Detailed and adaptive surface reconstruction of implicit models

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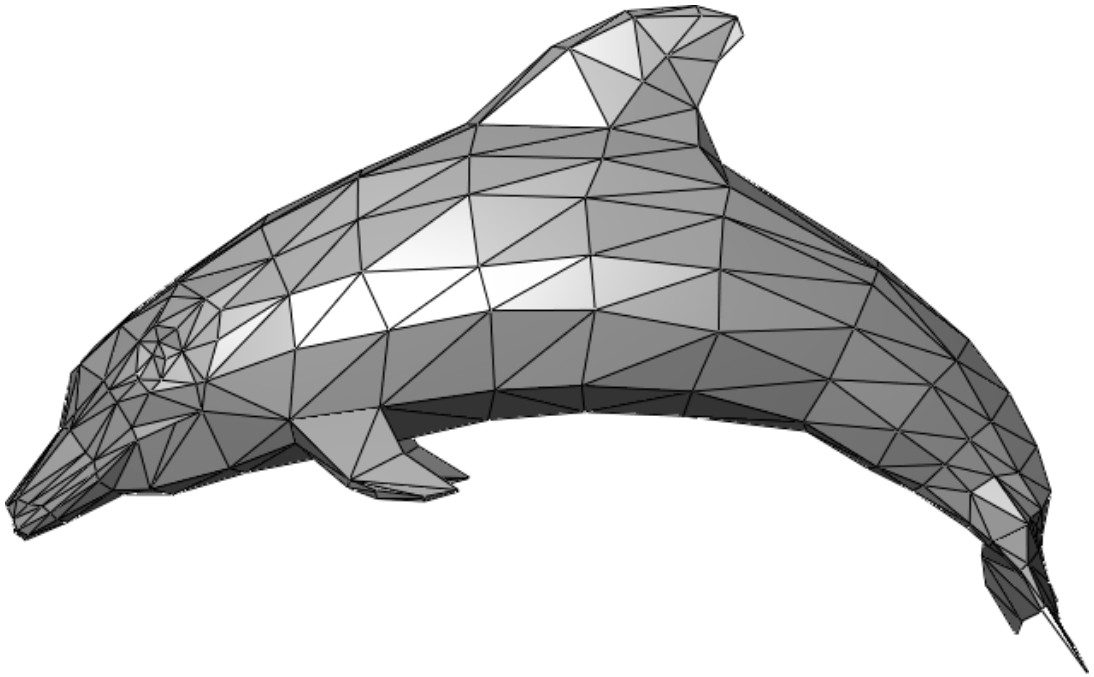
2014-12-10

What are implicit models?

Explict surface models

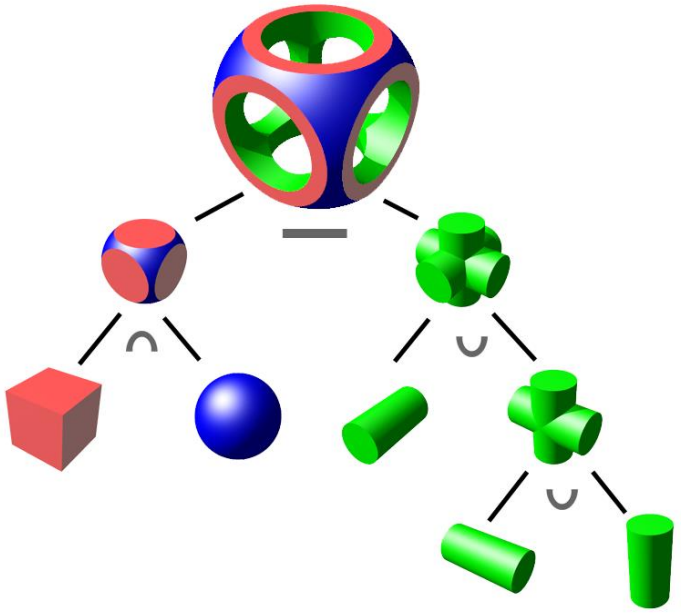


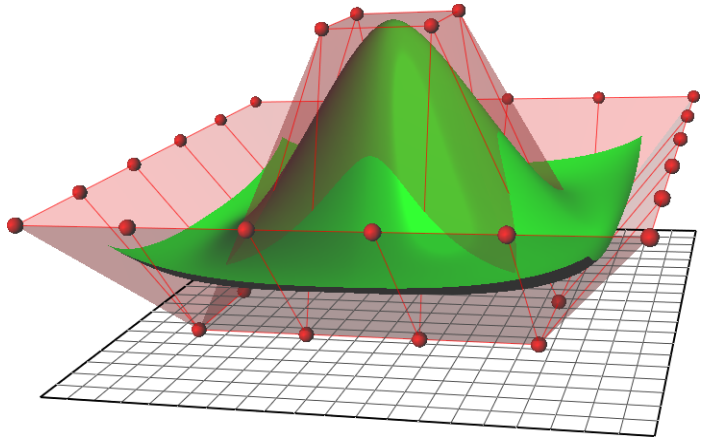
http://en.wikipedia.org/wiki/Triangle_mesh#mediaviewer/File:Dolphin_triangle_mesh.png

