

Surface reconstruction from models for subtractive manufacturing simulation

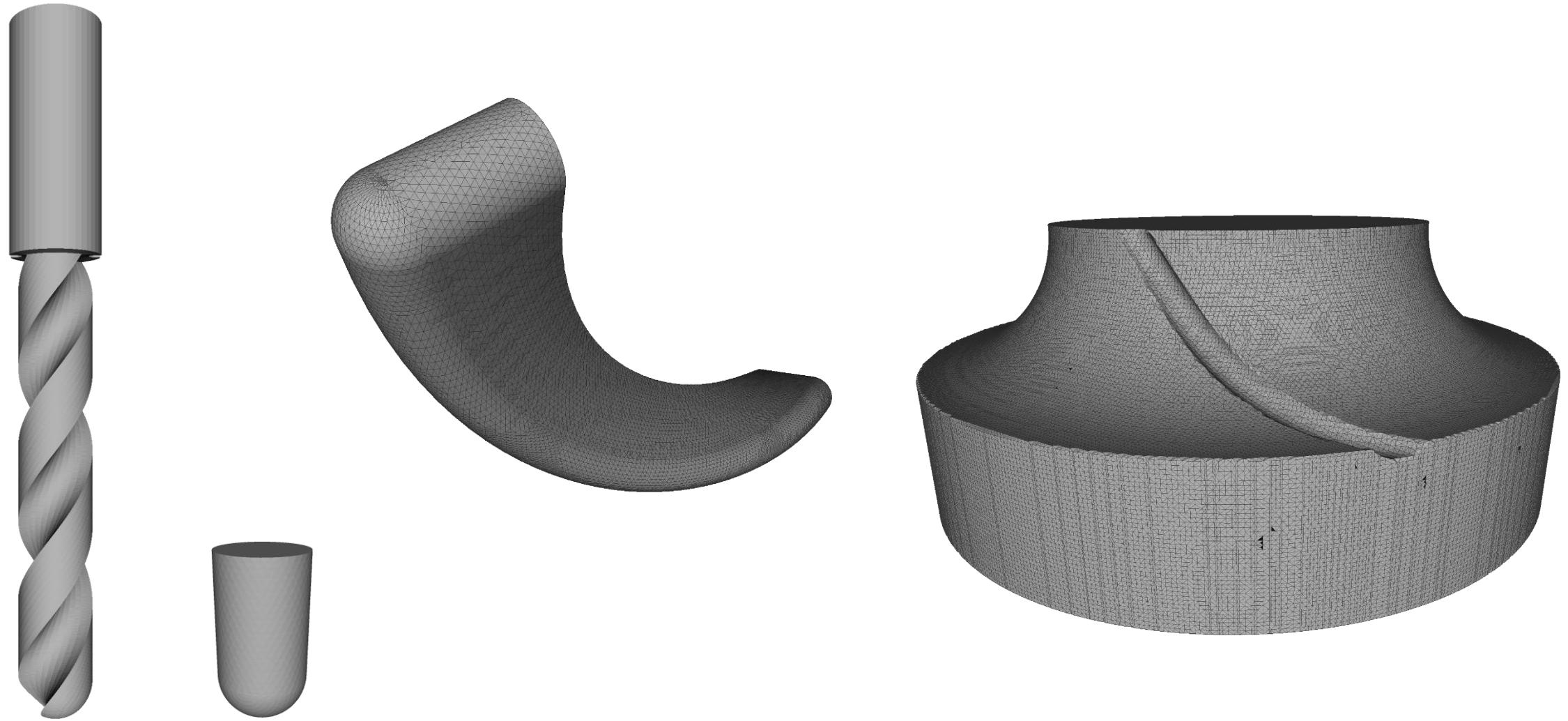
Bernhard Manfred Gruber
2015-05-07

Subtractive manufacturing

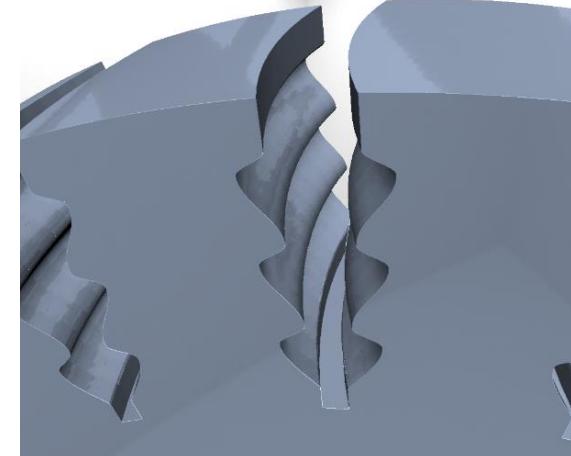
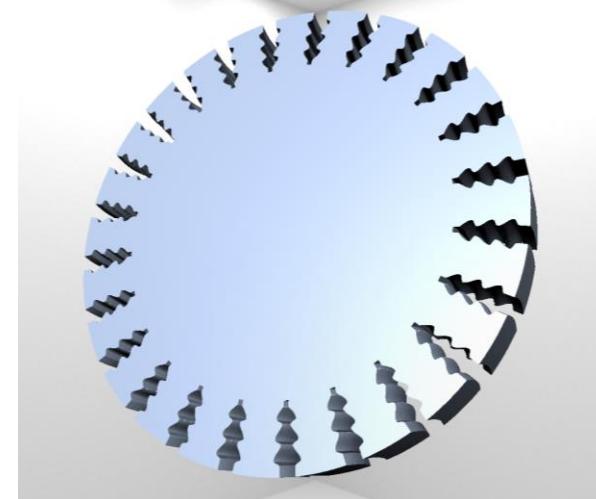
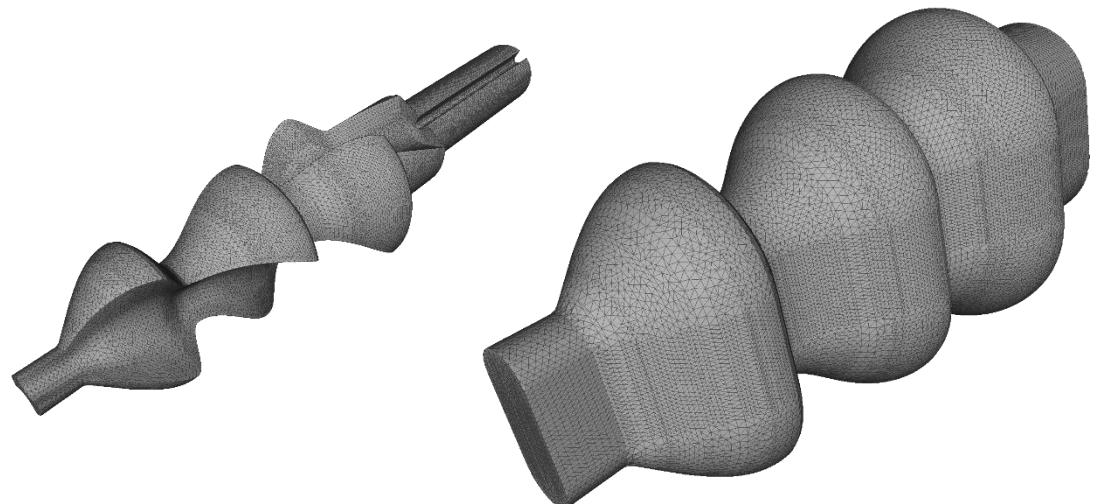
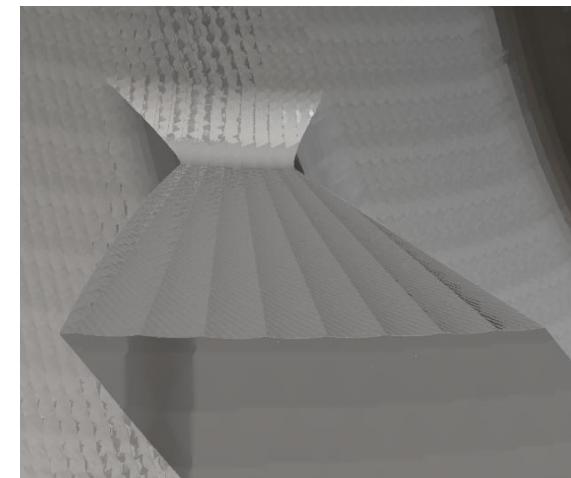
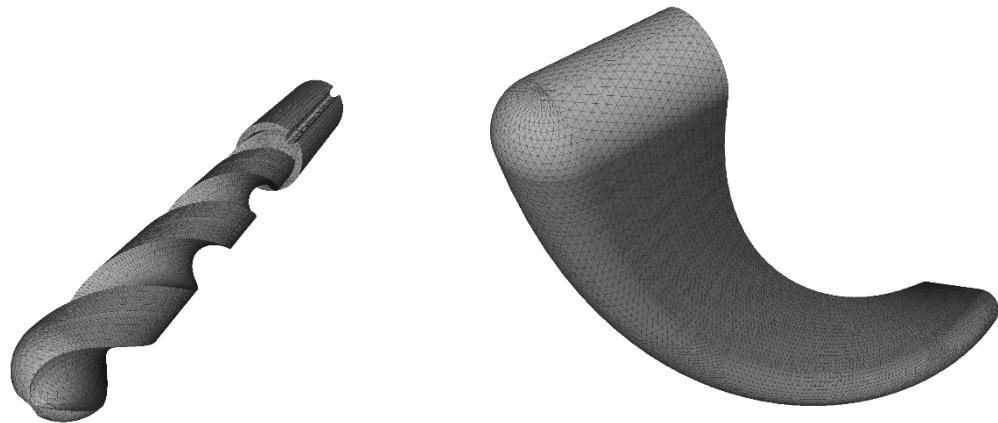


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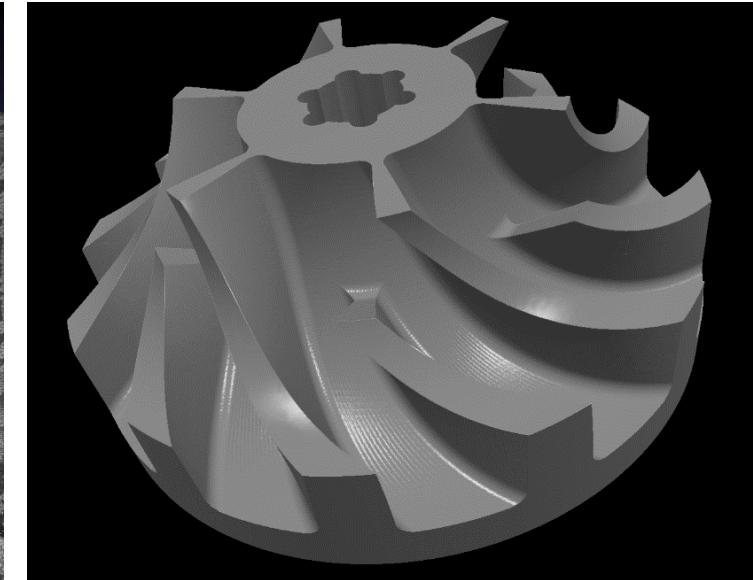
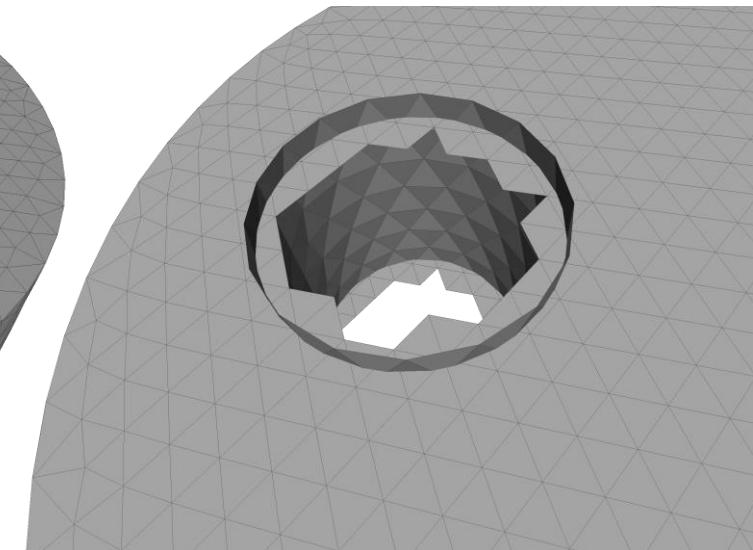
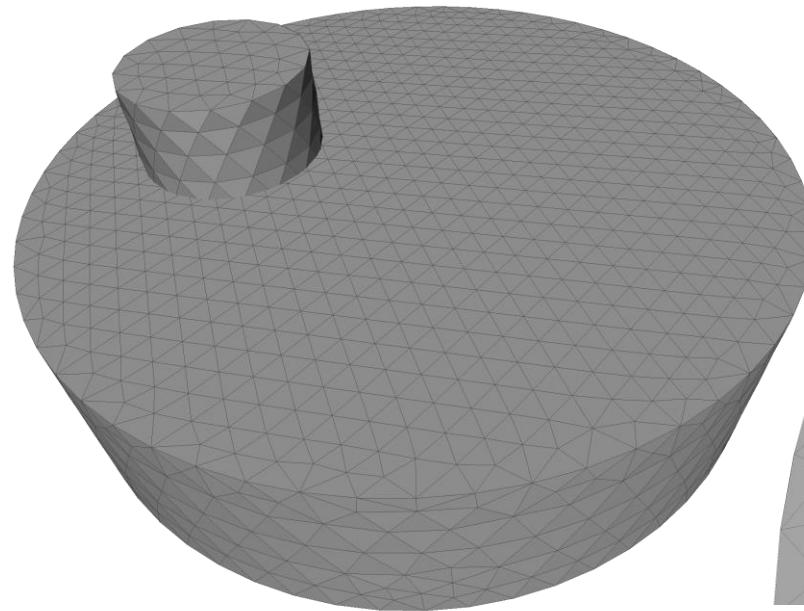
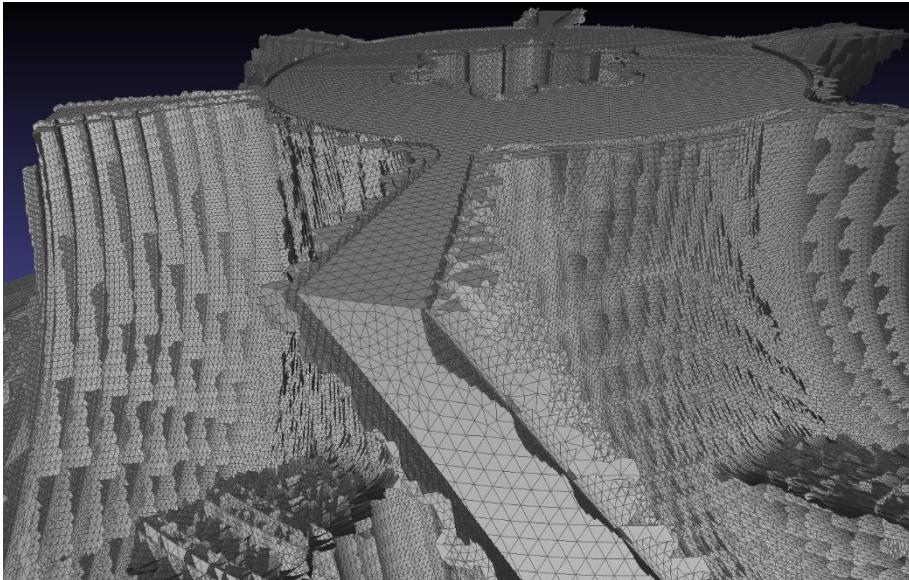
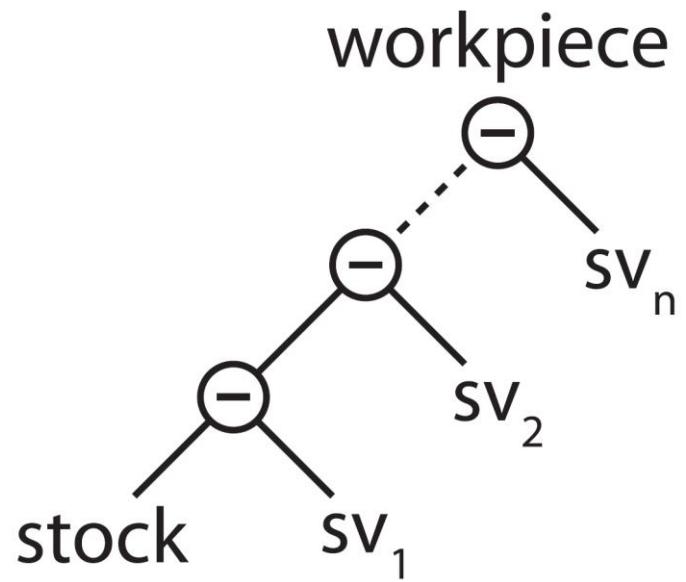
Subtractive manufacturing simulation



