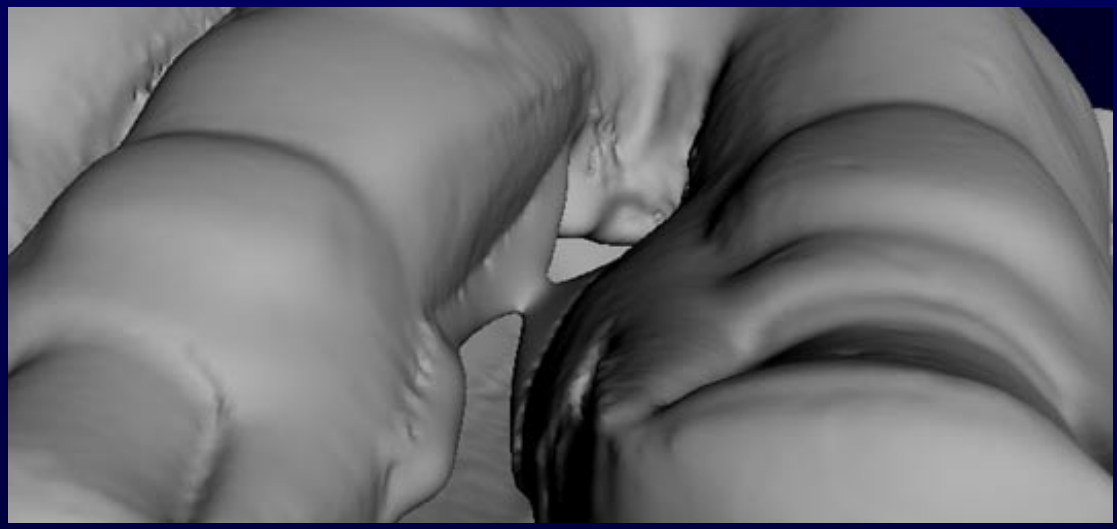
Examples from real meshes



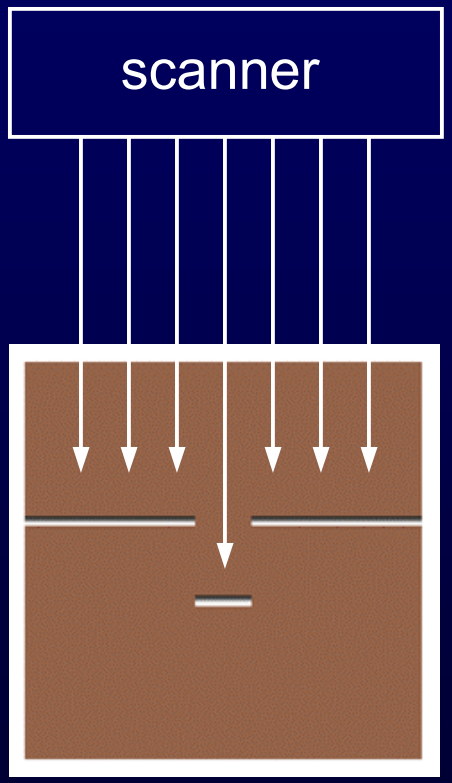
[video]

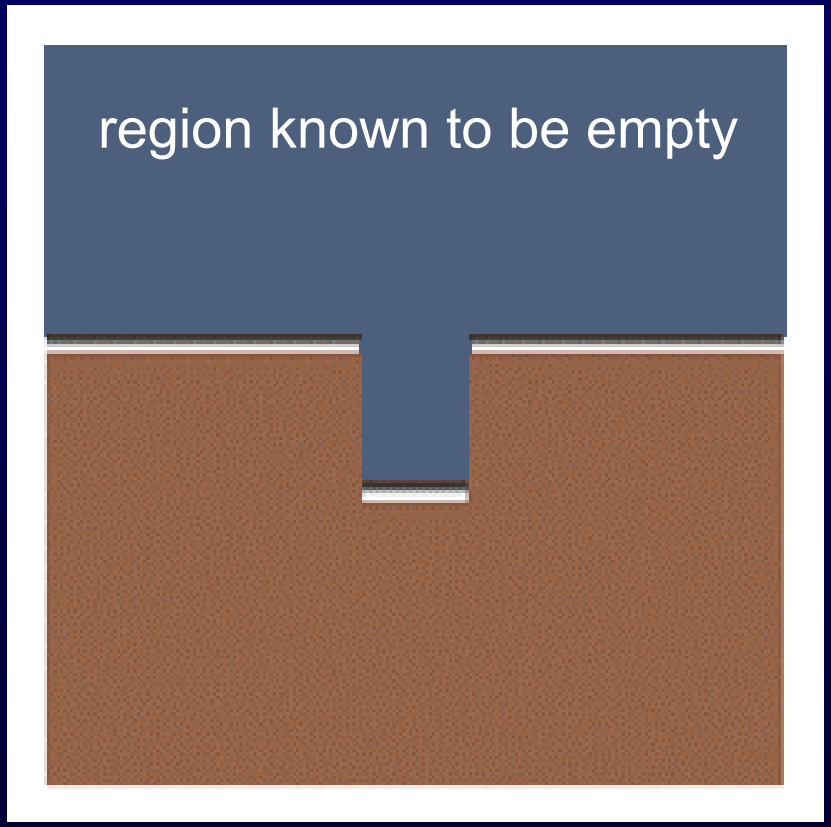
Flexible but not always correct topology