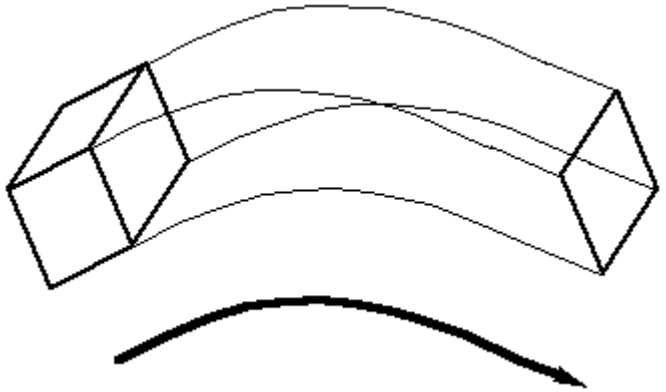
Implict surface models

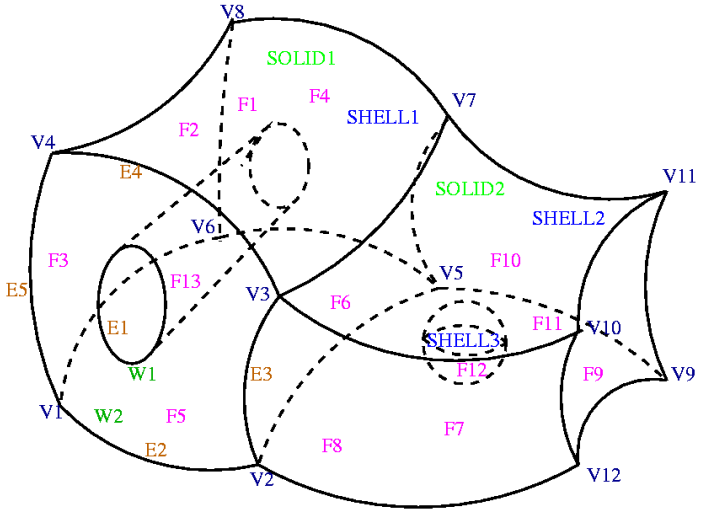
- Parametric
- Functional (iso surface)
- Boundary Representation
- Constructive Solid Geomtry
- Sweeps
- …

What are implicit models?









$$f(x,y,z) = x^2 + y^2 + z^2 - 5^2$$
$$f(x,y,z) < 0 \quad inside$$
$$f(x,y,z) > 0 \quad outside$$
$$f(x,y,z) = 0 \quad surface$$

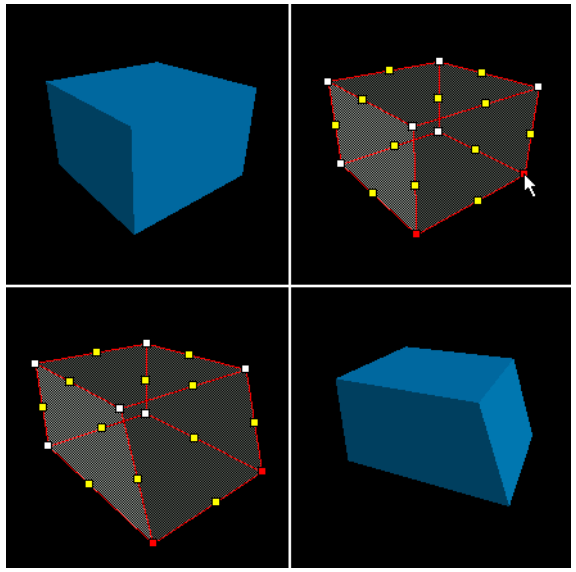
$$S = \{(x,y,z) \mid x^2 + y^2 + z^2 = 5^2\}$$

http://en.wikipedia.org/wiki/Constructive_solid_geometry#mediaviewer/File:Csg_tree.png
https://www.ljll.math.upmc.fr/perronnet/mit/mit.html
http://de.wikipedia.org/wiki/Non-Uniform_Rational_B-Spline#mediaviewer/File:NURBS_surface.png
http://www.cs.cf.ac.uk/Dave/3DVG/IMAGES/sweep.gif