Previous work – VML



VML data model



Problem statement

Extract triangulated surface
from VML data model

- Determine state of the art
- Prototypic implementation and comparison
 - runtime, memory, complexity, visual quality, errors, divergence, numeric, mesh quality, feature conservation, adaptivity
- Testing on selected scenes
 - Is there a "best" algorithm? Under which circumstances?
 - How to select best suited algorithm?



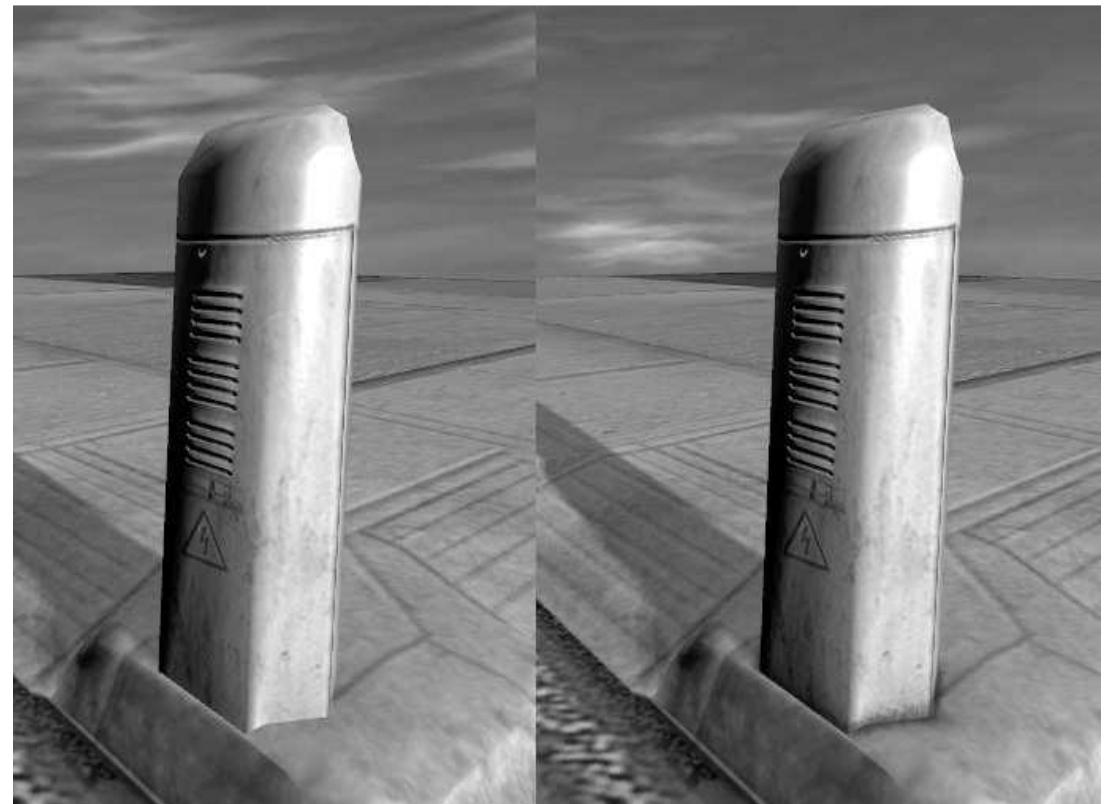
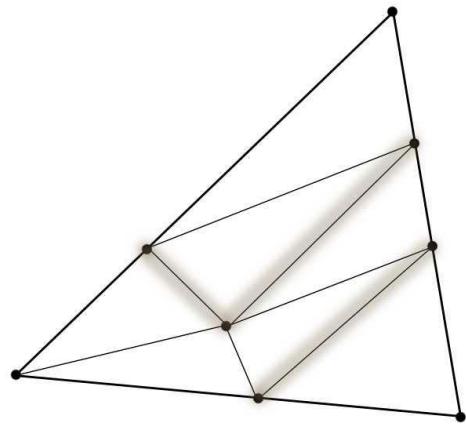
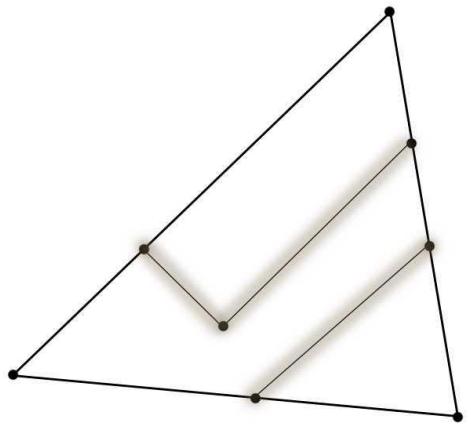
Approaches

- Direct intersection of swept volumes
 - Most naïve, theoretically most accurate
- Point cloud based
 - Point cloud easy to create using raycast
 - Reconstruction already implemented in swept volume computation
- Dexel based
 - Dexel images easy to create using raycast
- Implicit function and voxel based
 - VML already uses a voxel grid

State of the art

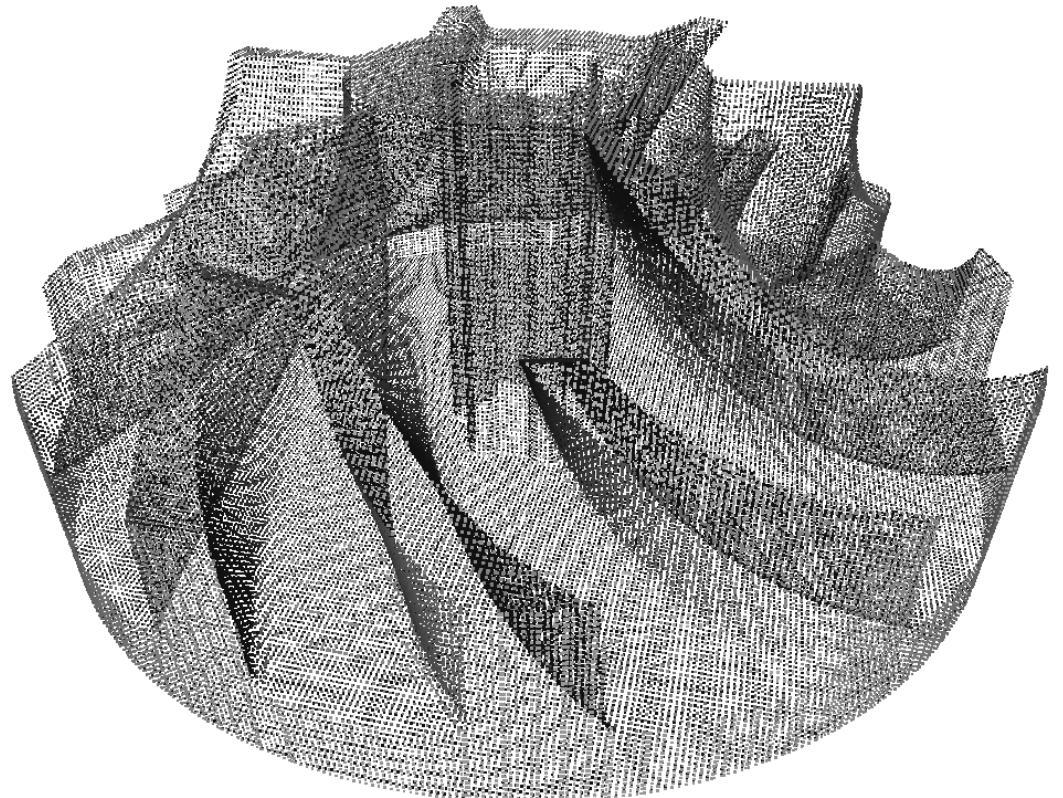
Direct intersection

- David Rosen,
Seamless Intersection Between
Triangle Meshes,
2008



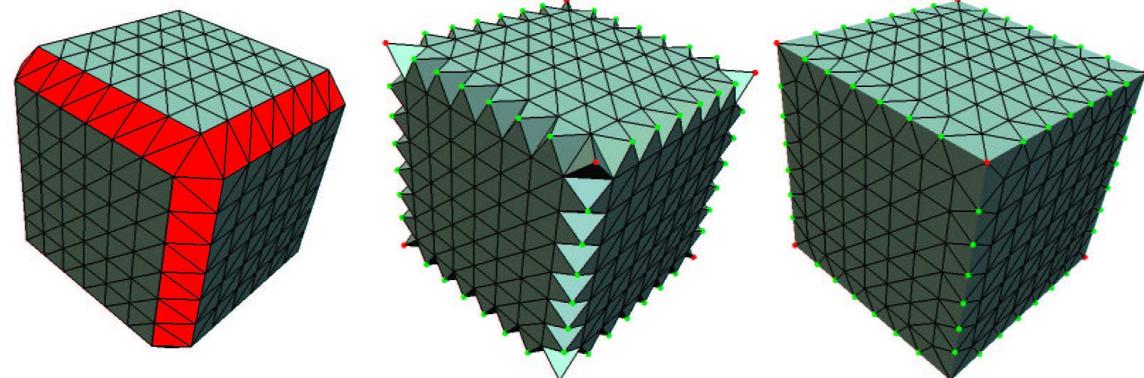
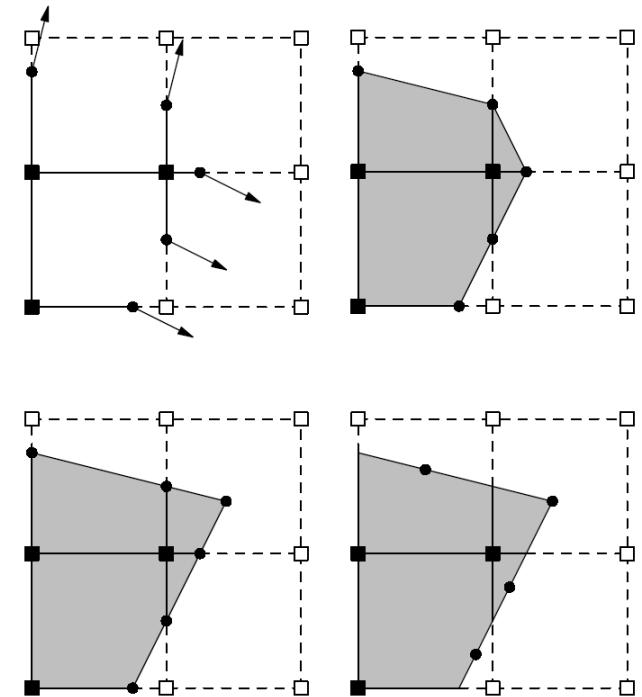
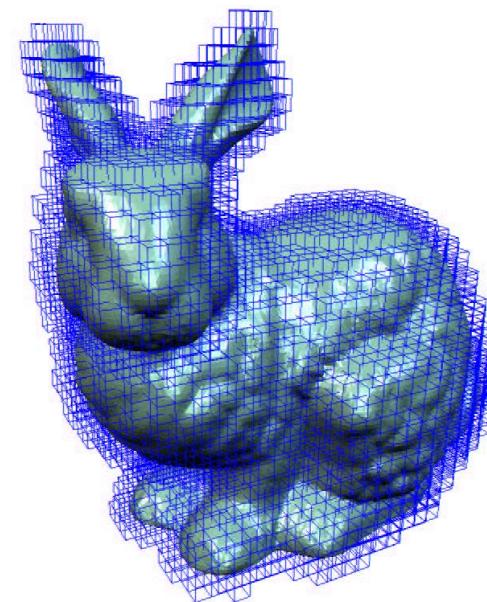
Point cloud based

