CS348C – Winter 1997

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Surface Reconstruction
Part I: Range Image Methods

Zippered polygon meshes from range images

Turk and Levoy, 1994

Overview:

1. Tesselate range images and assign weights to vertices.

2. Remove redundant triangles.

3. Zipper meshes together.

4. Extract a weighted, consensus geometry.

Weight assignment

The final surface is going to be a weighted combination of the range images.

The weights are assigned at each vertex in order to:

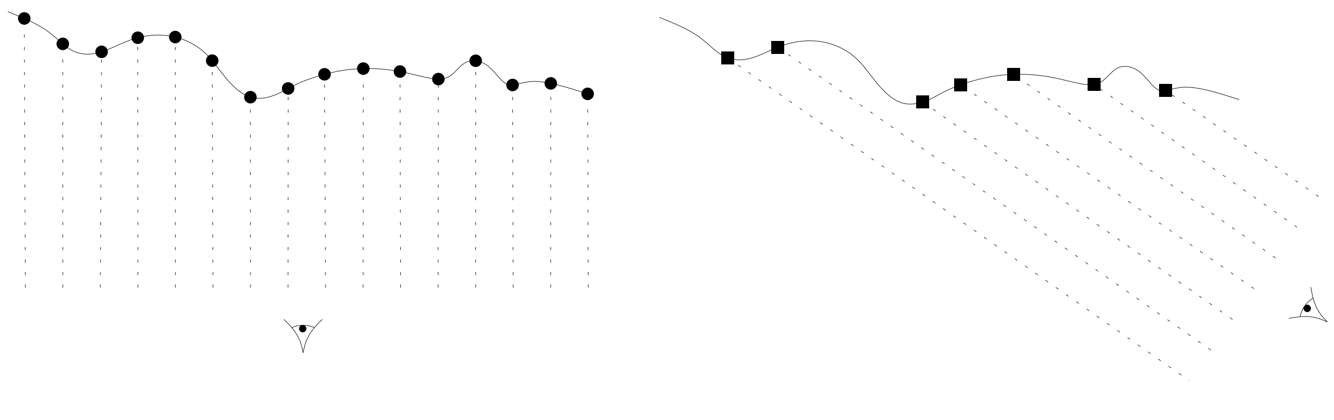
- Favor views with higher sampling rates
- Encourage smooth blends between range images

Sampling Rates

The range image is most densely sampled when the surface normal is facing the range sensor. To force these samples to contribute more than samples acquired at grazing angles, the weights are assigned as:

$$w_i = | n_i \bullet v |^q$$

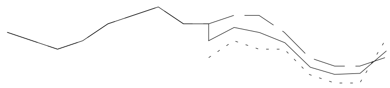
where n_i is the normal at the ith vertex, v is the view direction and q is an exponent that controls how quickly weights should fall off with grazing angle.



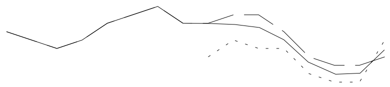
Smooth blends

In order to assure smooth blends among range surfaces, wieghts are also forced to taper in the vicinity of boundaries.

Two range surfaces

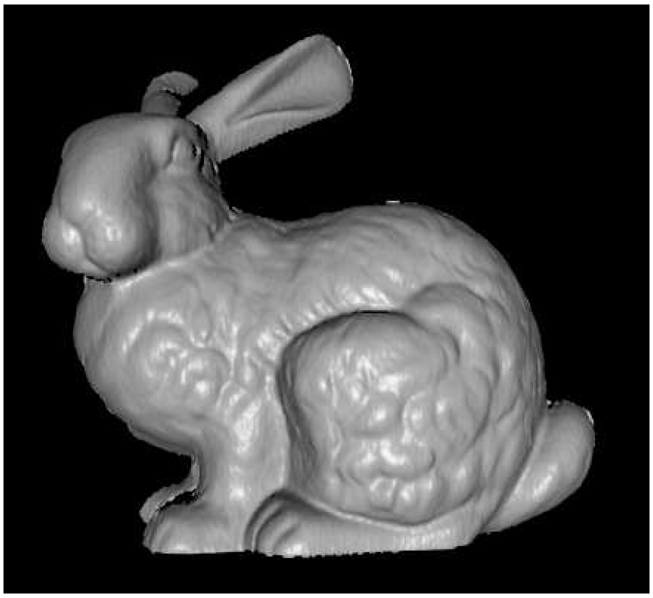


After unweighted blending

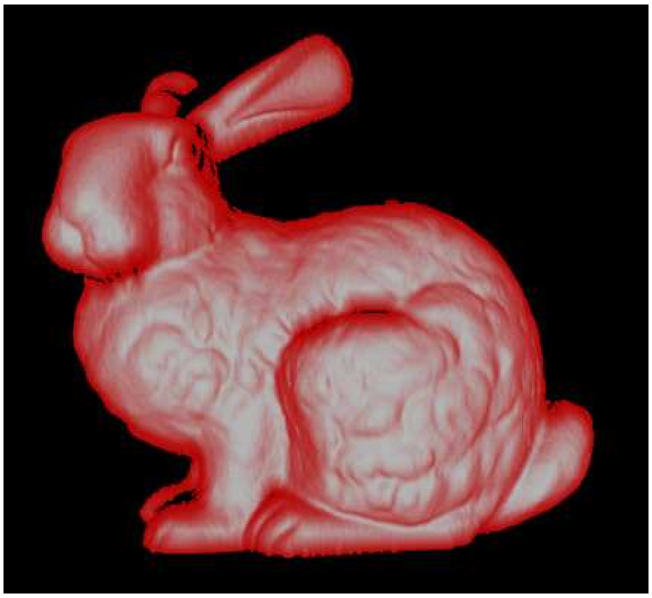


After weighted blending

Example of weight assignments

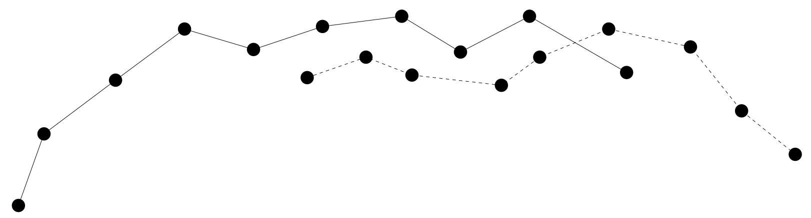


Range surface

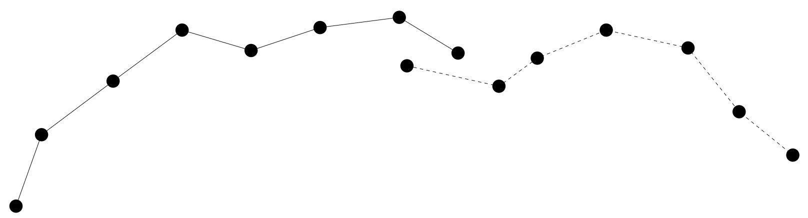


Weights over surface
(red = low weight)