Motivation

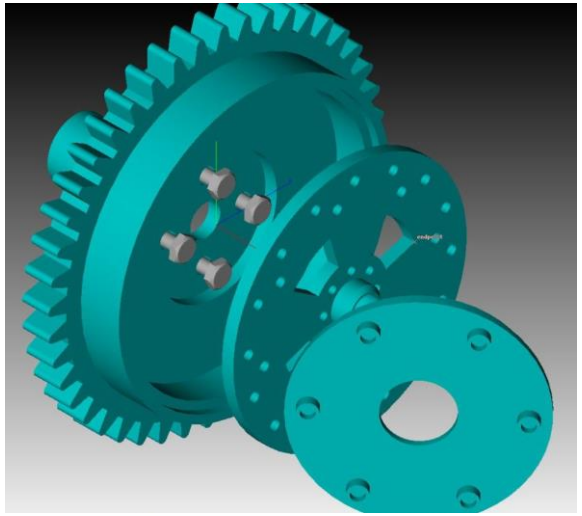
Explicit surfaces

- Wide support
- Render
- Process
- Store
- Edit
- Distribute
- Sell
- …



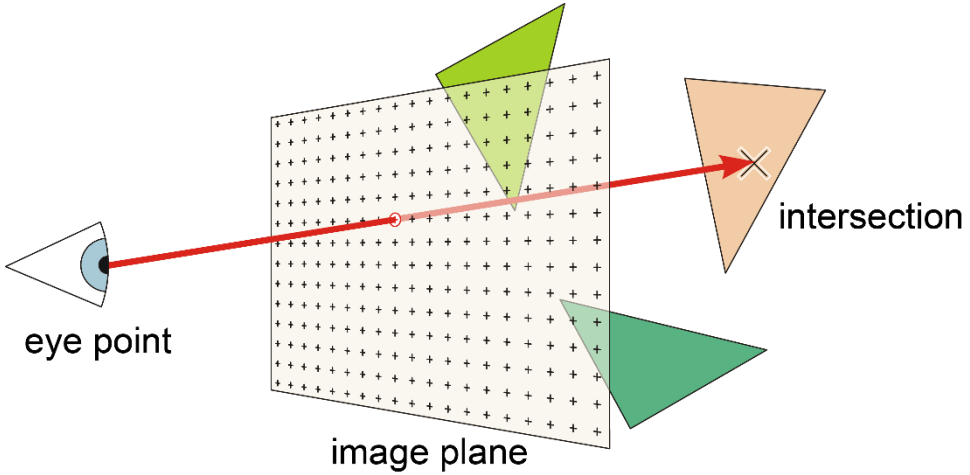
Implicit surfaces

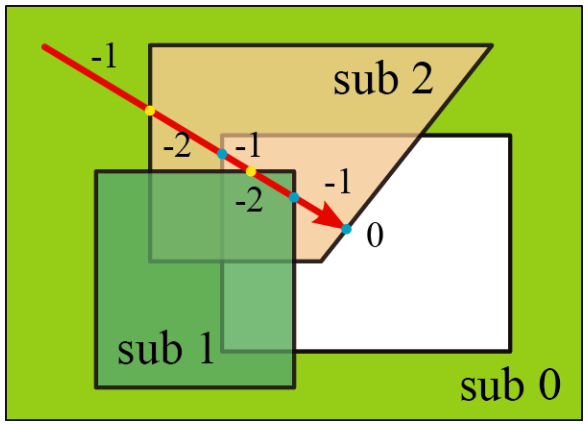
- Exact
- Expressive
- Small memory
- Ray tracing
- …

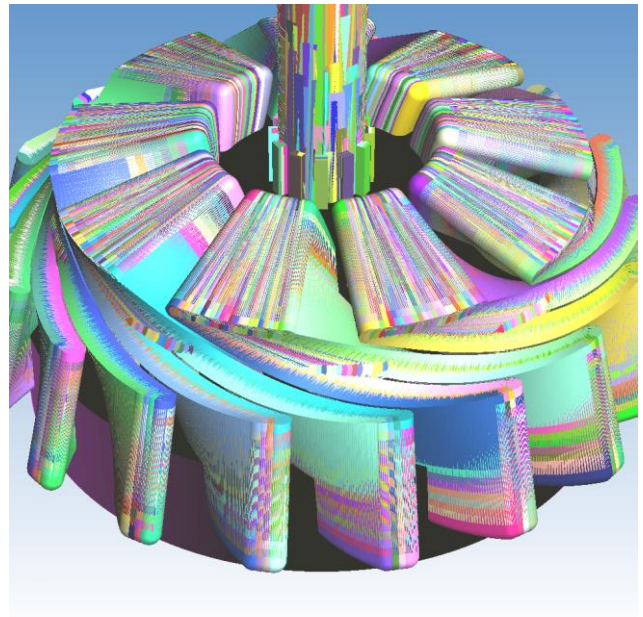


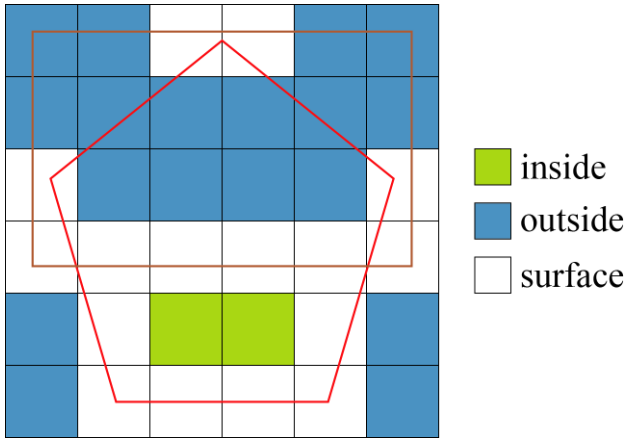
https://www.khronos.org/news/logos
http://blog.bestsoftware4download.com/wp-content/uploads/2010/04/TurboCAD-MAC.jpg
https://developer.valvesoftware.com/w/images/2/29/VertexEdit1.png