- α -shapes
- Delaunay and Voronoi:
 - Crust and powercrust
 - Cocone, tight cocone and robust cocone
- Region growing:
 - BPA, G2S



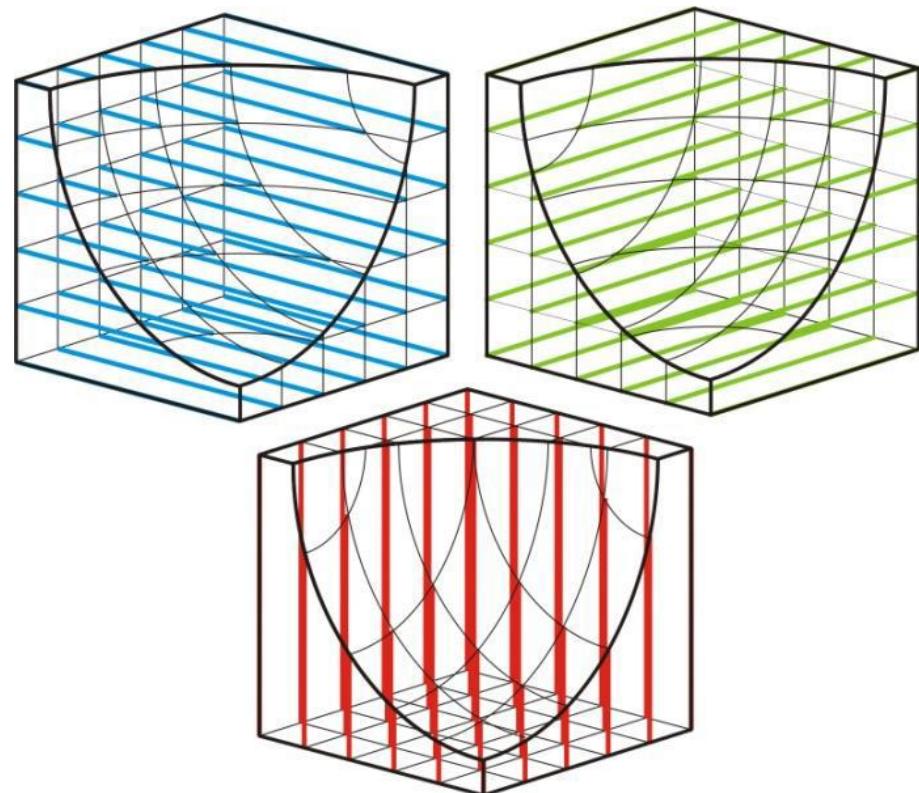
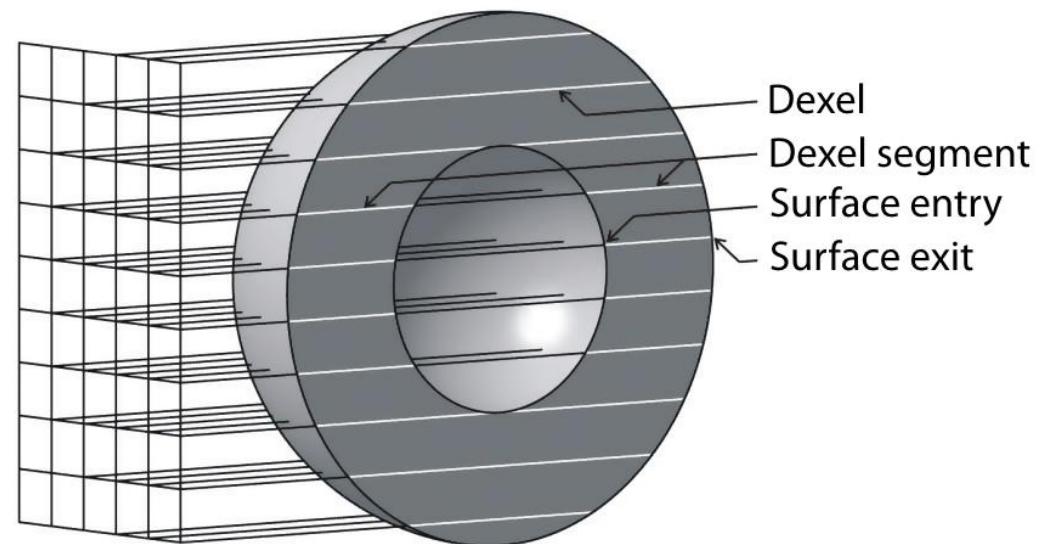
Implicit function and voxel based

- Describe surface by a function, sampled at a regular grid
 - SDF, Hoppe, Poisson, MLS, RBF
- Leif Kobbelt et al.,
Feature sensitive surface extraction
from volume data,
2001
- Tao Ju et al.,
Dual contouring of hermite data,
2002



Dixel based

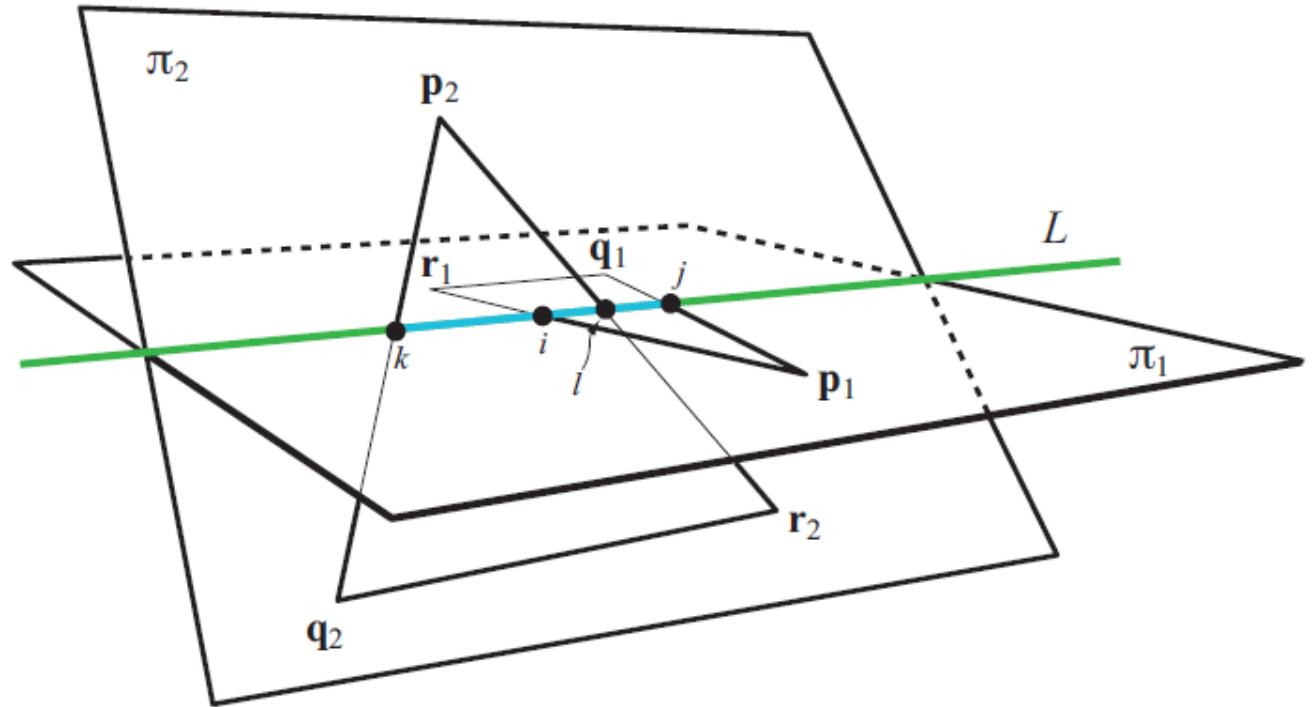
- Yongfu Ren et al.,
Feature conservation and
conversion of Tri-dixel
volumetric models to polyhedral
surface models for product
prototyping,
2008