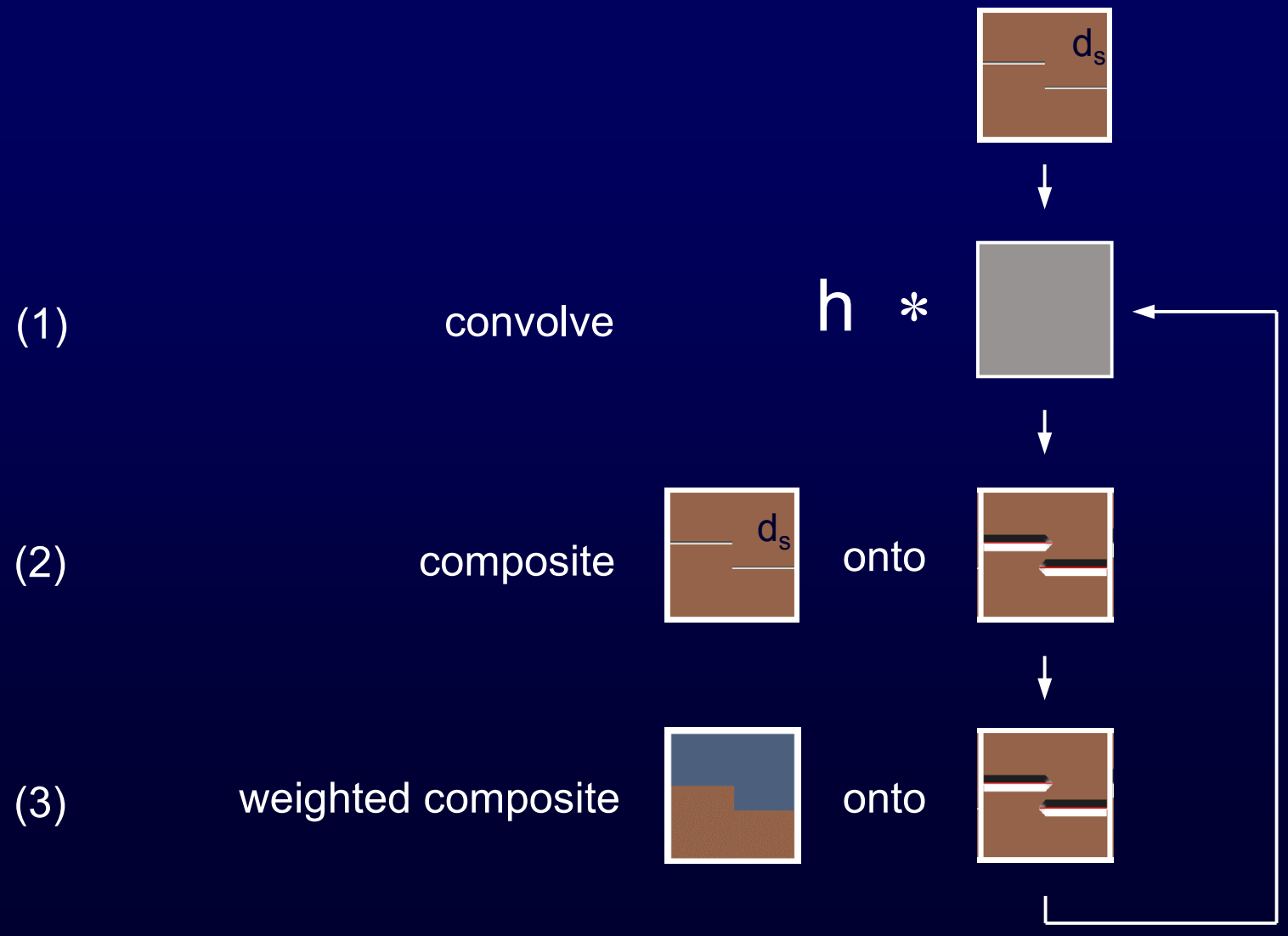


Scanner line of sight constraint

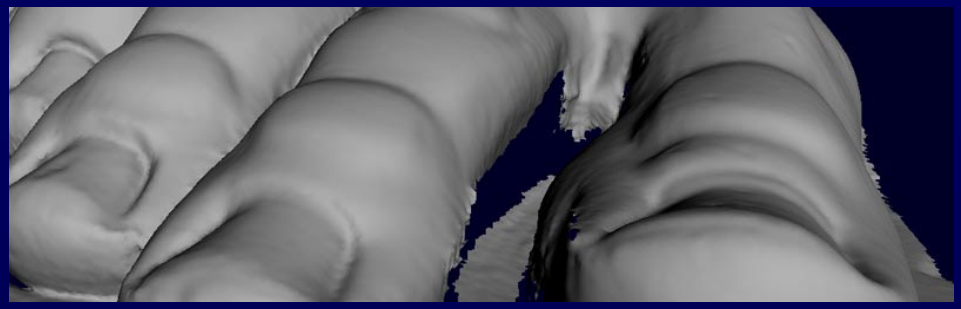


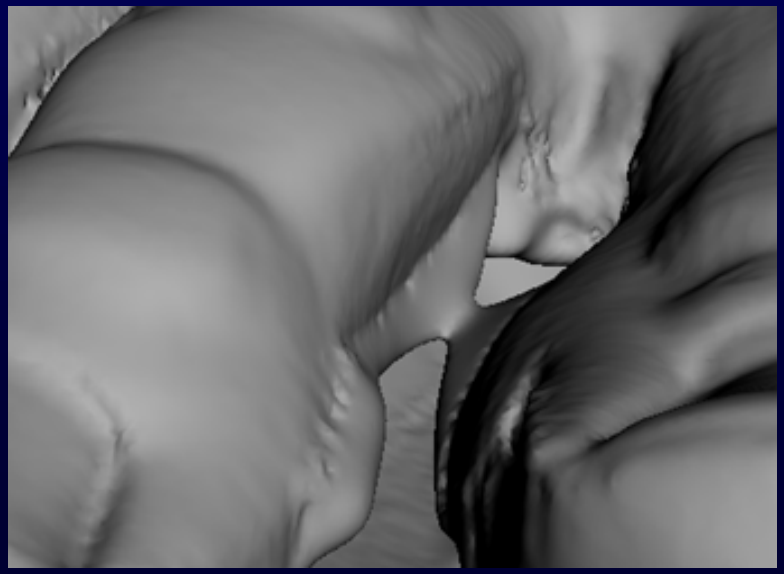


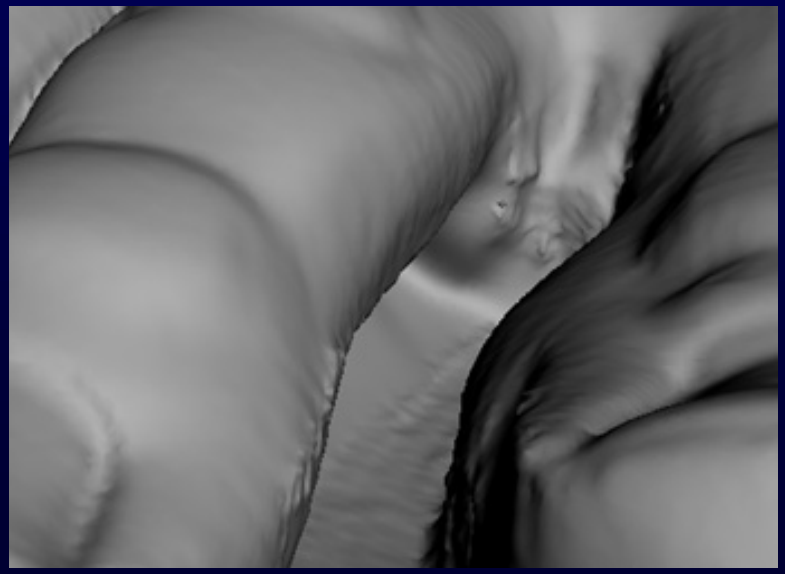