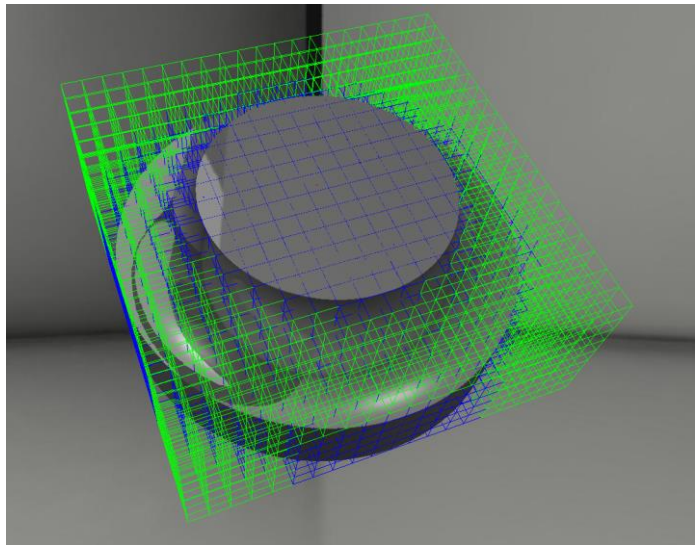
Previous work - Enlight

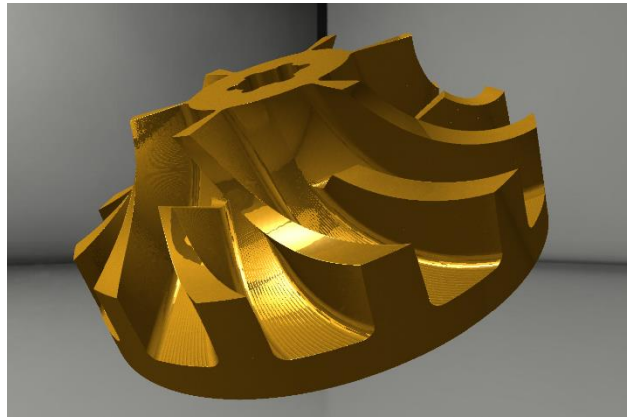






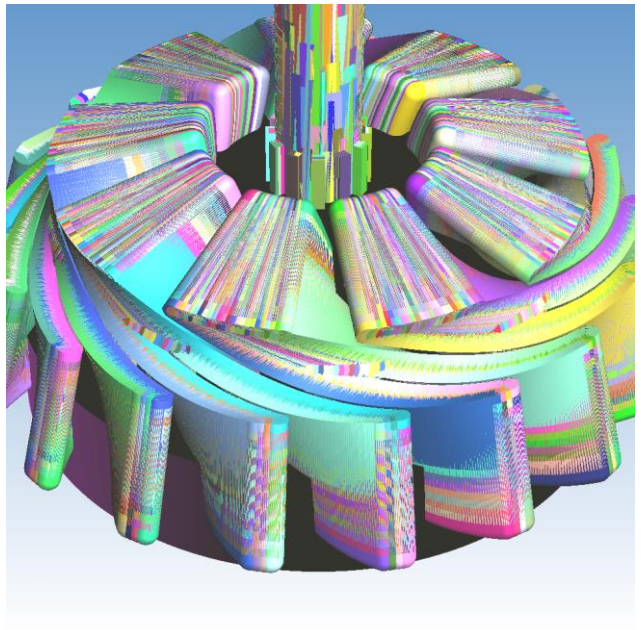




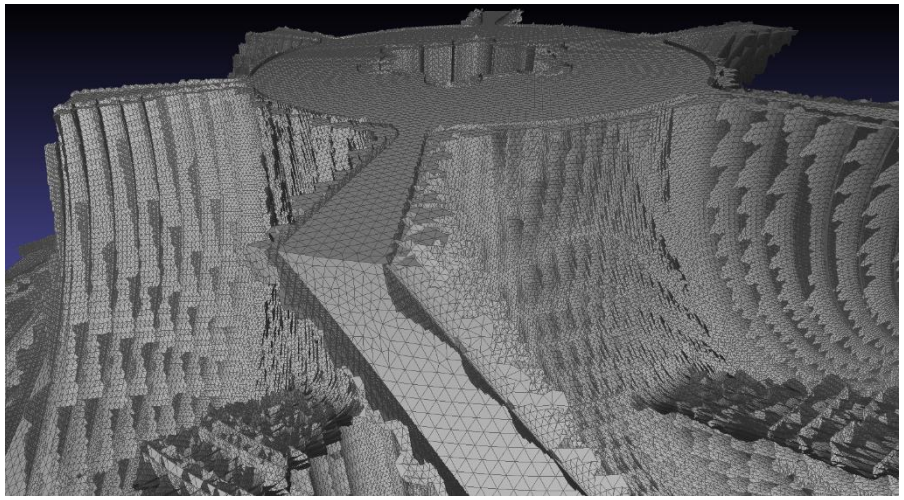


Enlight

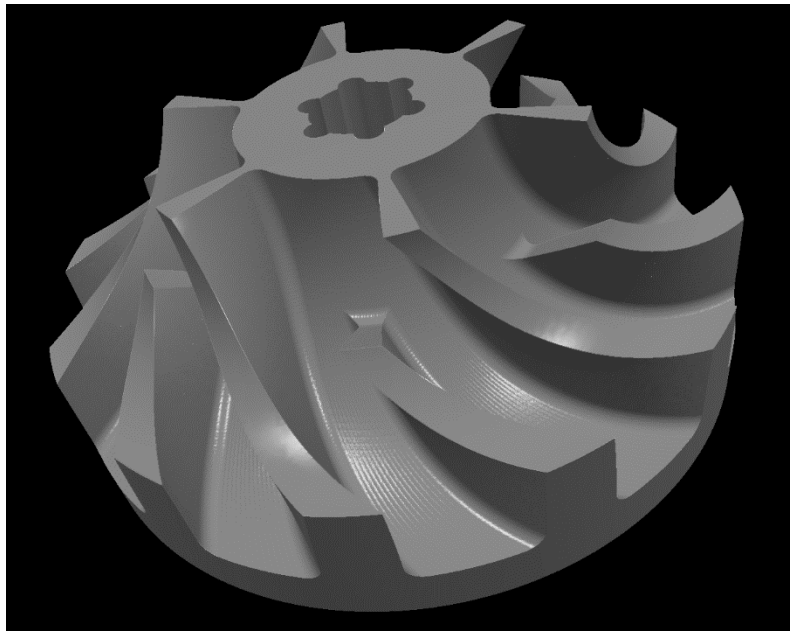
Swept volumes



Data model



Raycast



Problem statement

Surface mesh extraction from Enlight’s data model

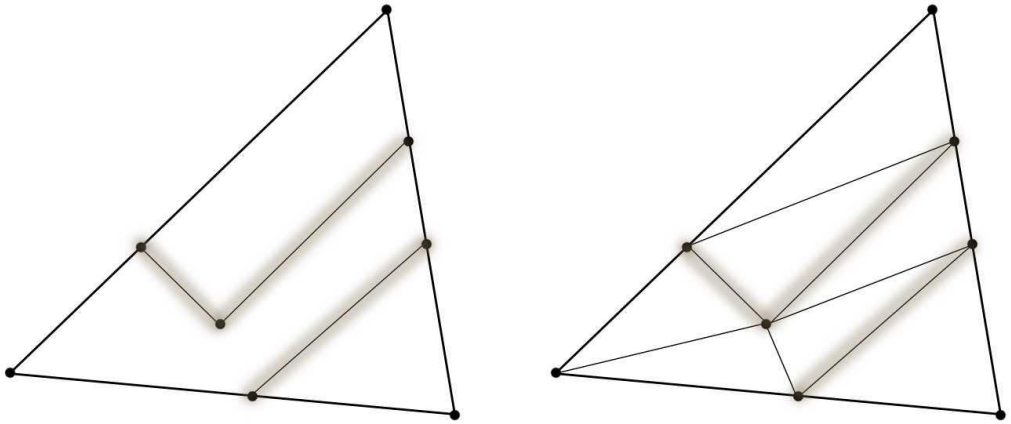
1. Determine state of the art
2. Prototypic implementation and comparison
   runtime, memory, complexity, visual quality, errors, divergence, numeric, mesh quality, feature conservation, adaptivity
3. Intensive testing on selected models.
   Is there a "best" algorithm? Under which circumstances?
   How to select best suited algorithm?