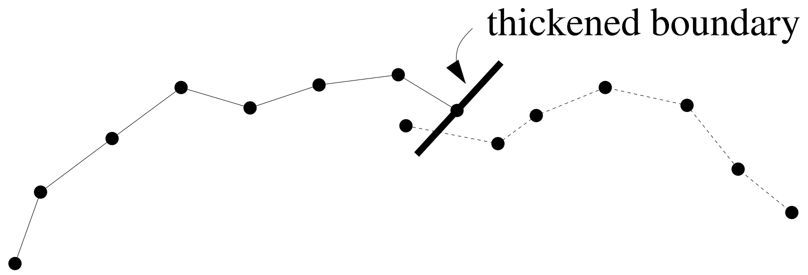
Remove redundant triangles and zipper surfaces



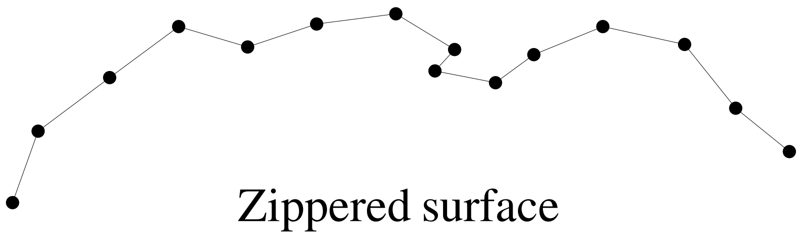
Overlapping range surfaces



After removing redundant geometry

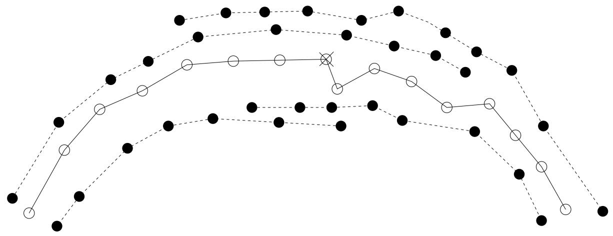


Thickening the mesh boundary for clipping

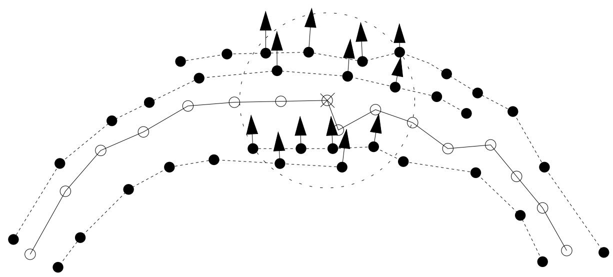


Zippered surface

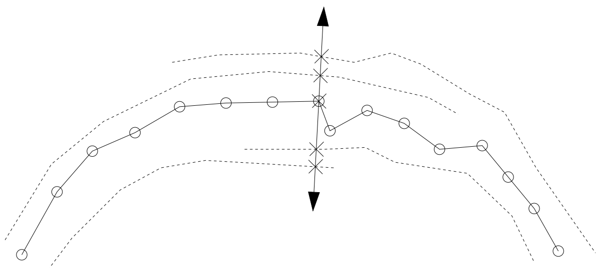
Compute consensus geometry



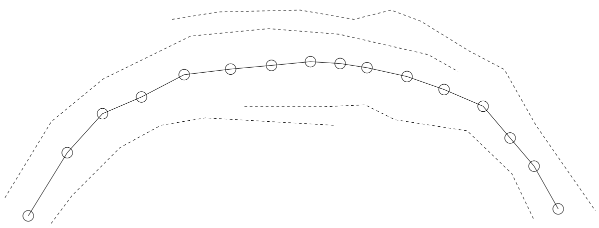
Zippered geometry + range surfaces



Compute consensus normal

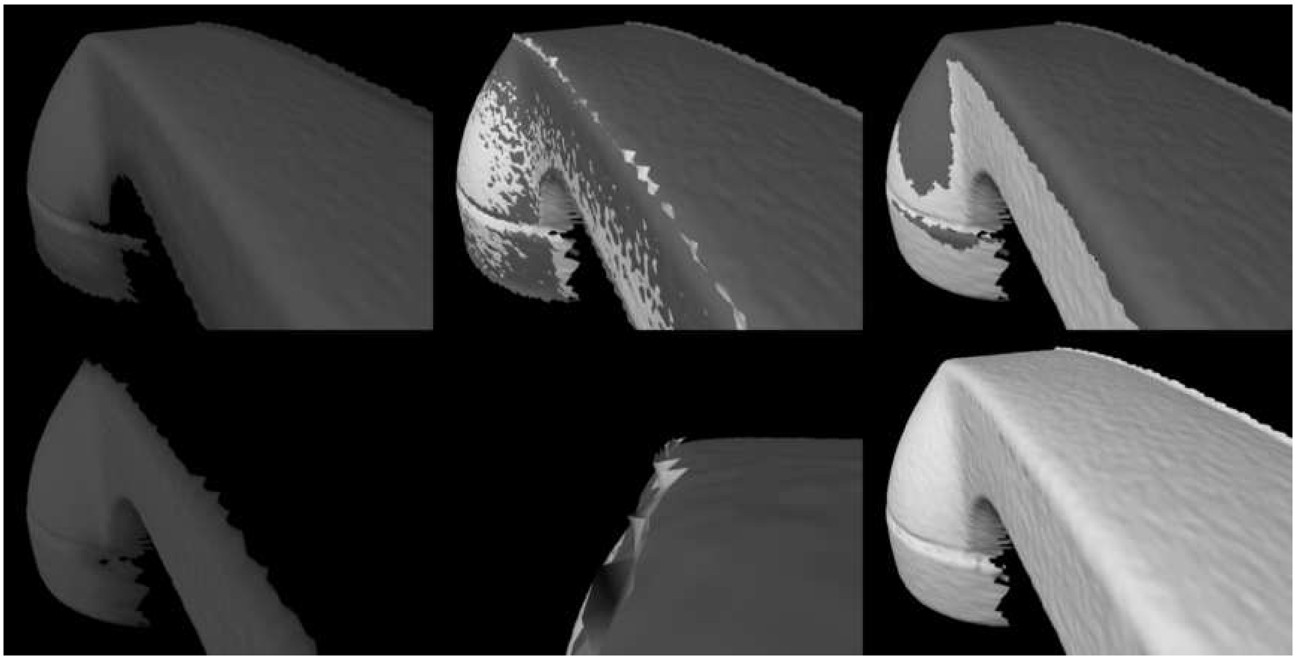


Find vertex positions on range surfaces