Method with line of sight constraint



Line of sight constraint enforces correct topology



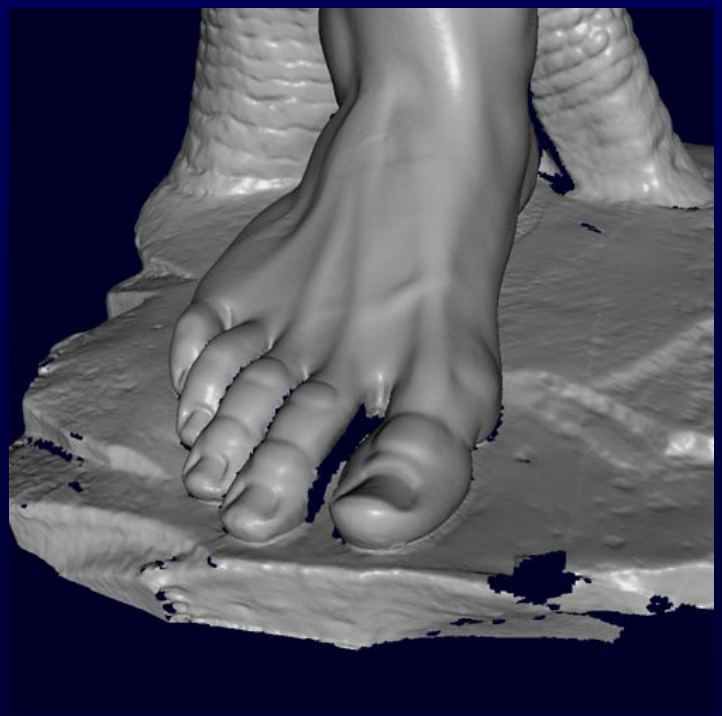


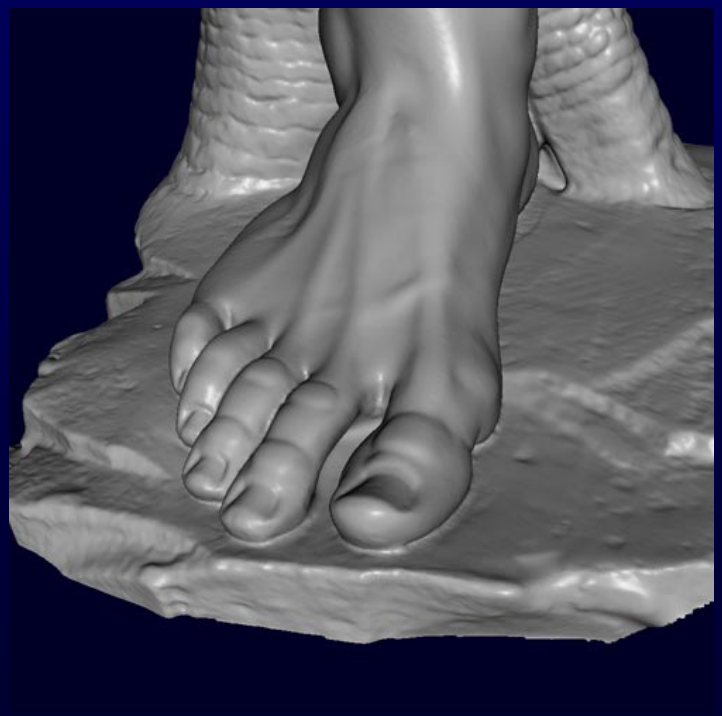


Efficient computation possible

Mesh size : 4.5 M triangles
Volume size : 440 M voxels
Voxels touched : 4.5%

Memory allocated : 550MB
Processing time : 20 minutes





[video]

