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

Brown is unknown or unimportant region
Surface holes are unknown regions

Brown is unknown or unimportant region
Diffuse to fill in missing volumetric regions
Simplified method description

(1) convolve

(2) composite onto
Examples from synthetic holes
Examples from real meshes
Flexible but not always correct topology
Scanner line of sight constraint

scanner

region known to be empty
Method with line of sight constraint

1. Convolve
2. Composite
3. Weighted composite
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 $\alpha$ be set to?

- low
- mid
- high

1. Compose $h *$ onto
2. Composite onto weighted composite
3. Weighted composite onto