by intersection with consensus normal

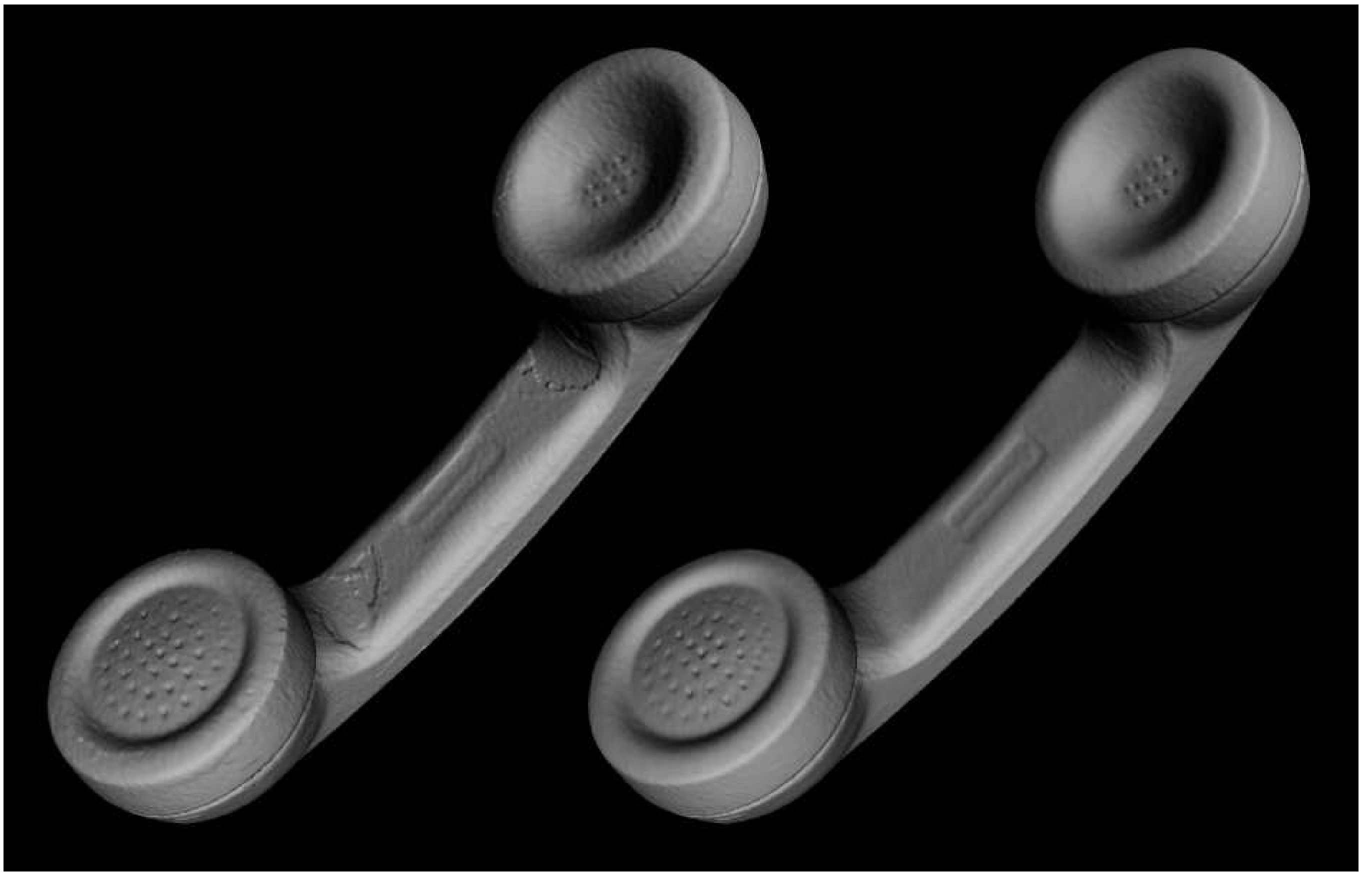


Compute weighted average of vertex positions

Range surfaces | Before merging | Redundant geometry removed



Zippered surface



Before consensus | After consensus

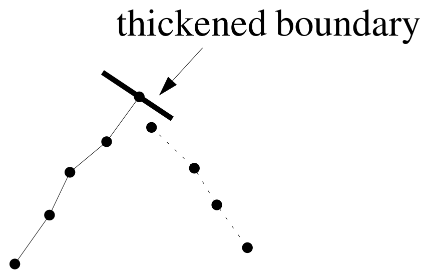
[Images from Turk 1994]

Notes on zippering

Incremental but not order independent.

Can handle thin features, because opposing surfaces are distinguished.

Problems in areas of high curvature:



Has been deomnstrated on models of moderate to high complexity (up to 500K input points with an ouput of 360K triangles).