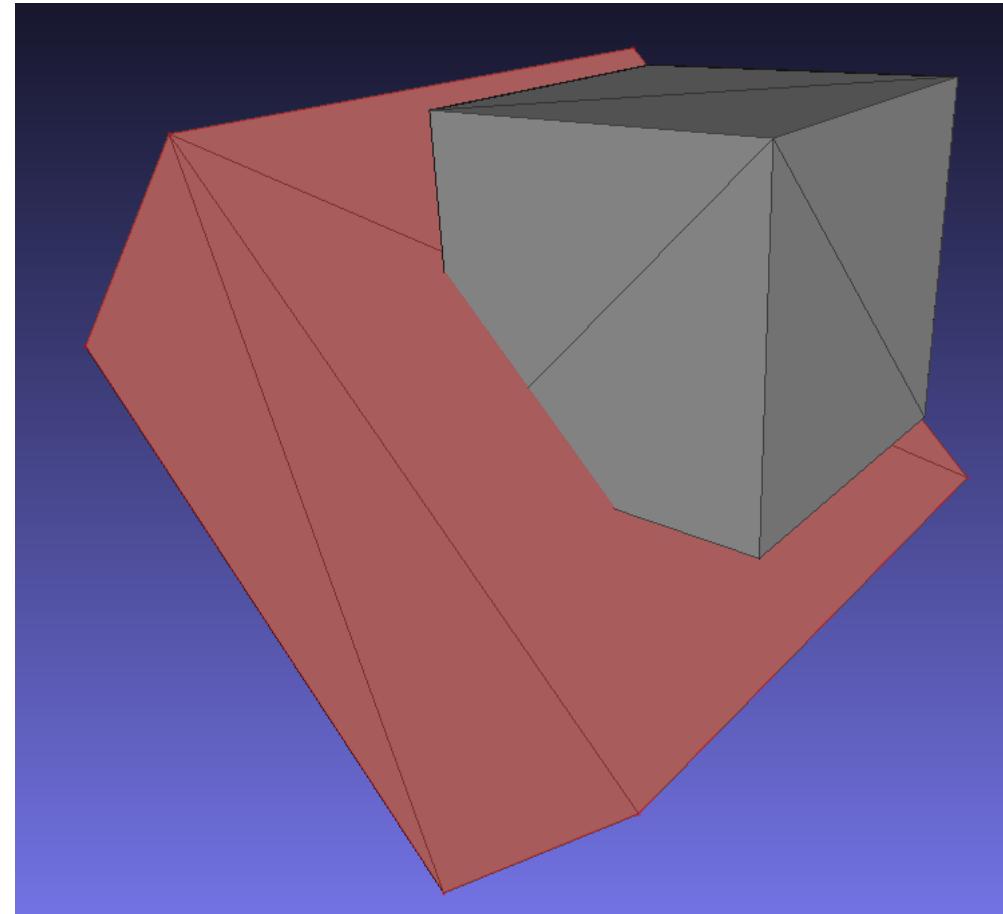
Implementations

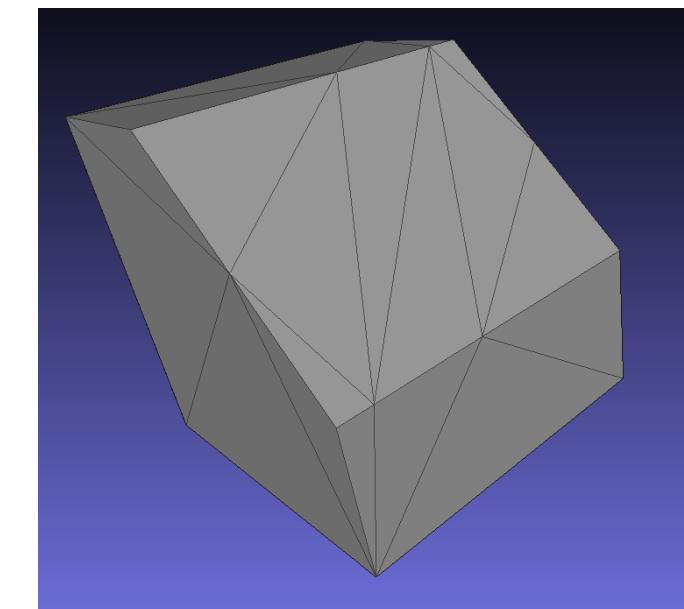
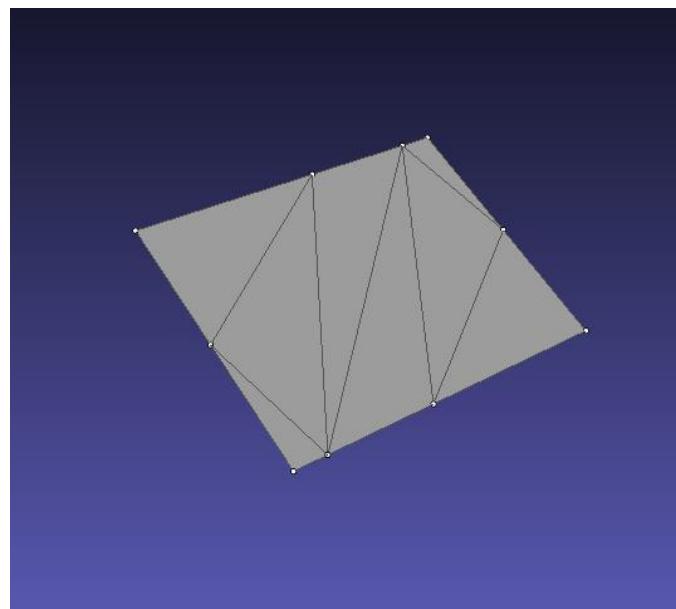
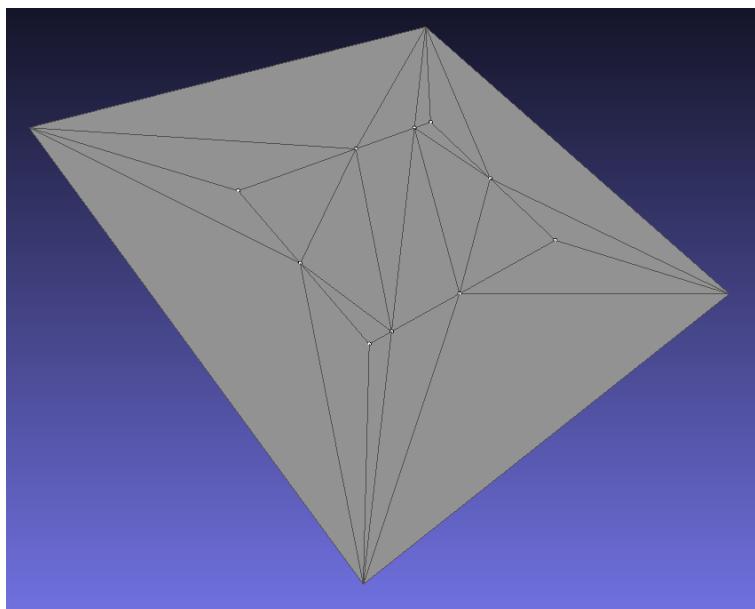
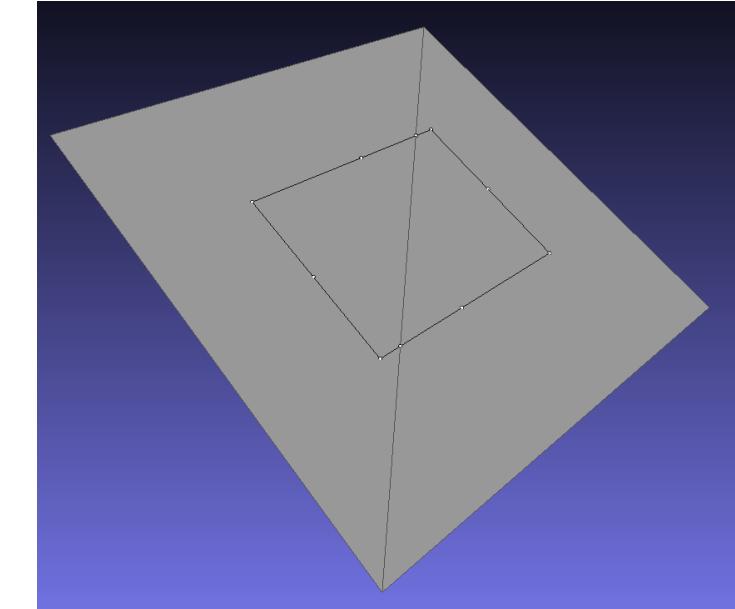
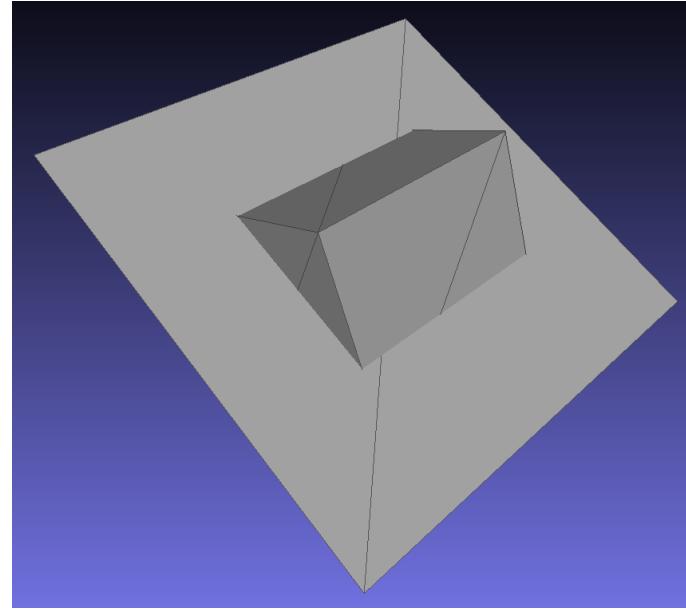
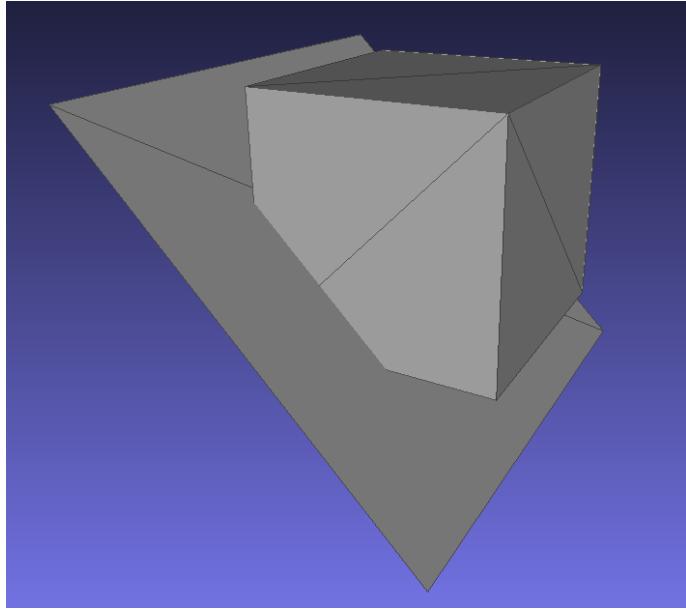
Direct triangle triangle intersection

- Tomas Möller,
A fast triangle-triangle
intersection test,
1997

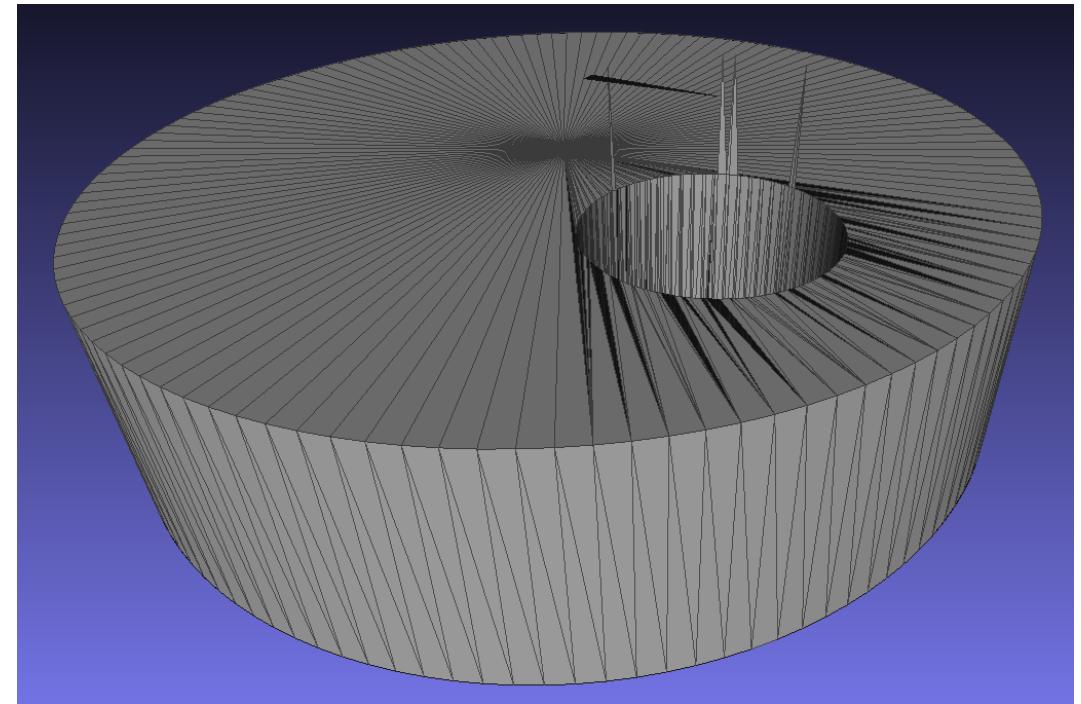
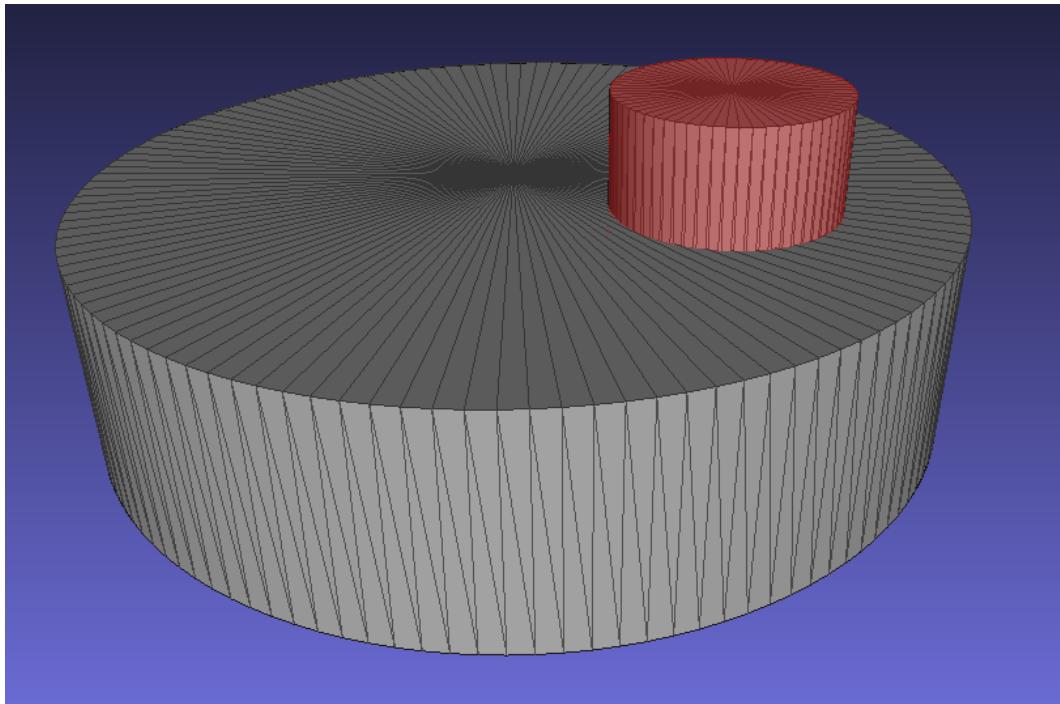