Summary

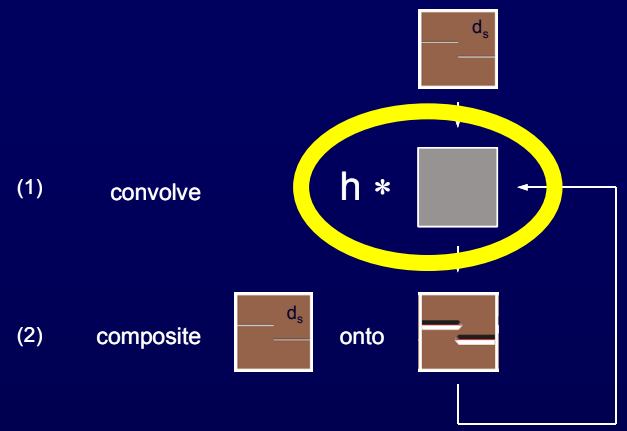
- Manifold non-self-intersecting surfaces
- Topological flexibility
- Use of all available information
- Efficient
- Simple

Algorithm's free parameters

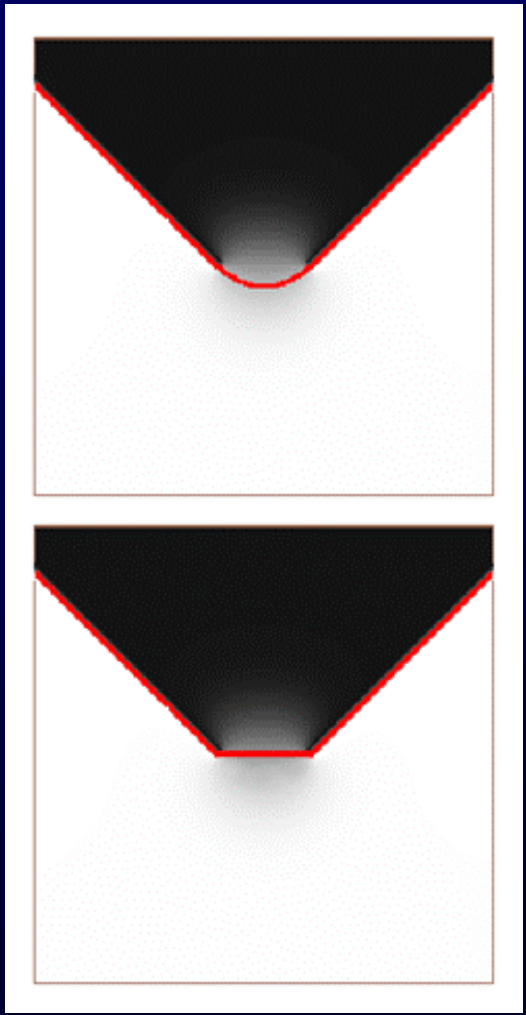
- Number of iterations
- Distance to clamp the computational domain
- Diffusion operator
- Compositing percentage

Future work – choice of diffusion operator

- **Convolution**
  - 3x3x3 box filter
  - 7-part plus filter
- **Anisotropic diffusion**
  - In direction of gradient?
- **Morphological operators**
  - Opening – closing