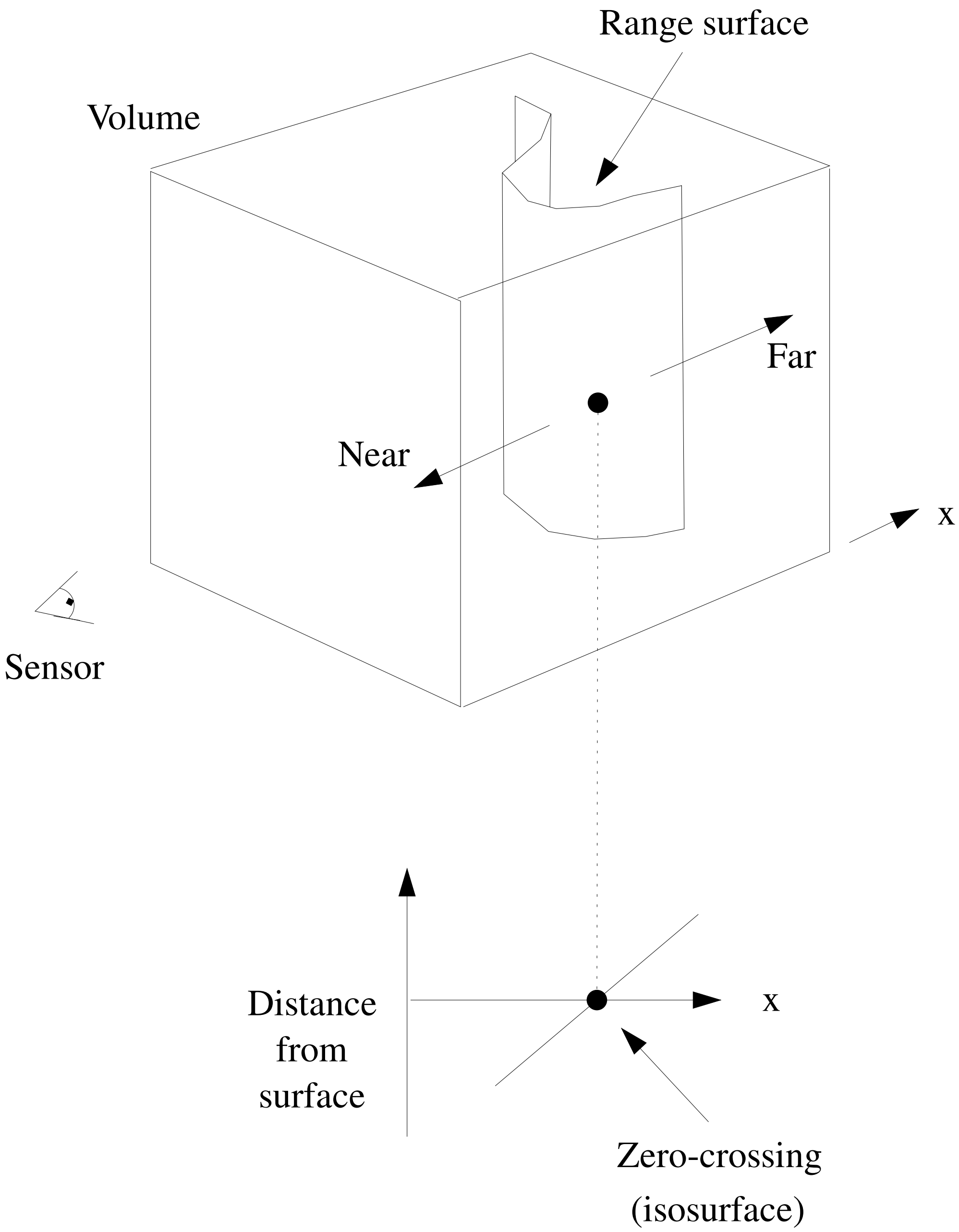
Volumetrically combining range images

Curless and Levoy, 1996

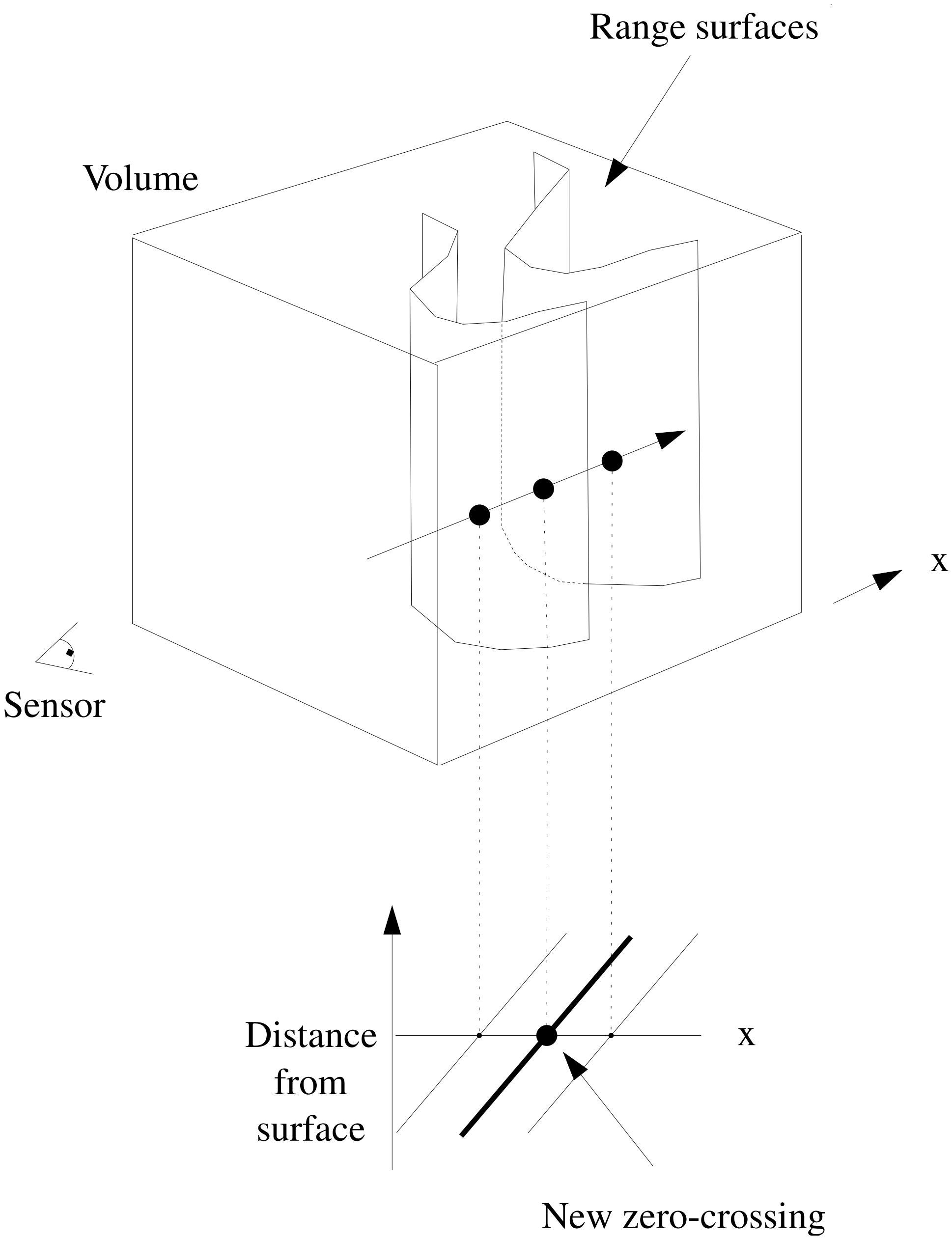
Overview:

1. Convert range images to signed distance functions.
2. Combine signed distance functions.
3. Carve away empty space.
4. Extract a hole−free isosurface.