Approaches

- Direct intersection
- Point cloud based
- Voxel based
- Dexel based

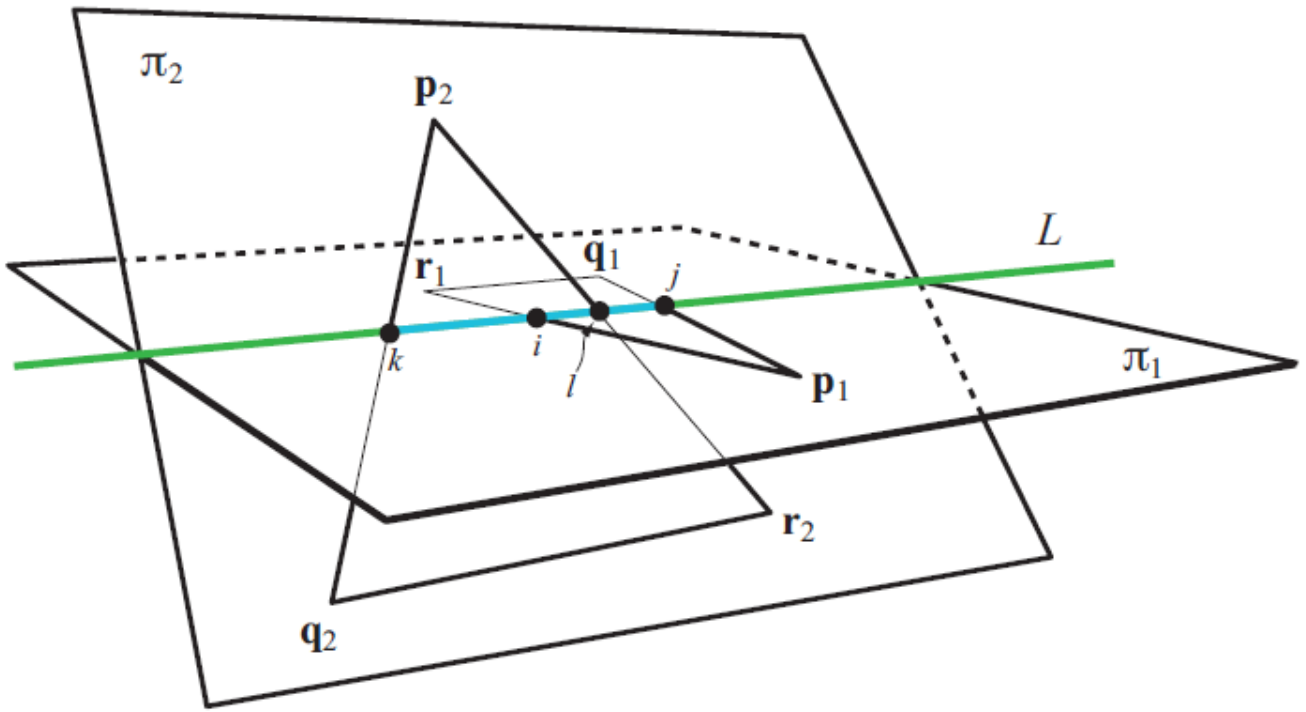
Direct intersection

- Most naïve, probably most accurate
- David Rosen,
  Seamless Intersection Between
  Triangle Meshes,
  2008