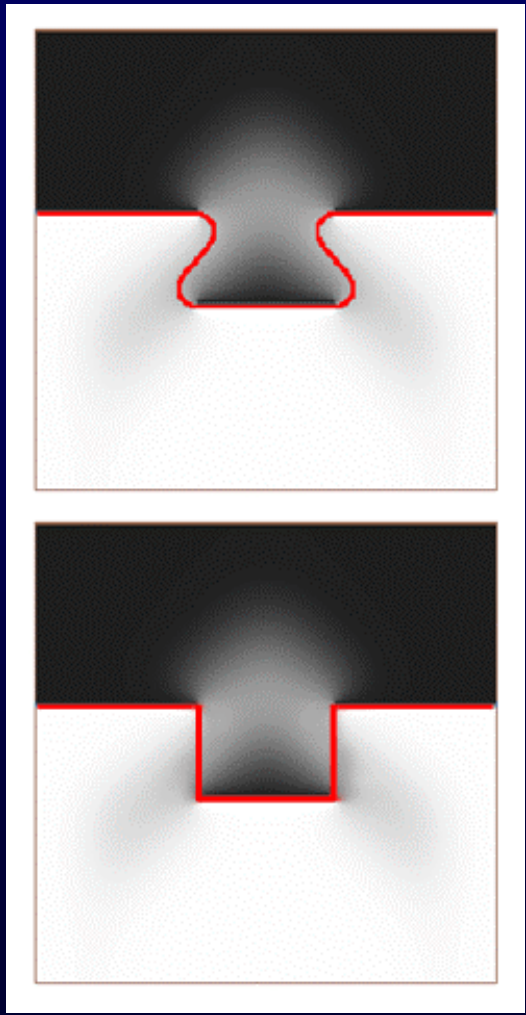


Future work – control of surface shape



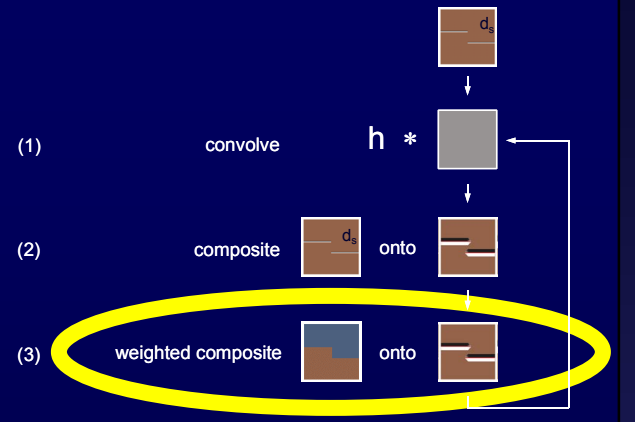
minimum curvature

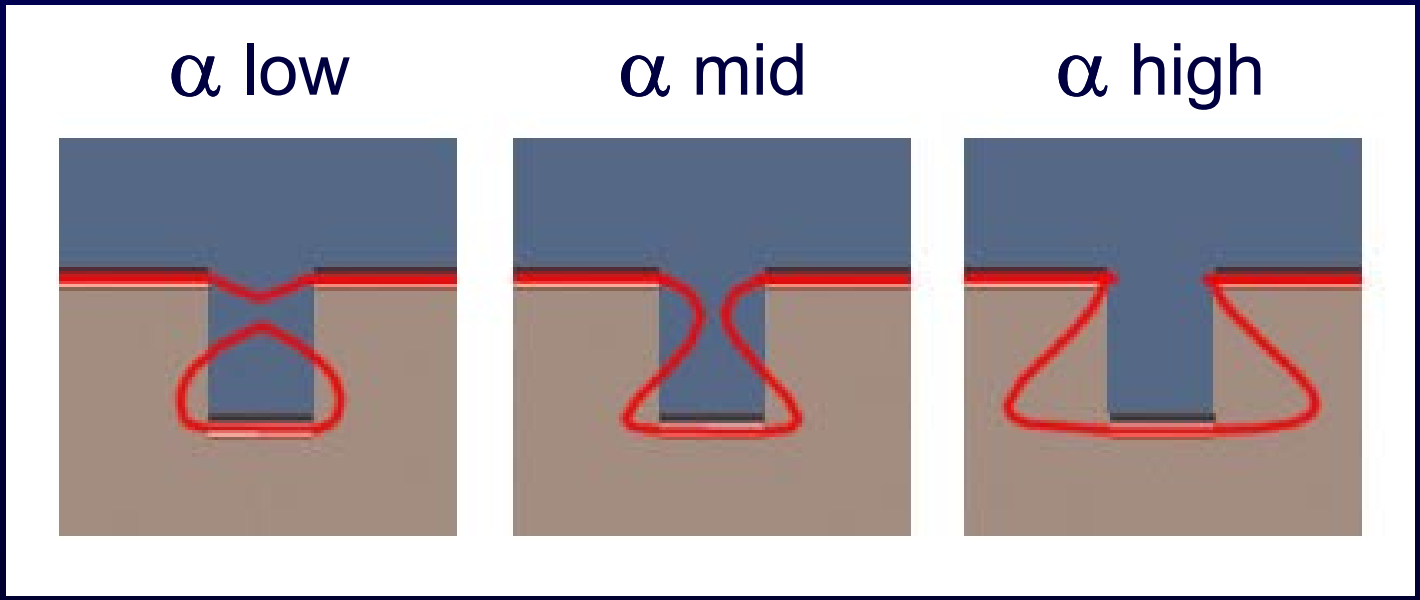
minimum area



Future work – line of sight constraint

What should compositing α be set to?





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