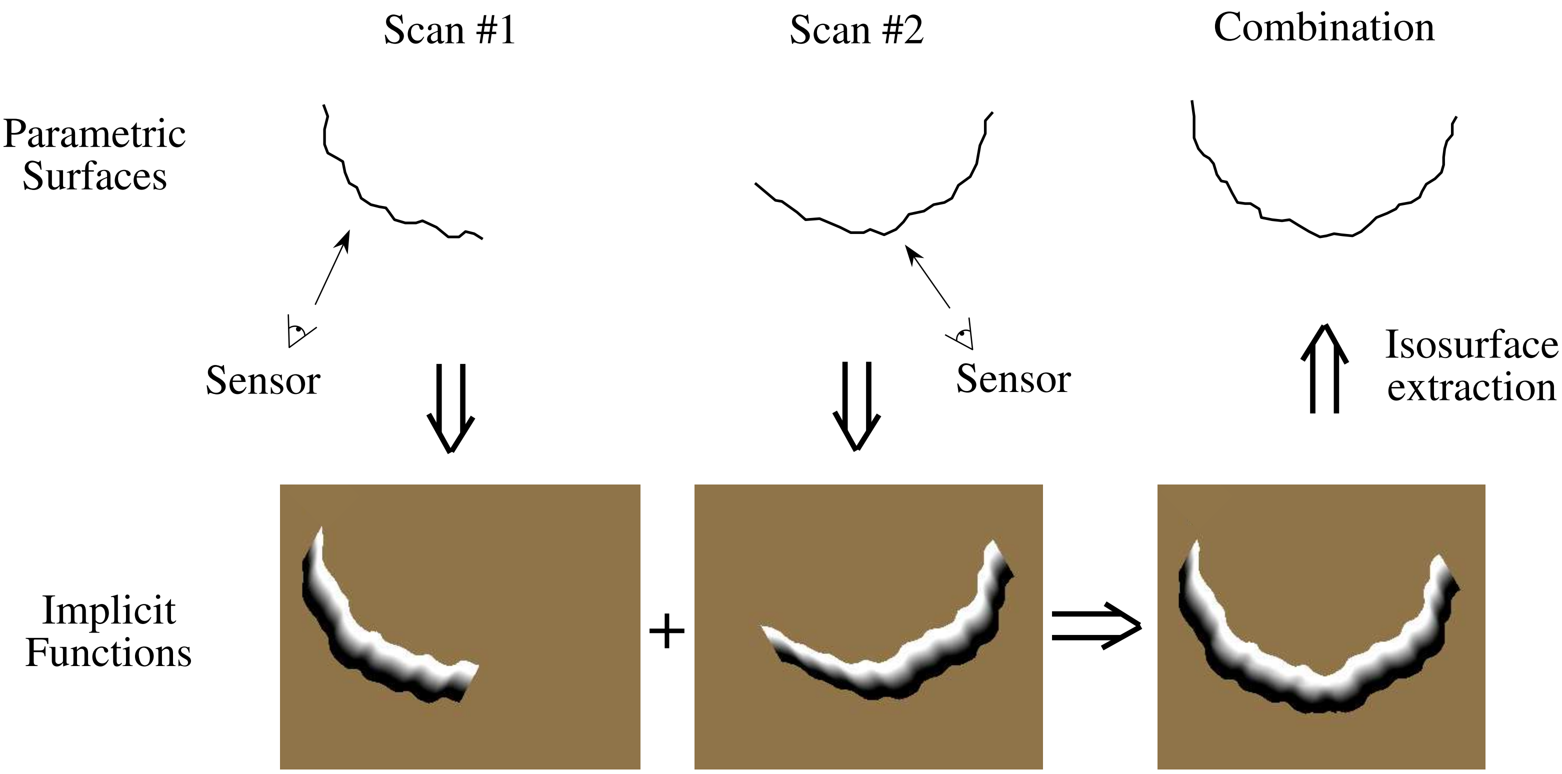
Signed Distance Function for a Range Surface