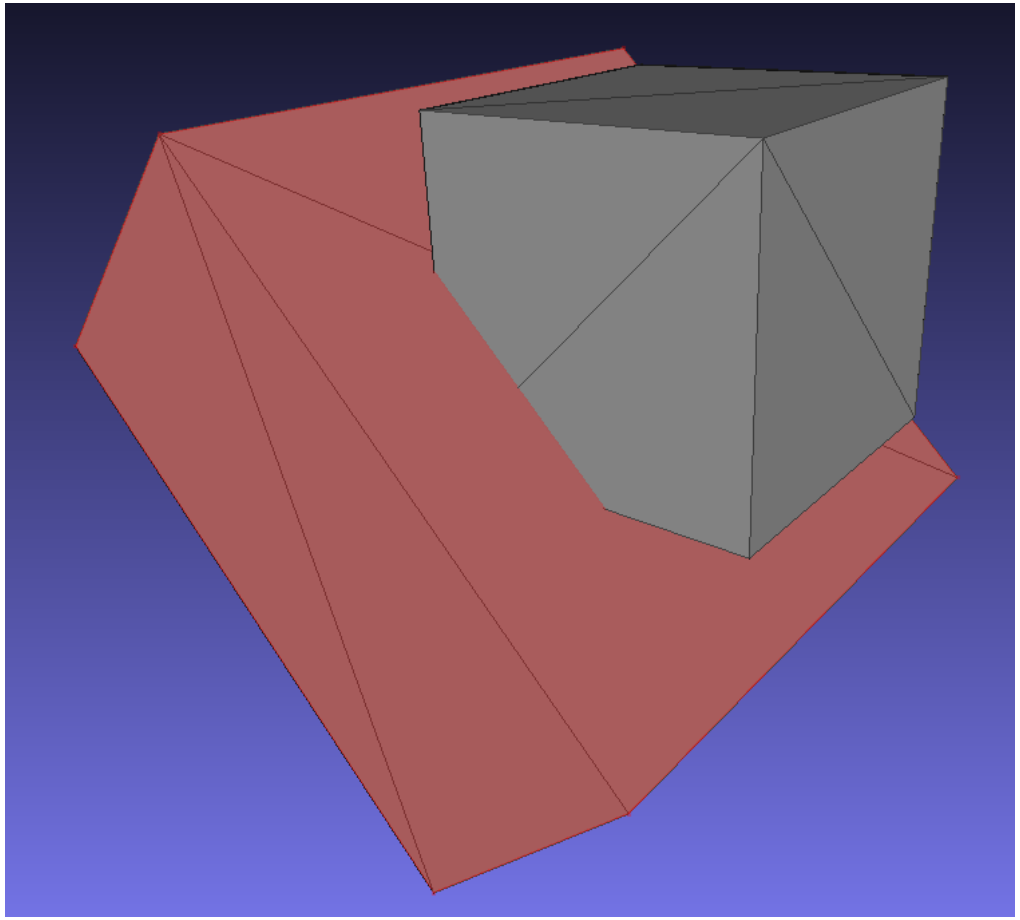
Triangle triangle intersection

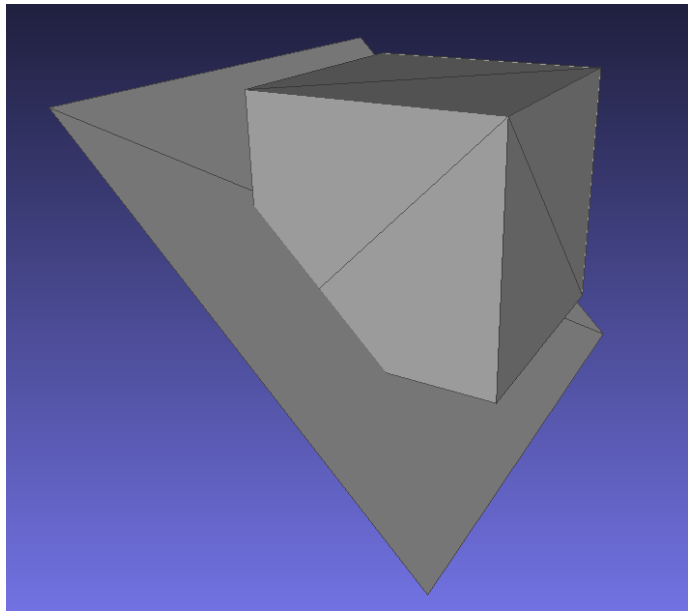
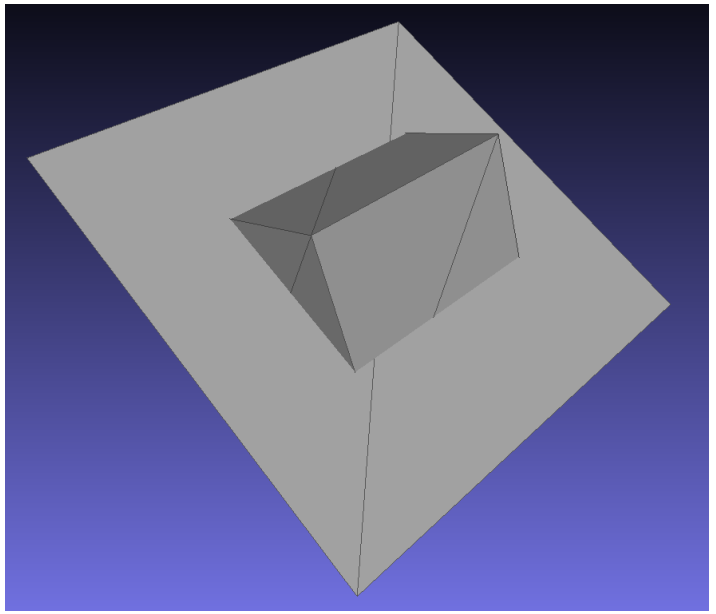
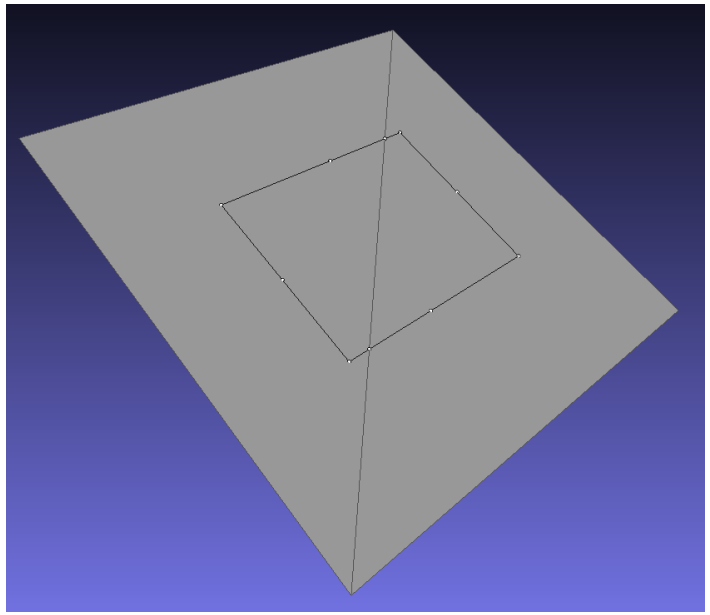