Cube vs. cube

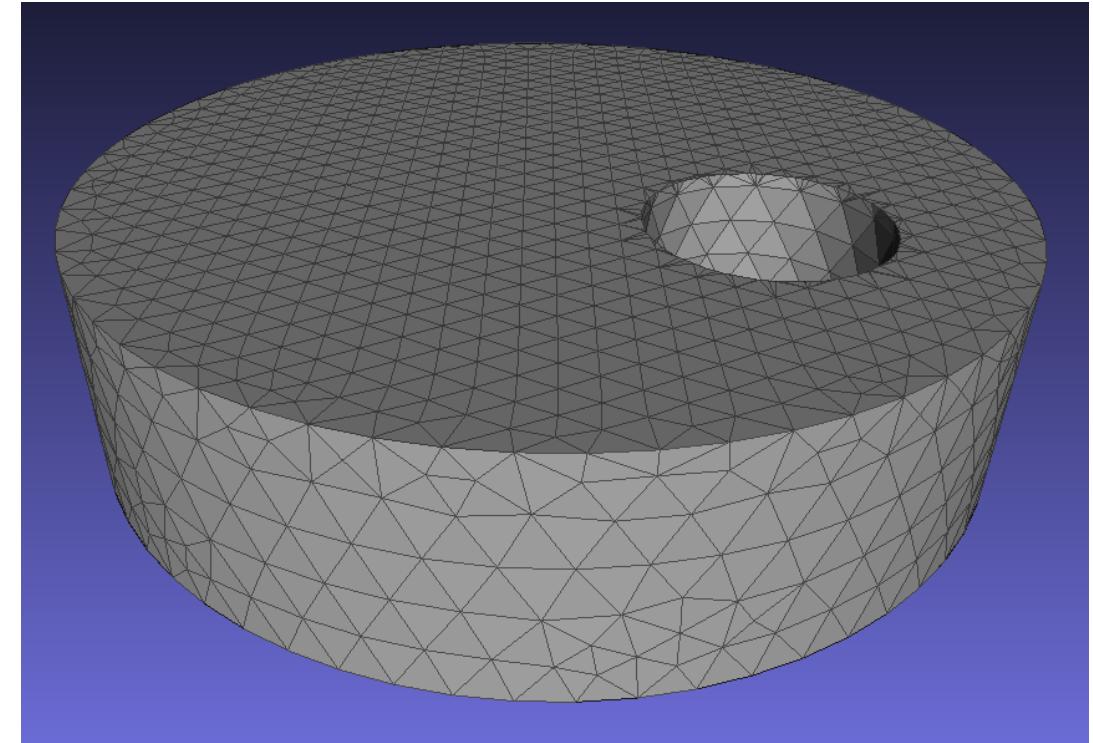
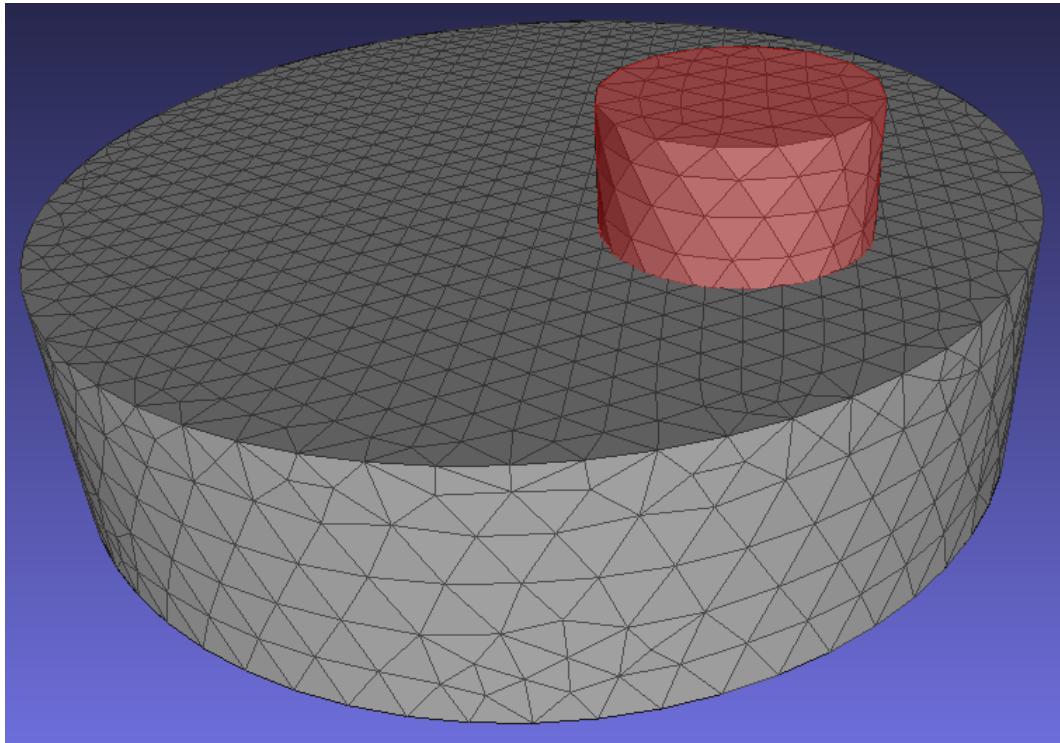




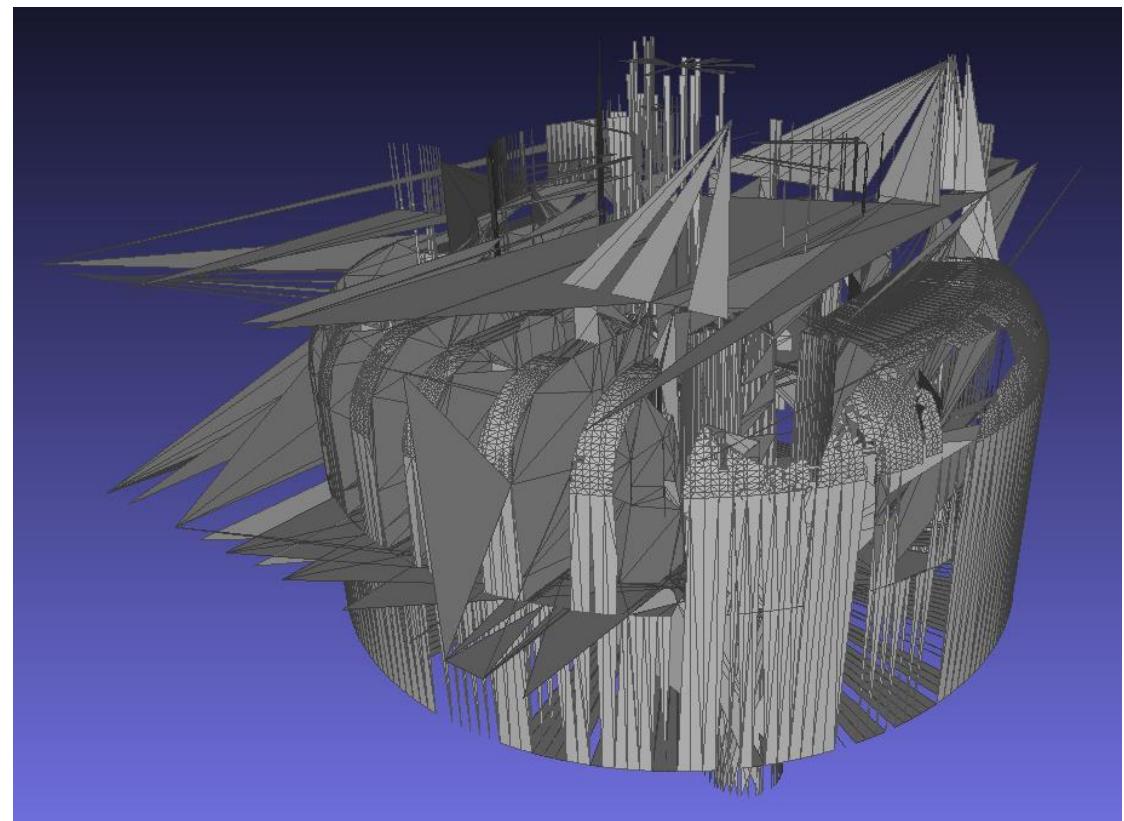
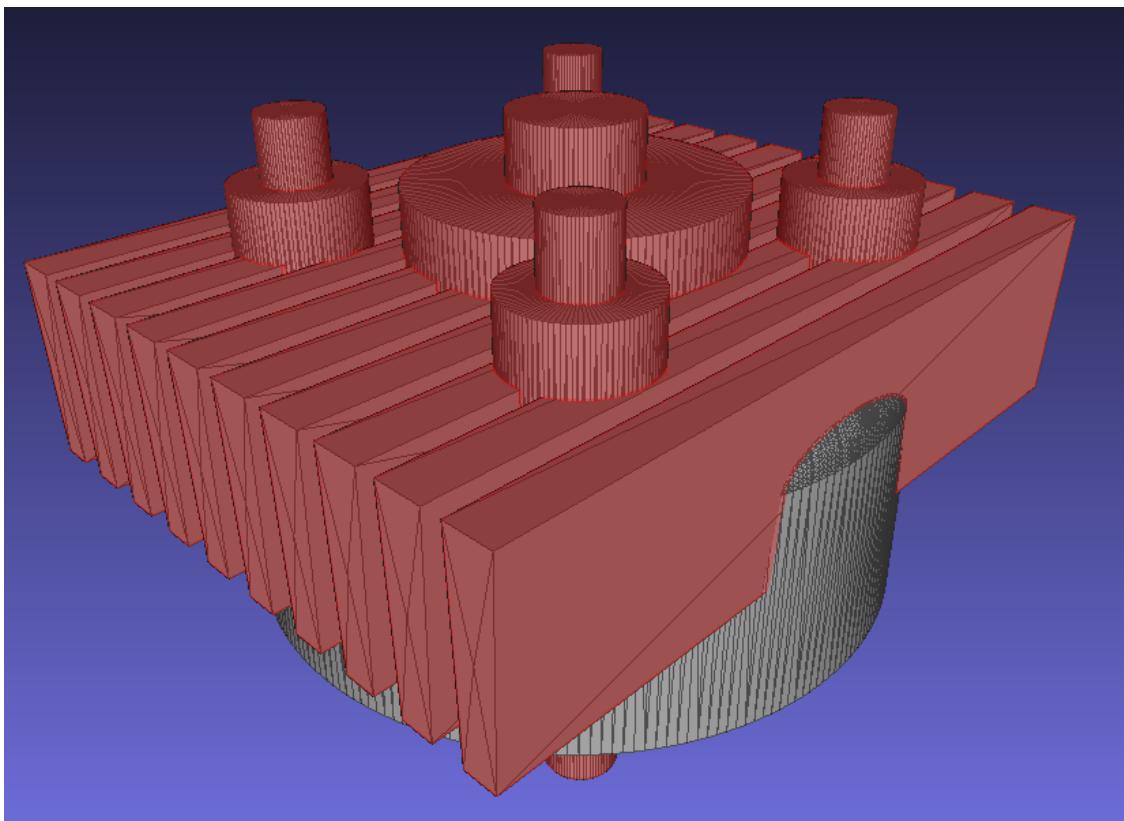
Cylinder vs. cylinder