Combining Signed Distance Functions

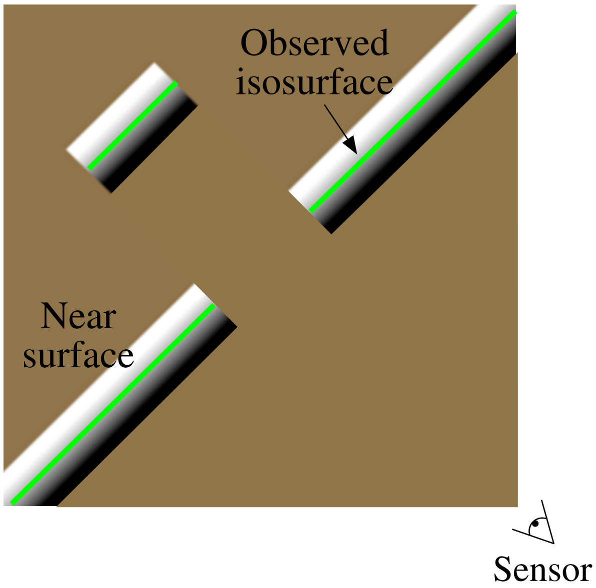


Volumetrically Merging Range Surfaces in 2D

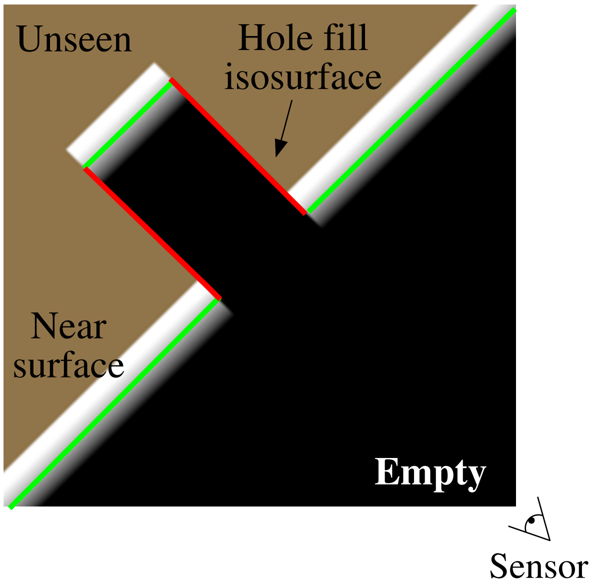


Space carving and hole filling

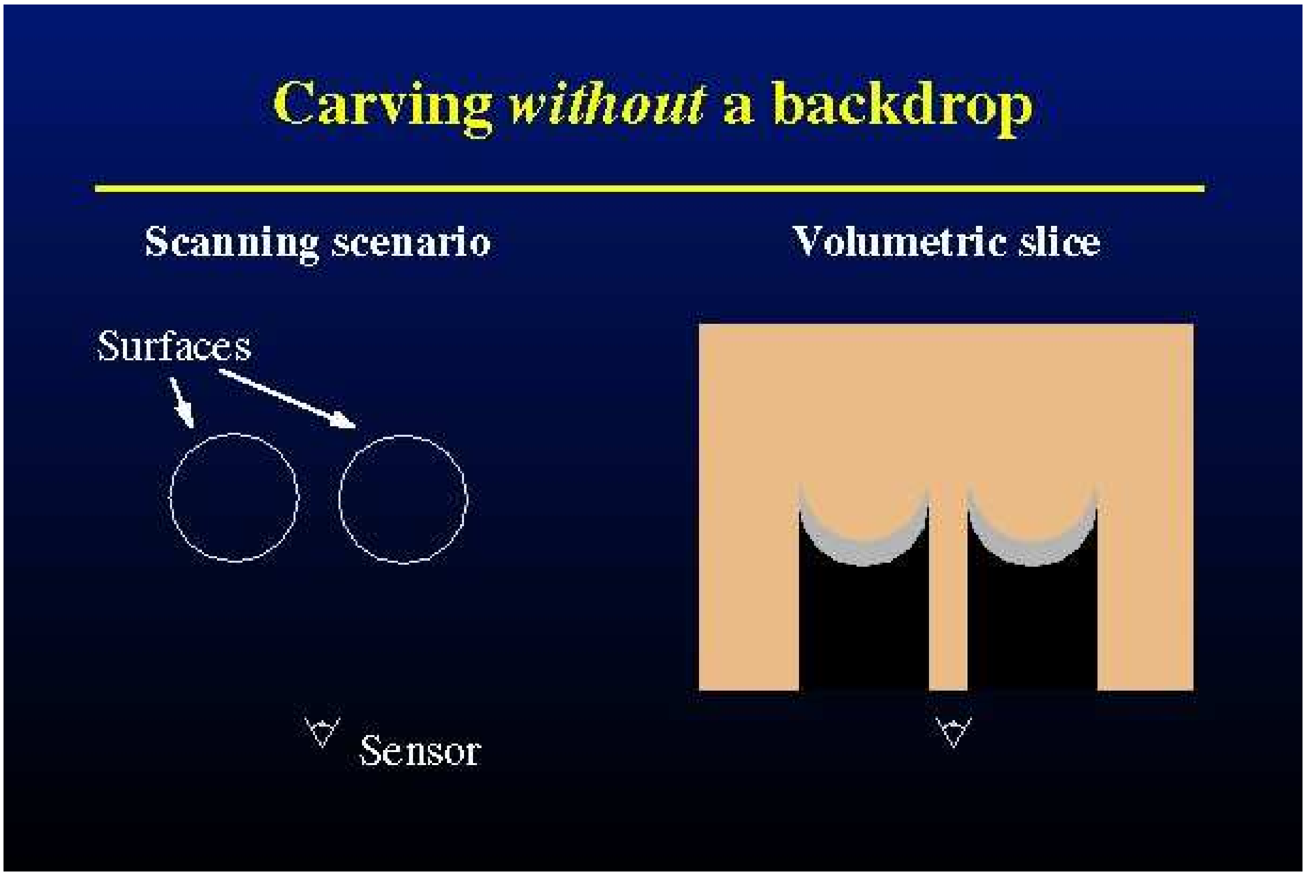
Volumetric grids and isosurfaces

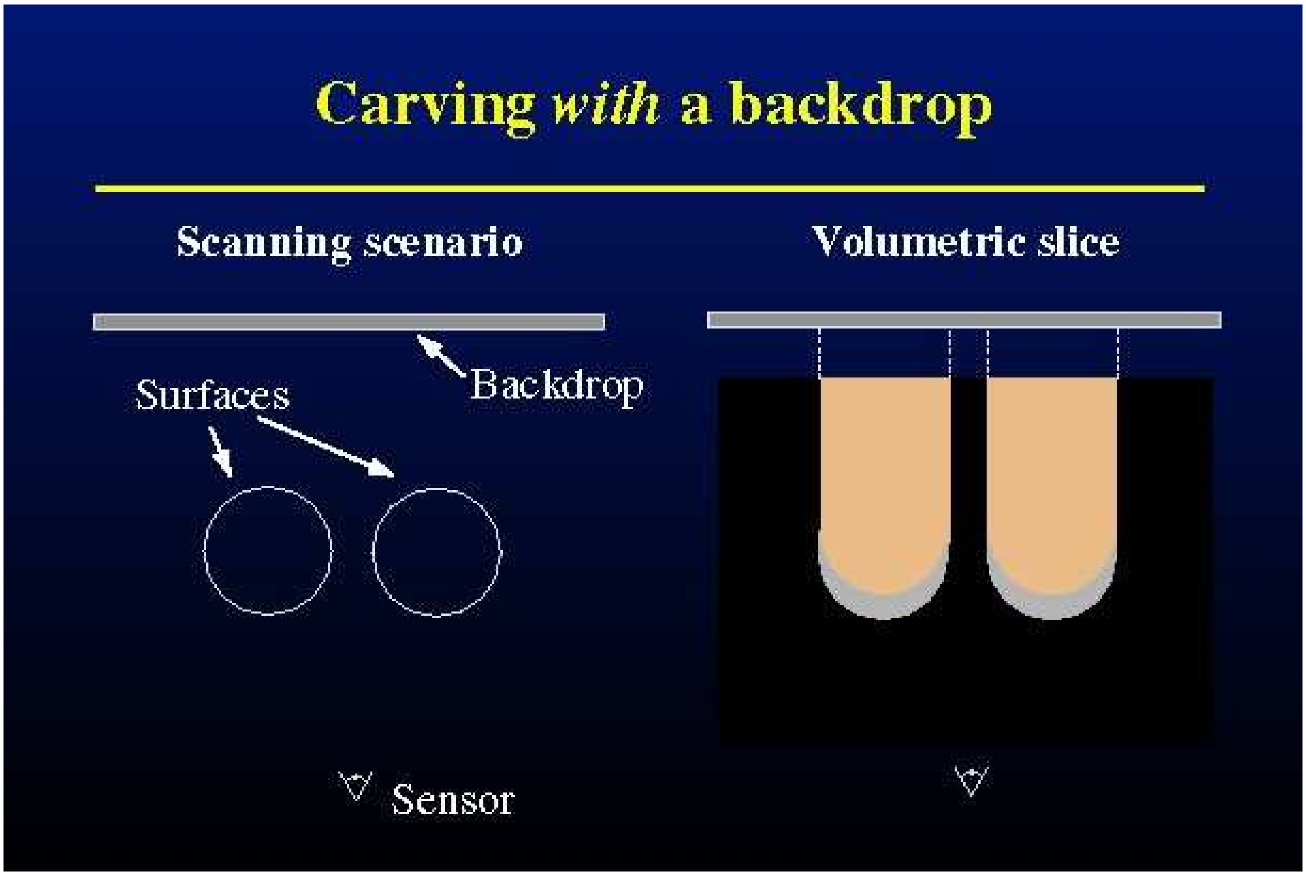


Without space carving

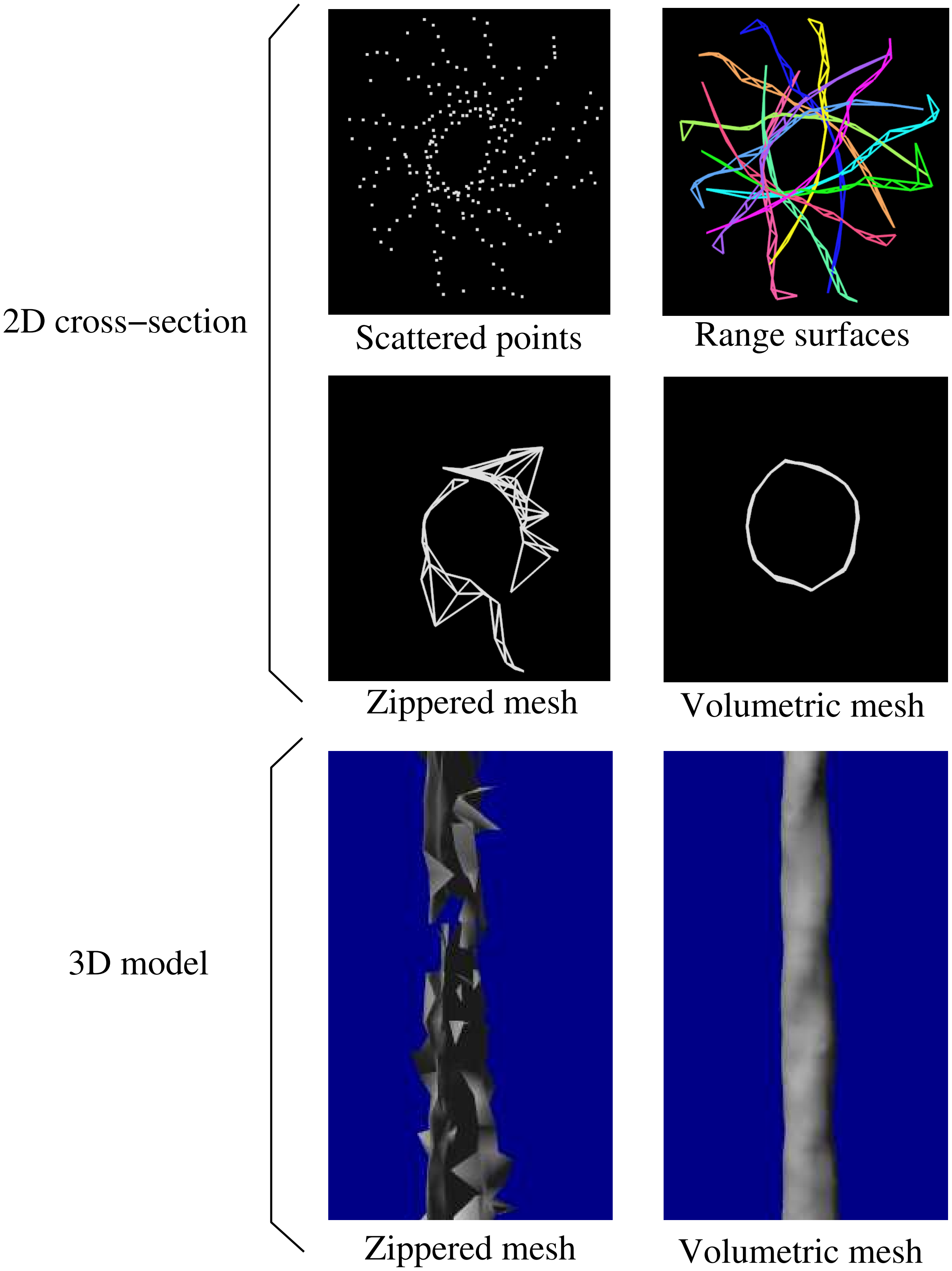


With space carving

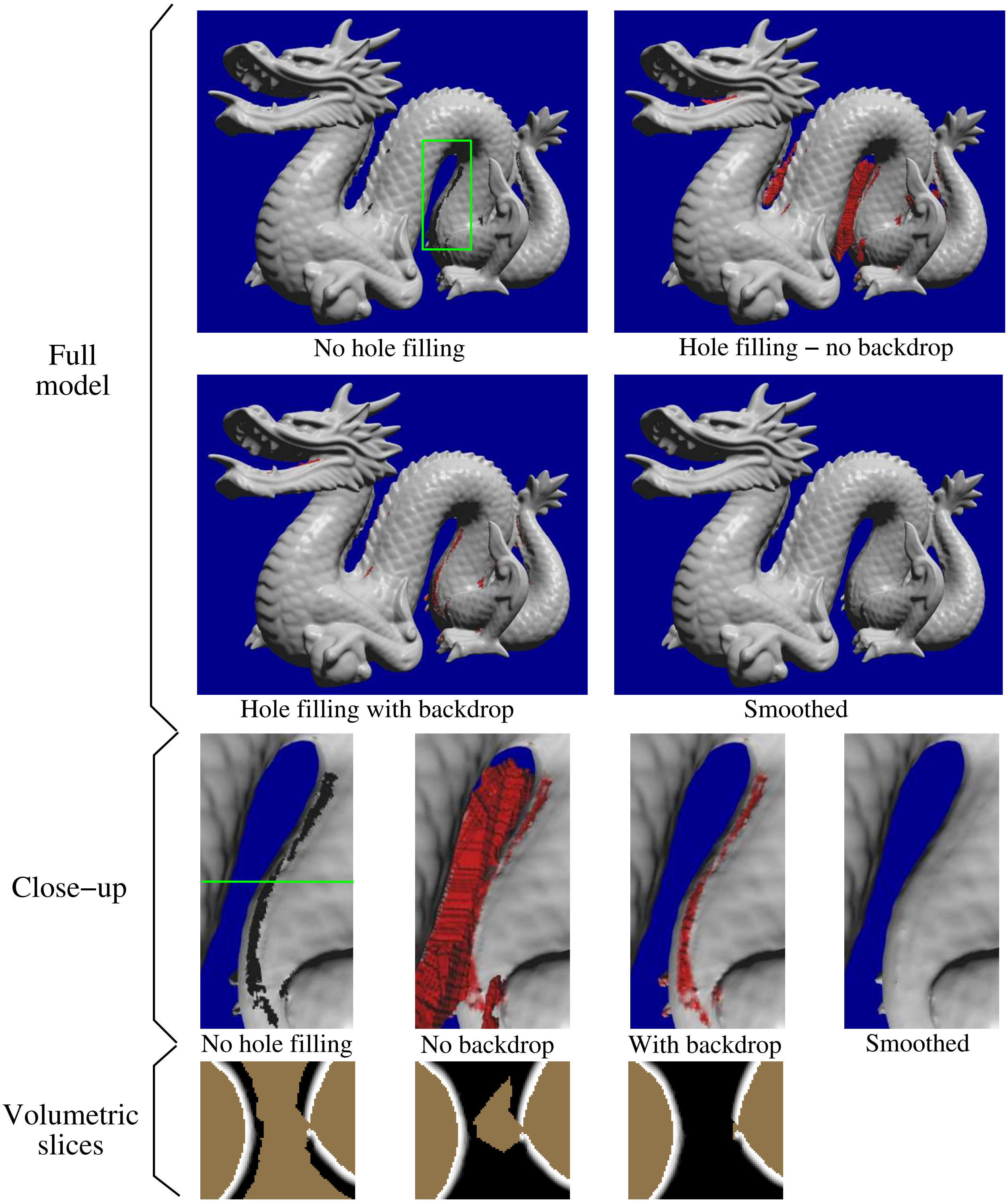

Carving *without* a backdrop
Scanning scenario
Volumetric slice
Surfaces
Sensor