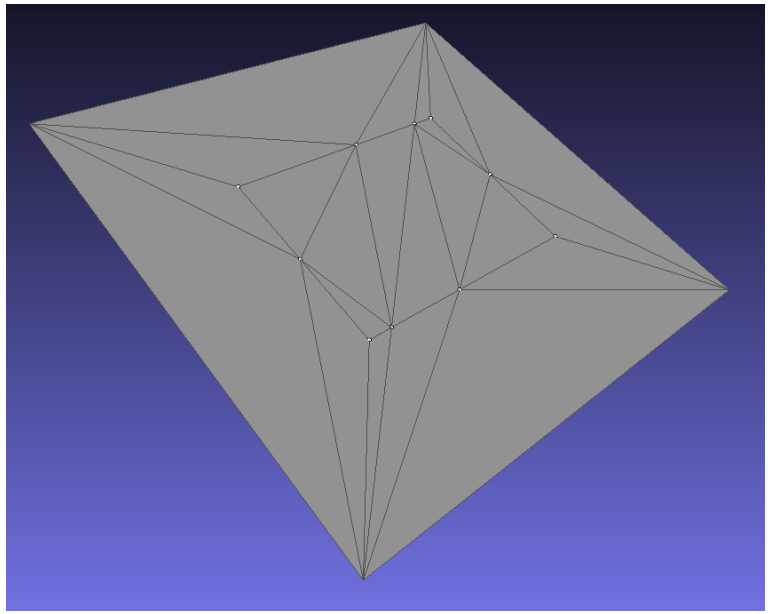
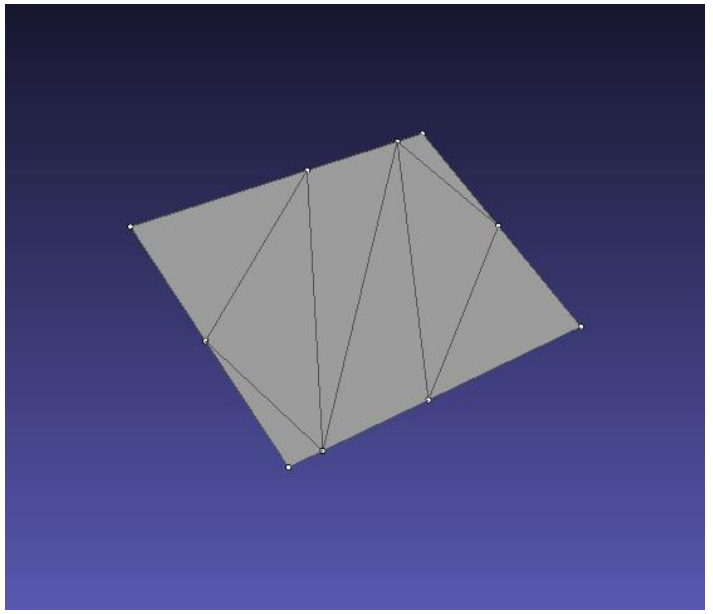
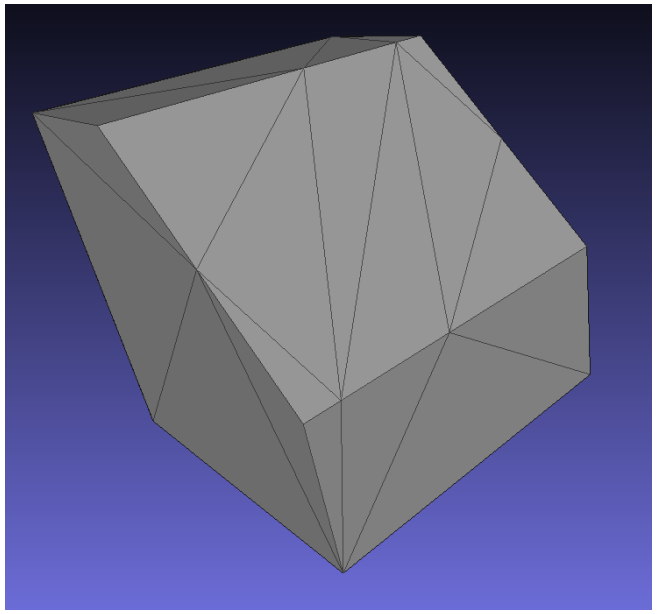
- Tomas Möller,
  A fast triangle-triangle intersection test,
  1997