Cylinder vs. cylinder - Delaunay

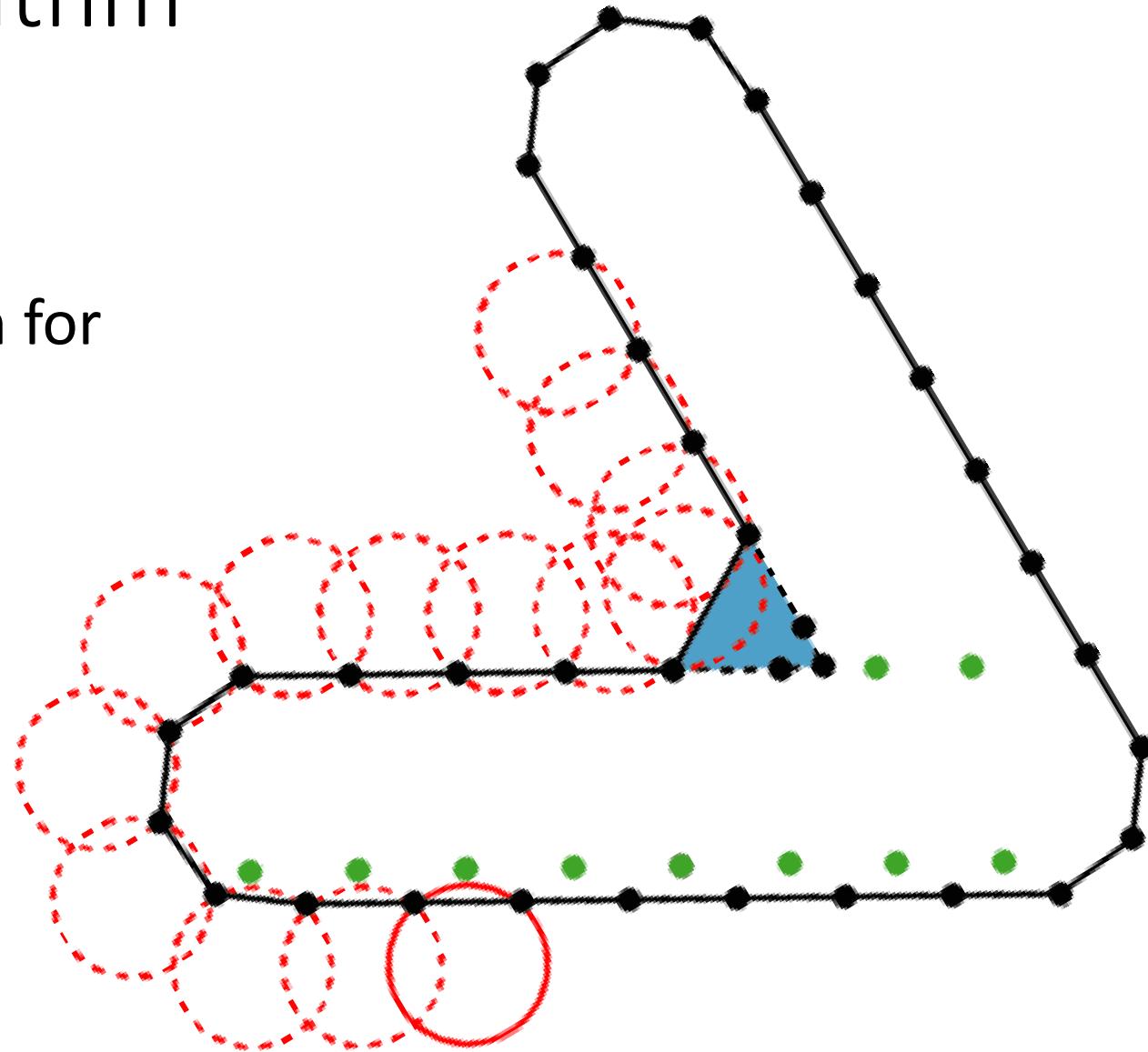


Cylinder head

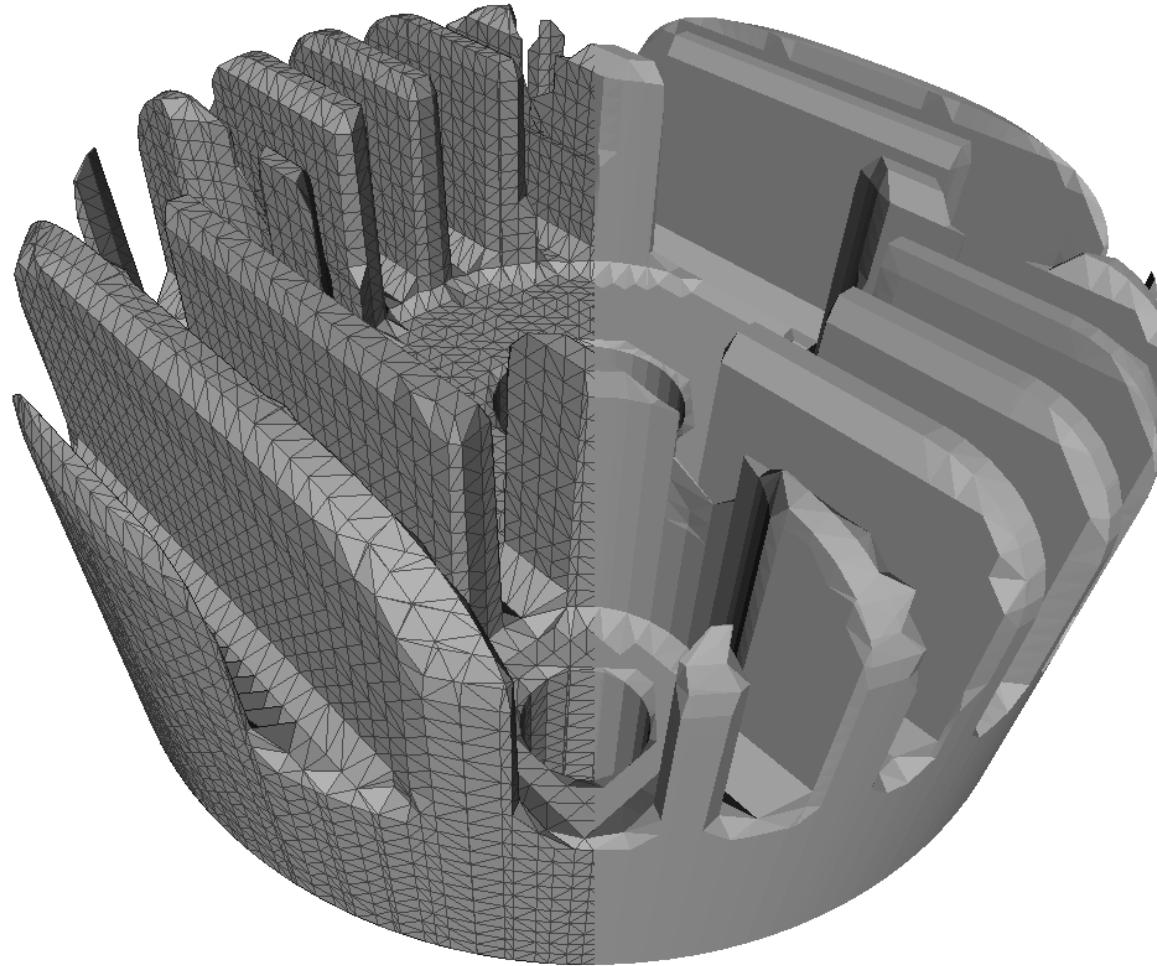


Ball pivoting algorithm

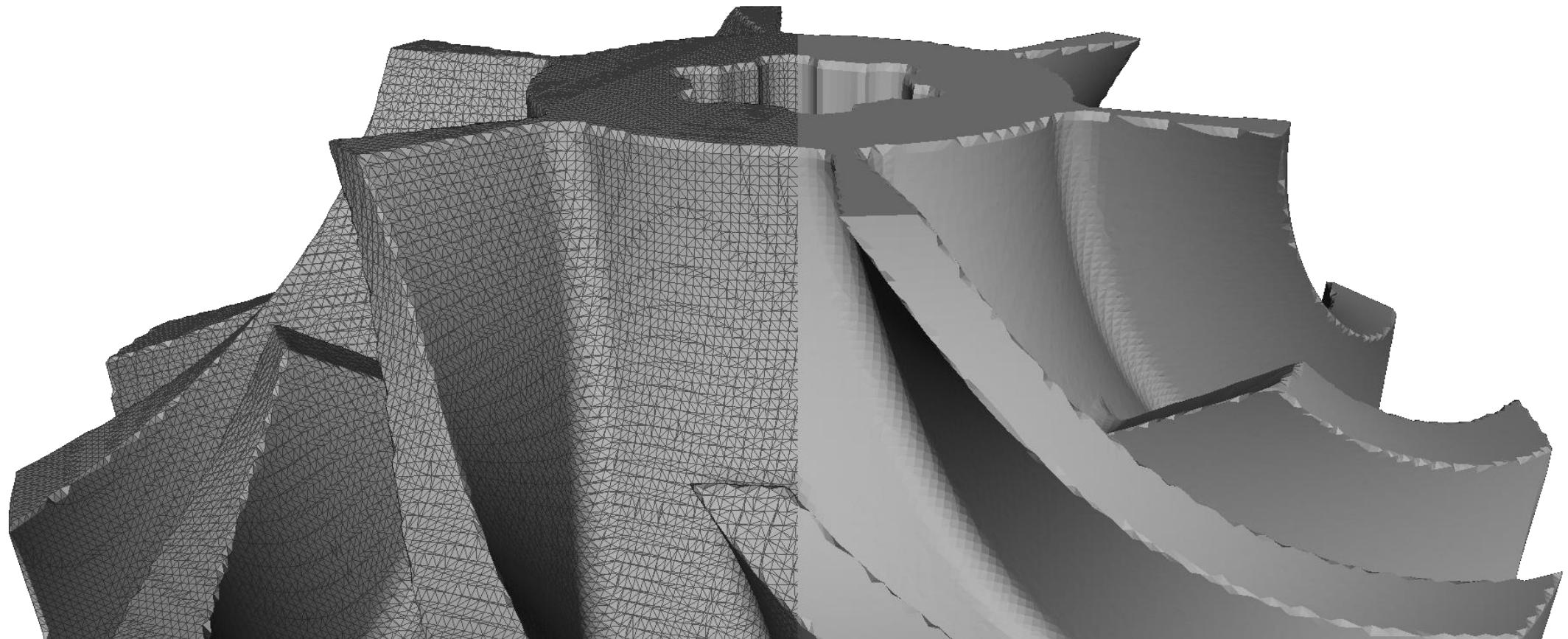
- Fausto Bernardini et al.,
The ball-pivoting algorithm for
surface reconstruction,
1999