Carving *with* a backdrop
Scanning scenario
Volumetric slice
Backdrop
Surfaces
Sensor

Merging 12 views of a drill bit



Building a hole–free dragon



Notes on Curless and Levoy's method

Only algorithm that offers a hole−free surface.

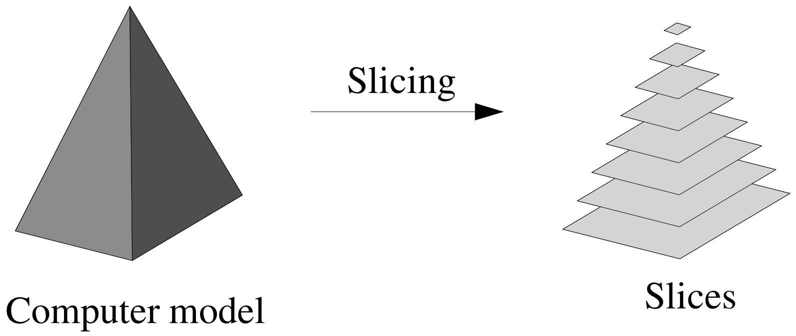
Has problems with thin surfaces:

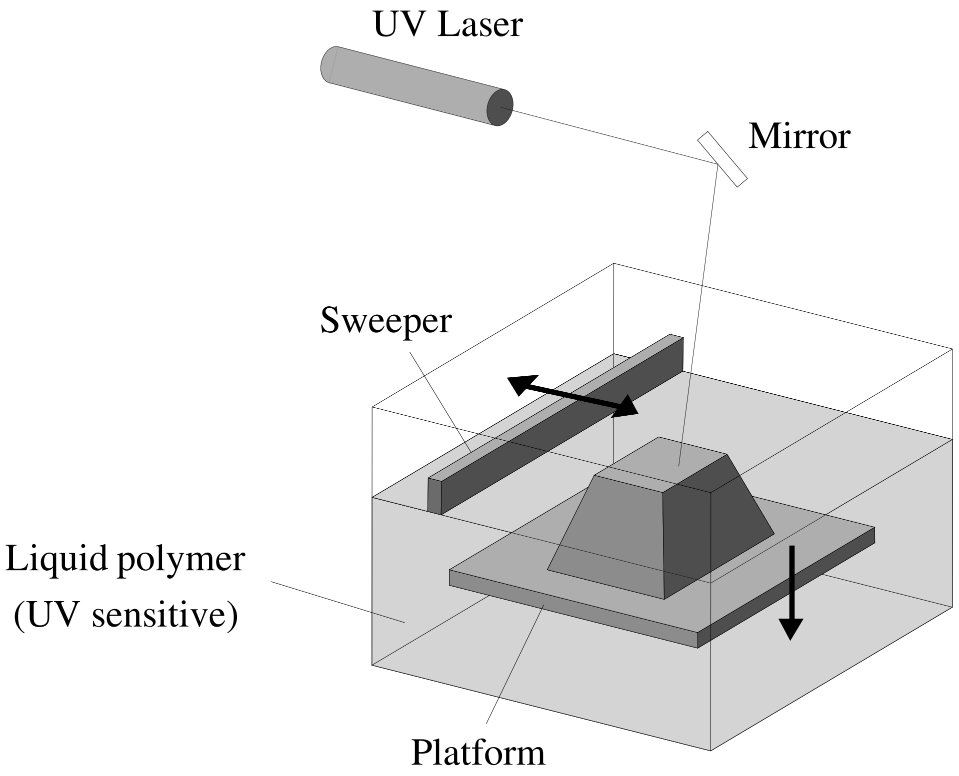
Has problems with sharp corners:

Time complexity is typically O(n + m^2), where n is the number of input points and m is the voxel grid dimension. Storage is O(p + m^2), where p is the average number of points per range image.

Has been deomstrated on models of very high complexity (up to 10 million input points and 2.5 million output triangles).

Stereolithography





Bibliography

Curless, B. and Levoy, M. "A volumetric method for building complex models from range images." In *Proceedings of SIGGRAPH '96*, pp. 303–312. ACM Press, August 1996.

Turk, G. and Levoy, M. "Zippered polygon meshes from range images." In *Proceedings of SIGGRAPH '94*, pp. 311–318. ACM Press, July 1996.