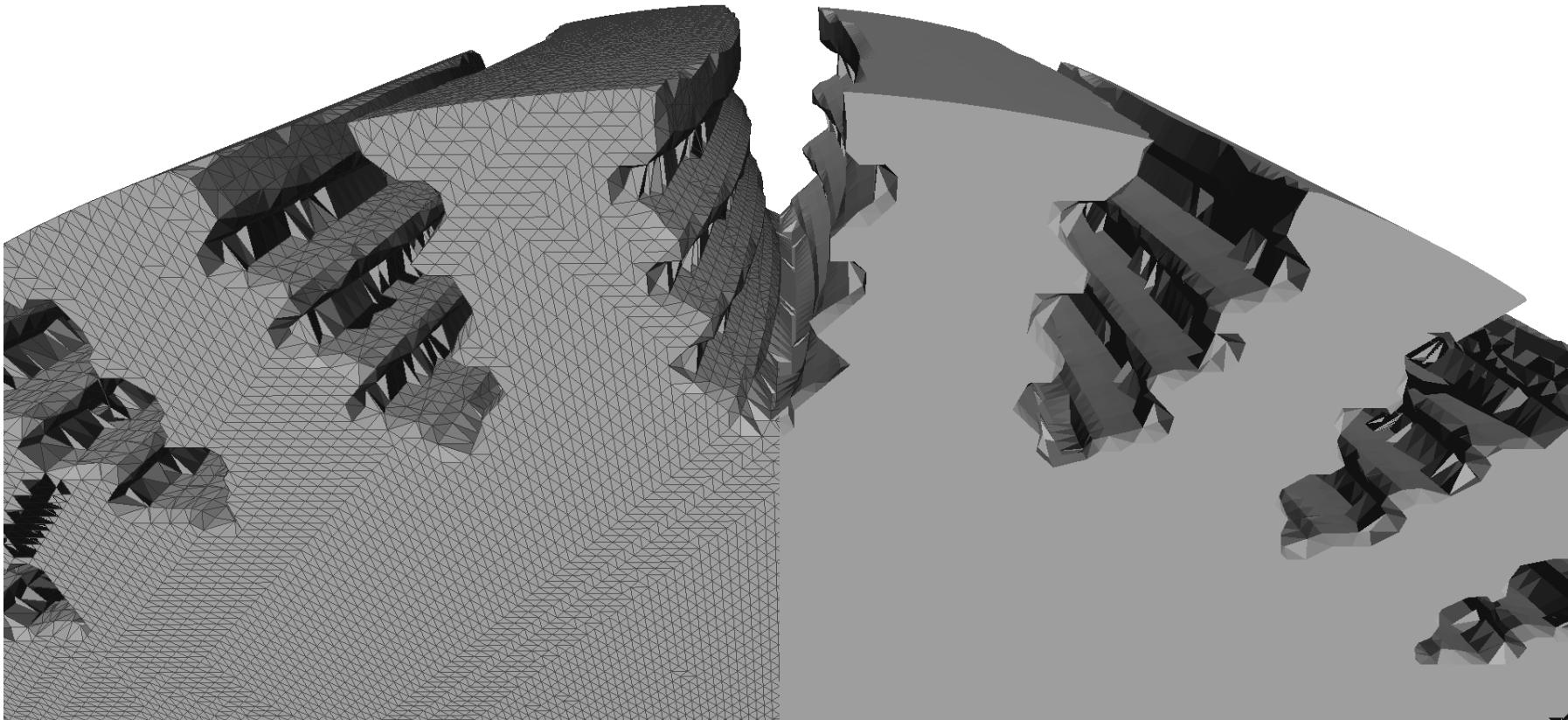
Cylinder head



Impeller

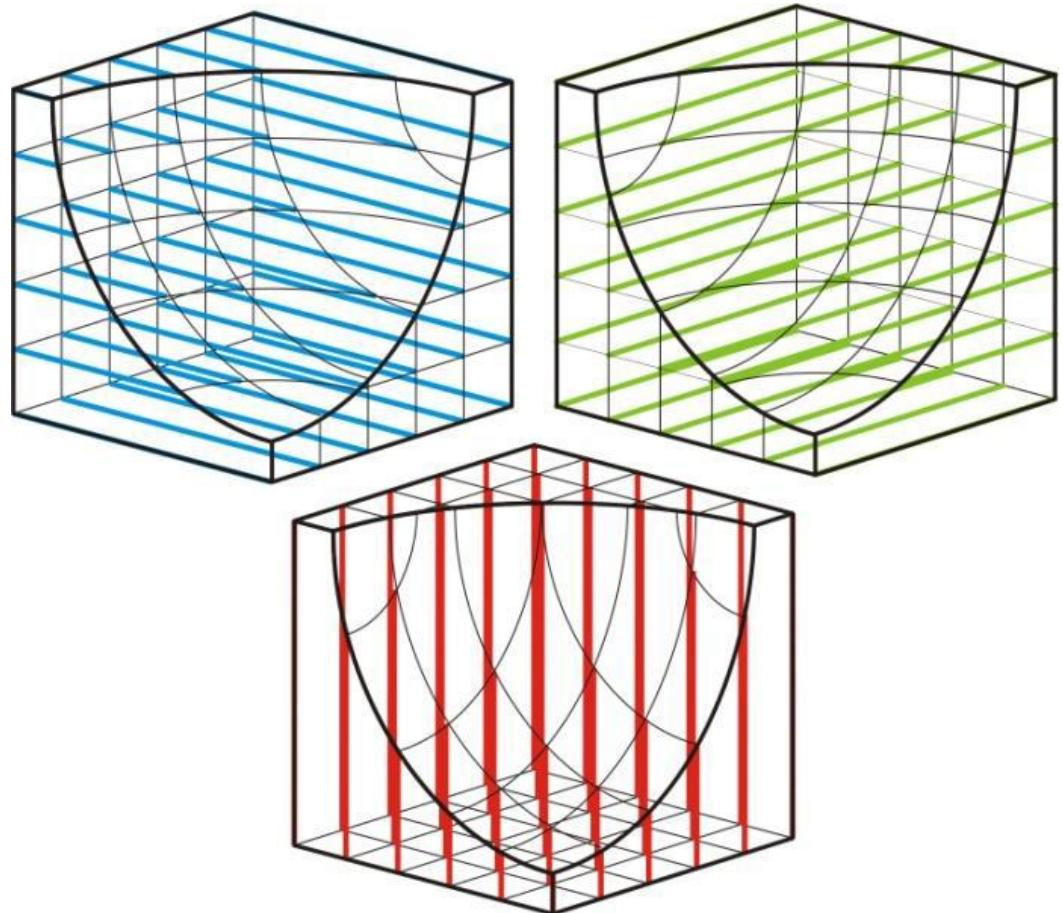


Turbine wheel

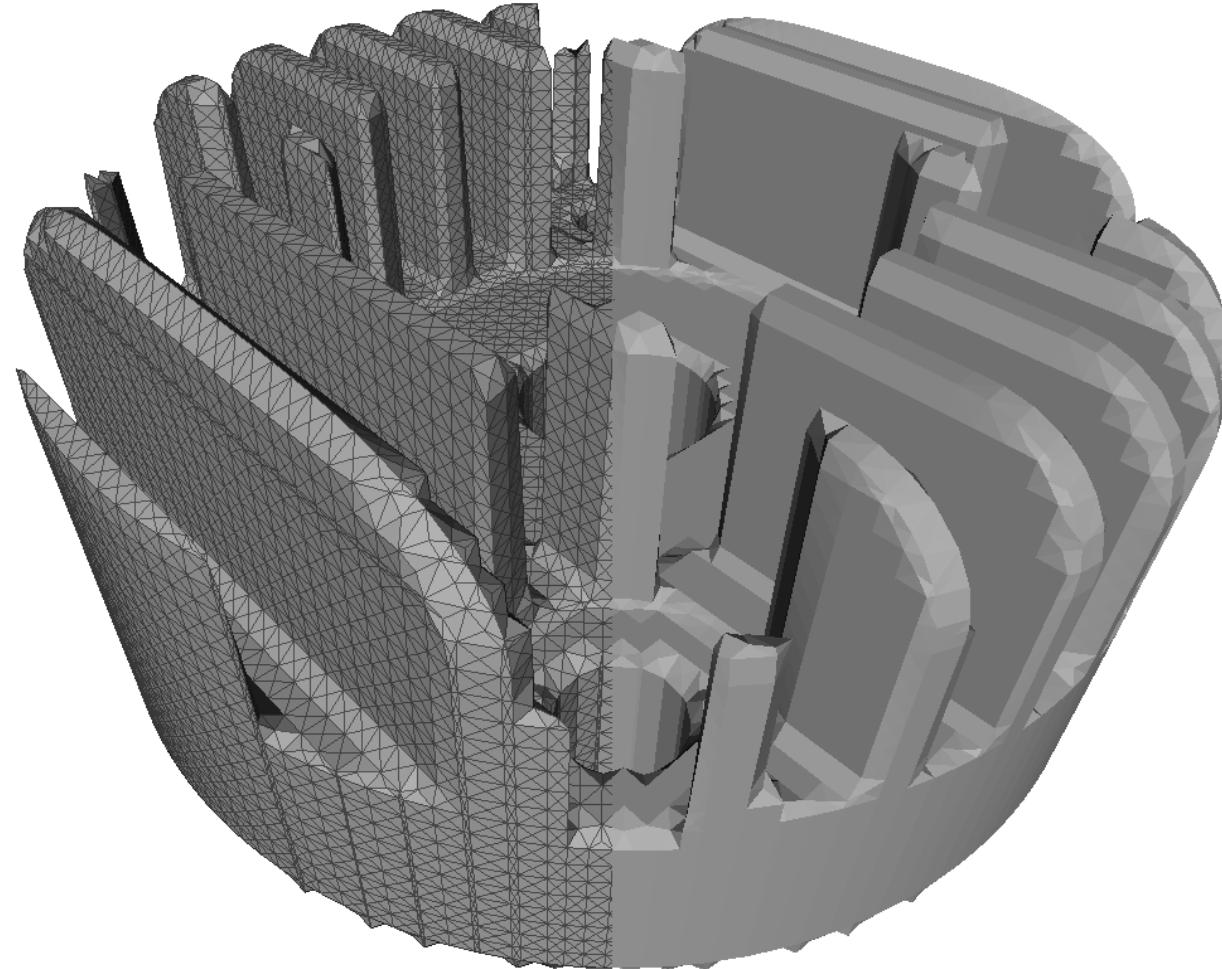


Tri-dixel

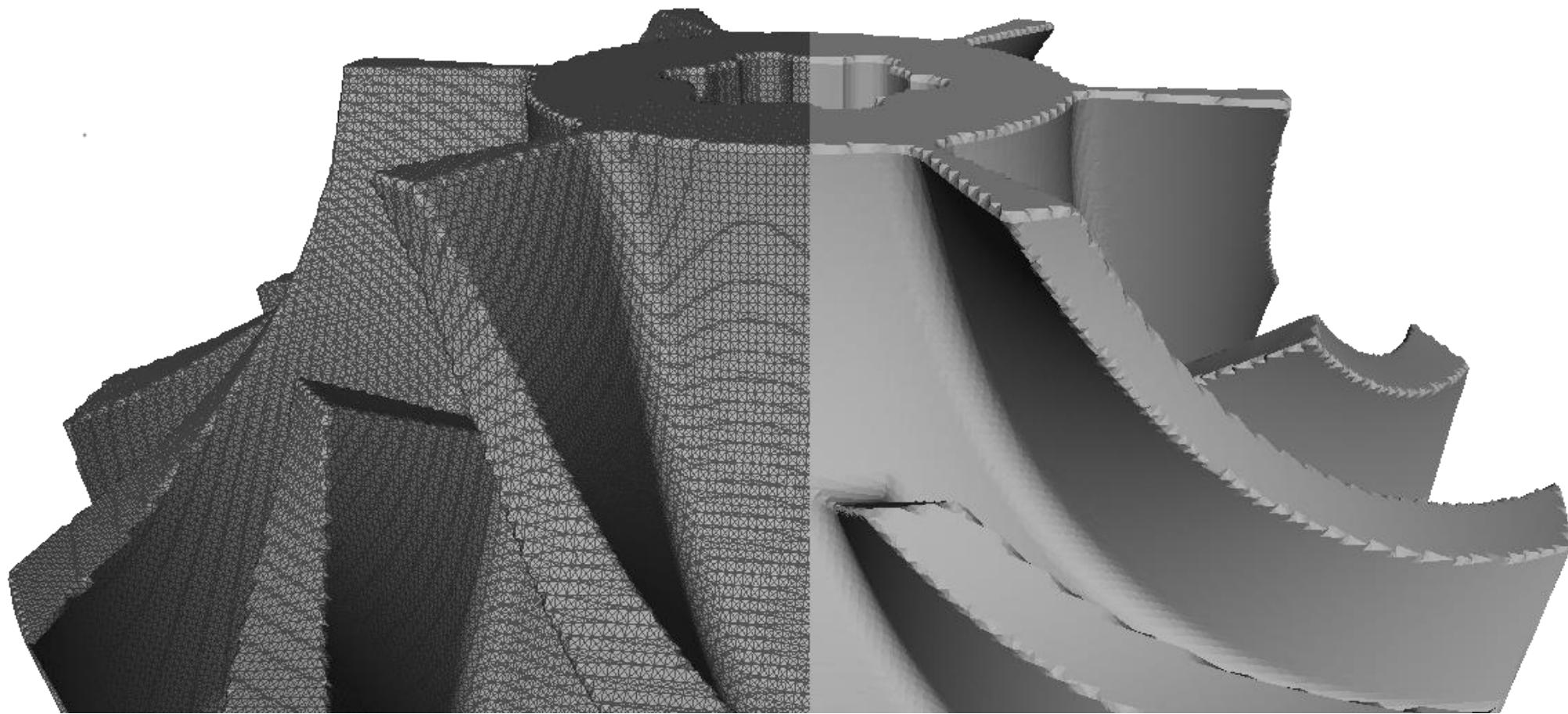
- Yongfu Ren et al.,
Feature conservation and
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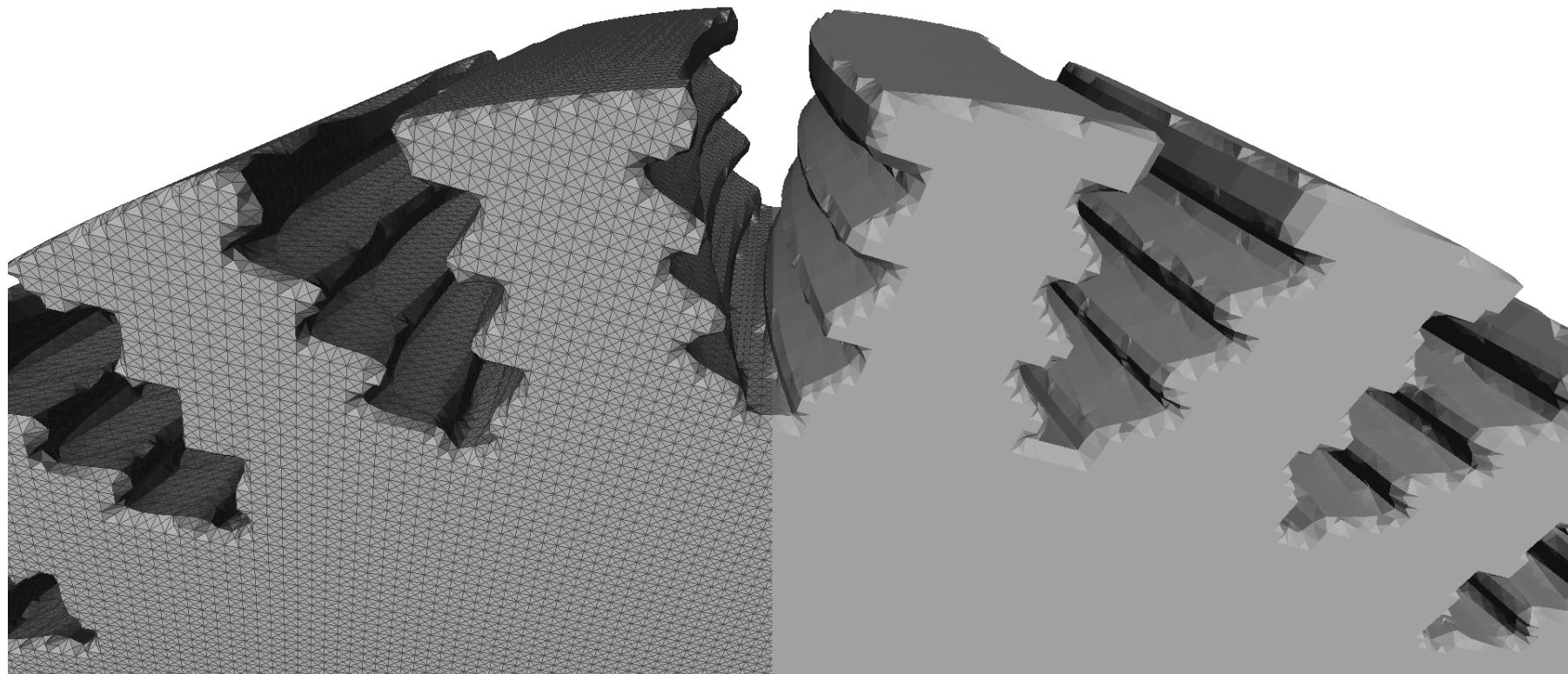
Cylinder head



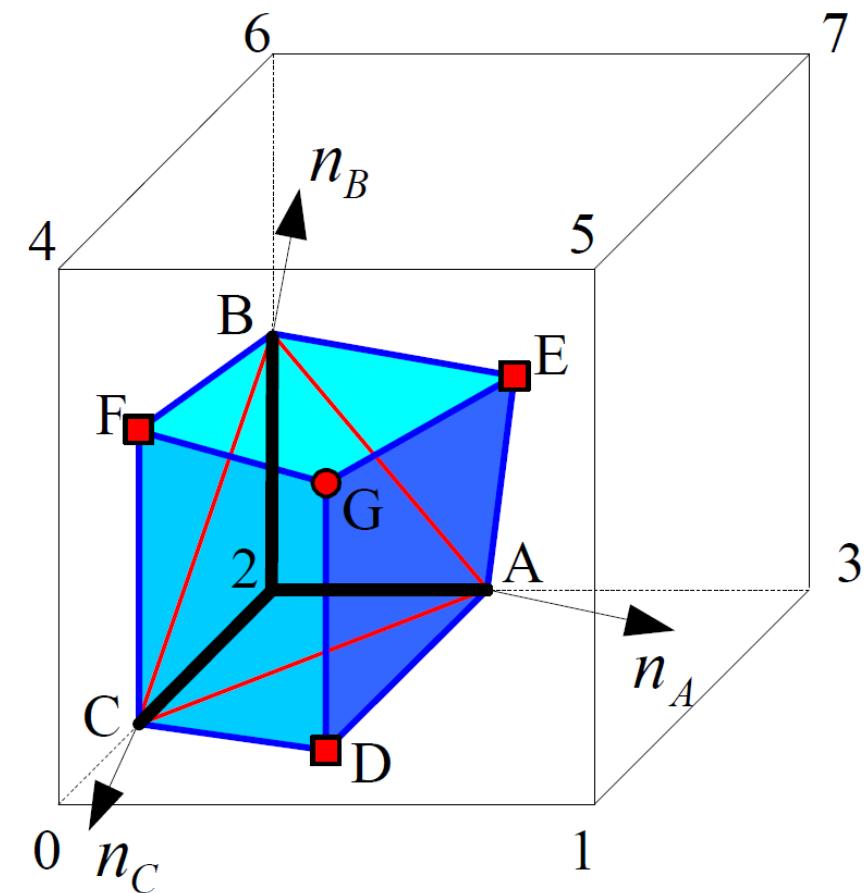
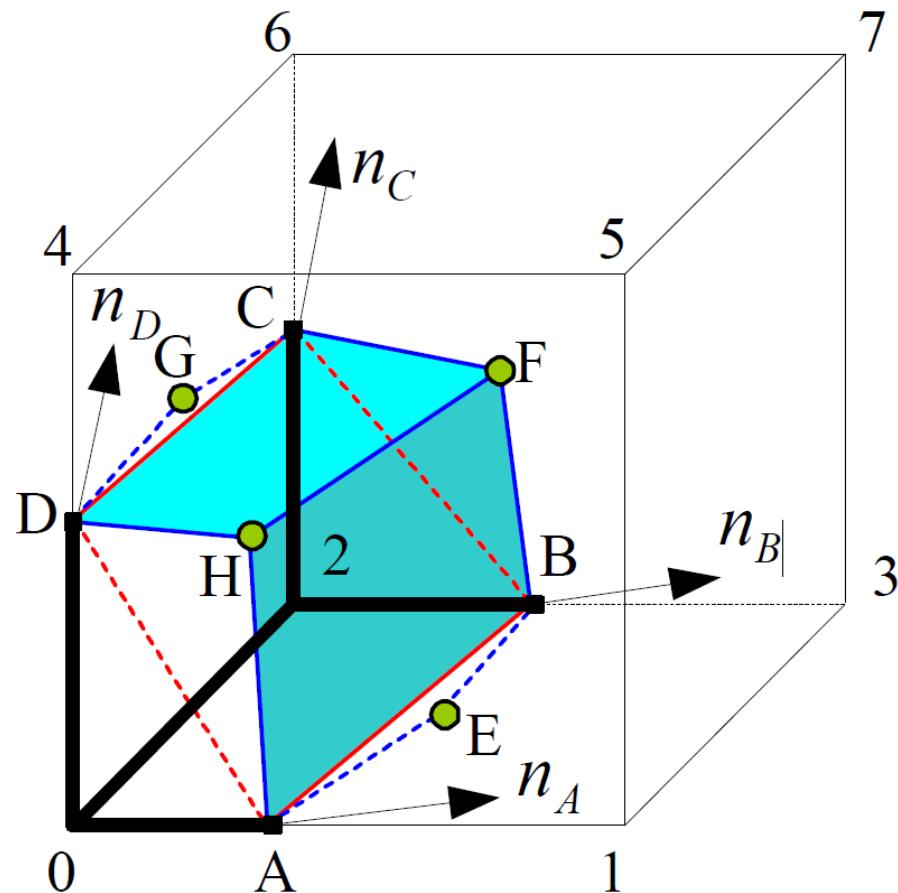
Impeller



Turbine wheel

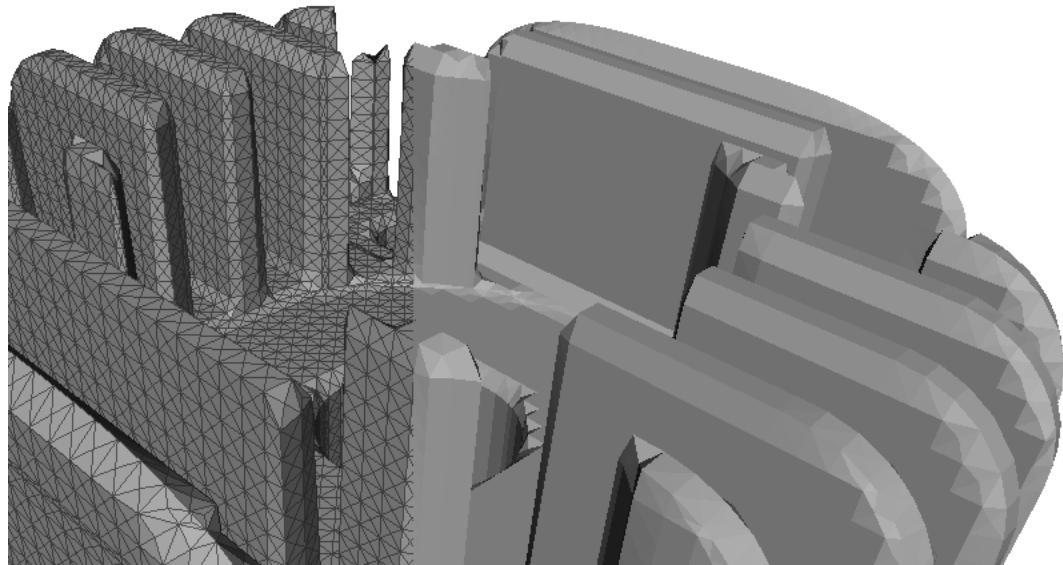


Tri-dexel features

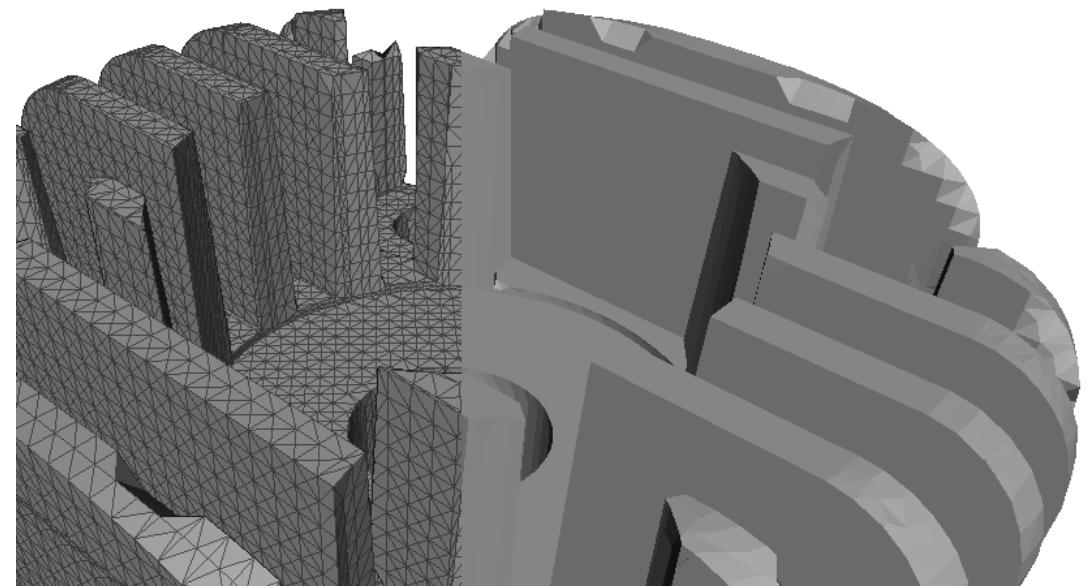


Cylinder head

Without feature reconstruction

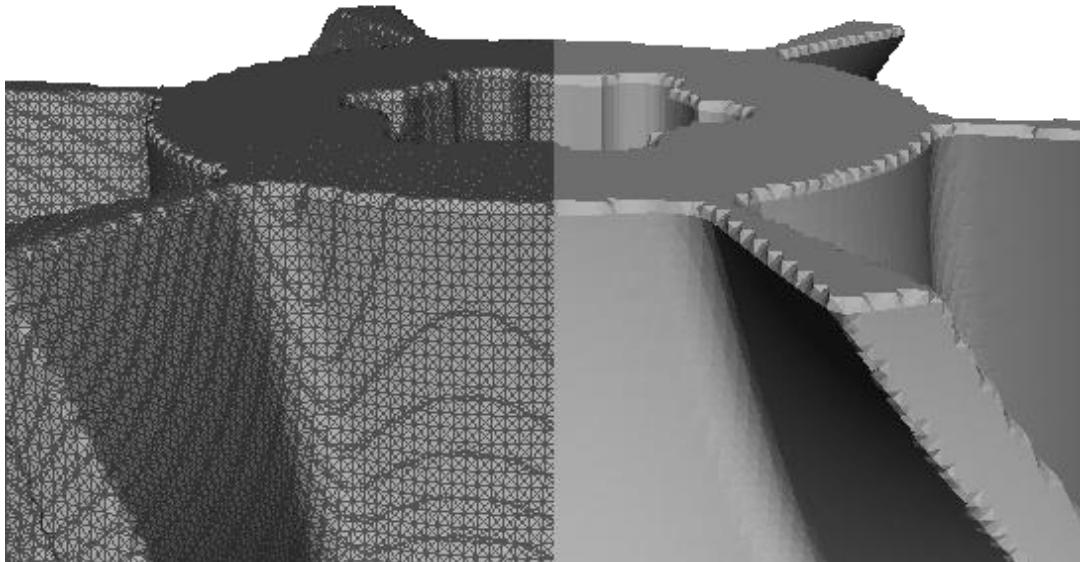


With feature reconstruction

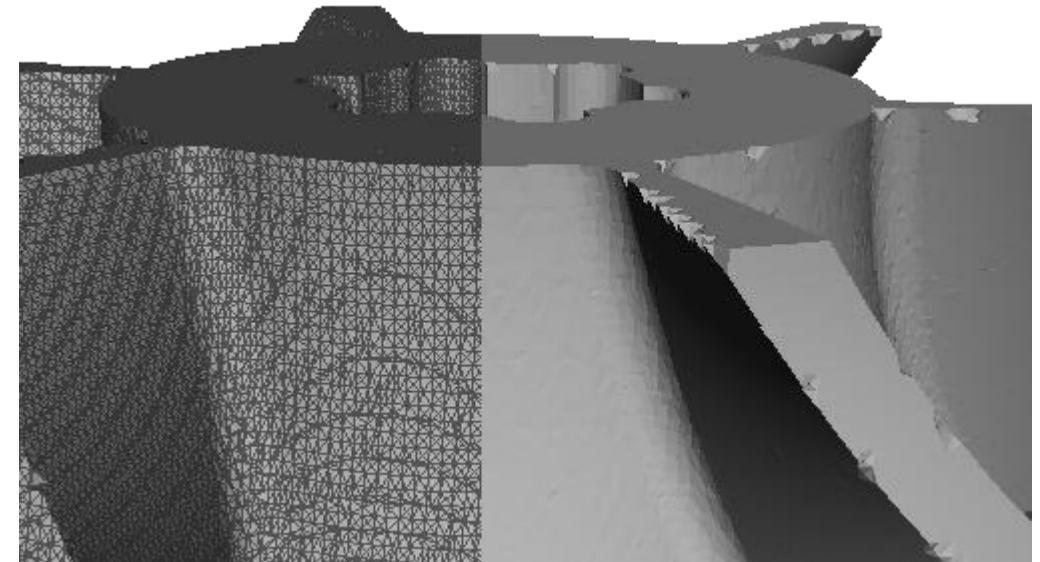


Impeller

Without feature reconstruction

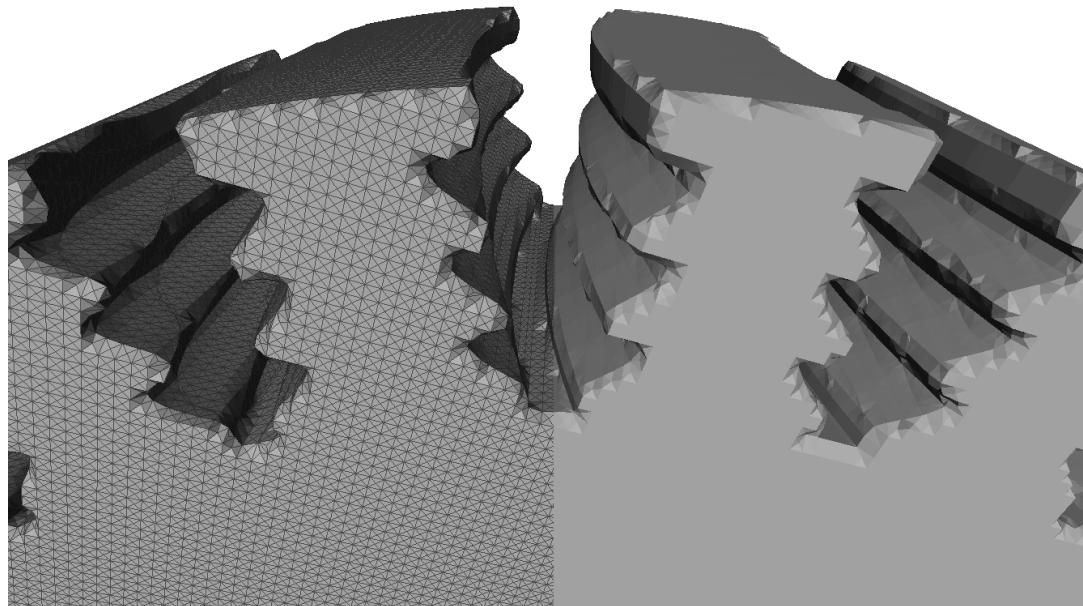


With feature reconstruction

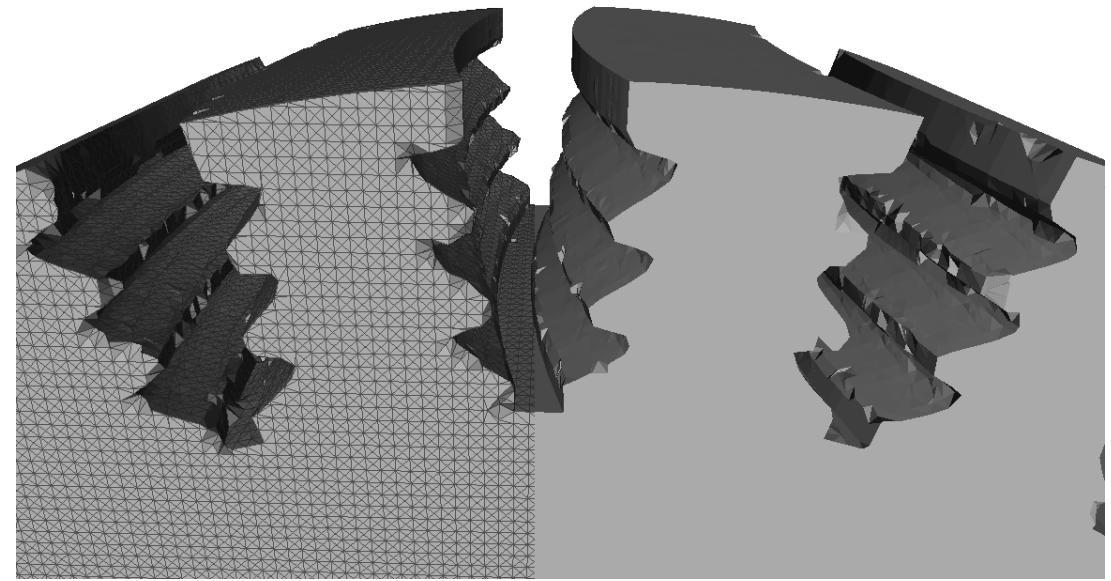


Turbine wheel

Without feature reconstruction



With feature reconstruction



Conclusion

Ball pivoting algorithm

- Perfectly captures convex features
- Completely loses concave features (ball size)
 - bend triangles according to attached normal (work in progress)
- May create holes and role inside

Tri-dexel

- Good reconstruction of larger convex/concave features
- Completely loses thin features
 - on demand subdivision (work in progress)
- Embarrassingly parallel

Thank you!

Questions?