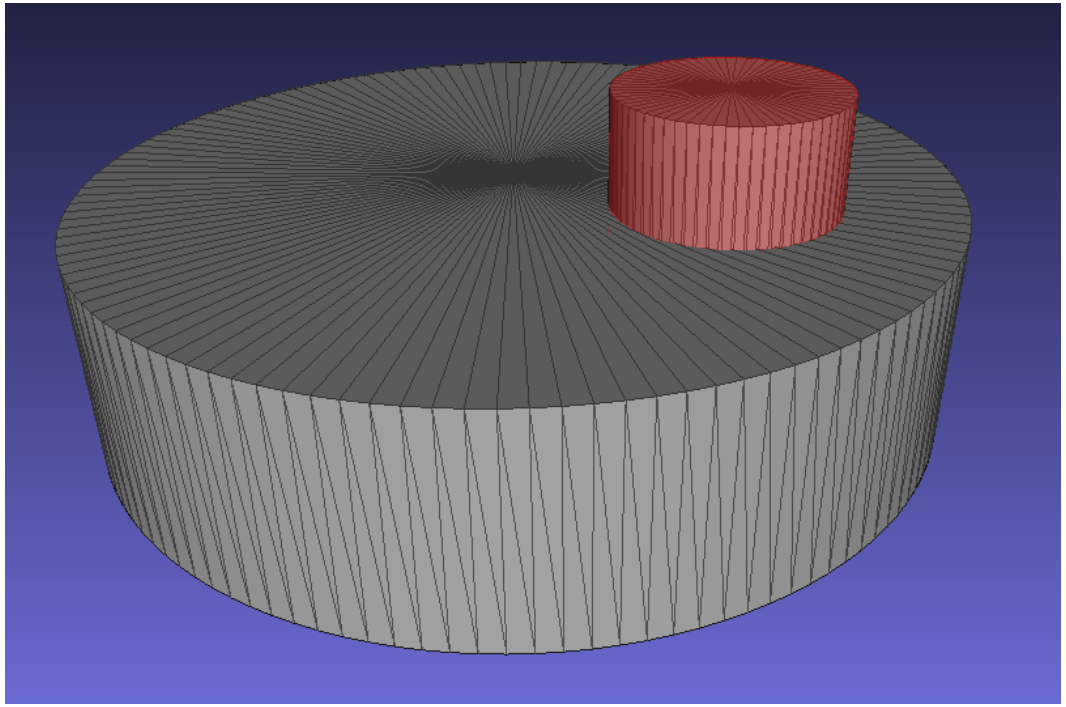
http://lib.znate.ru/docs/index-40240.html?page=3

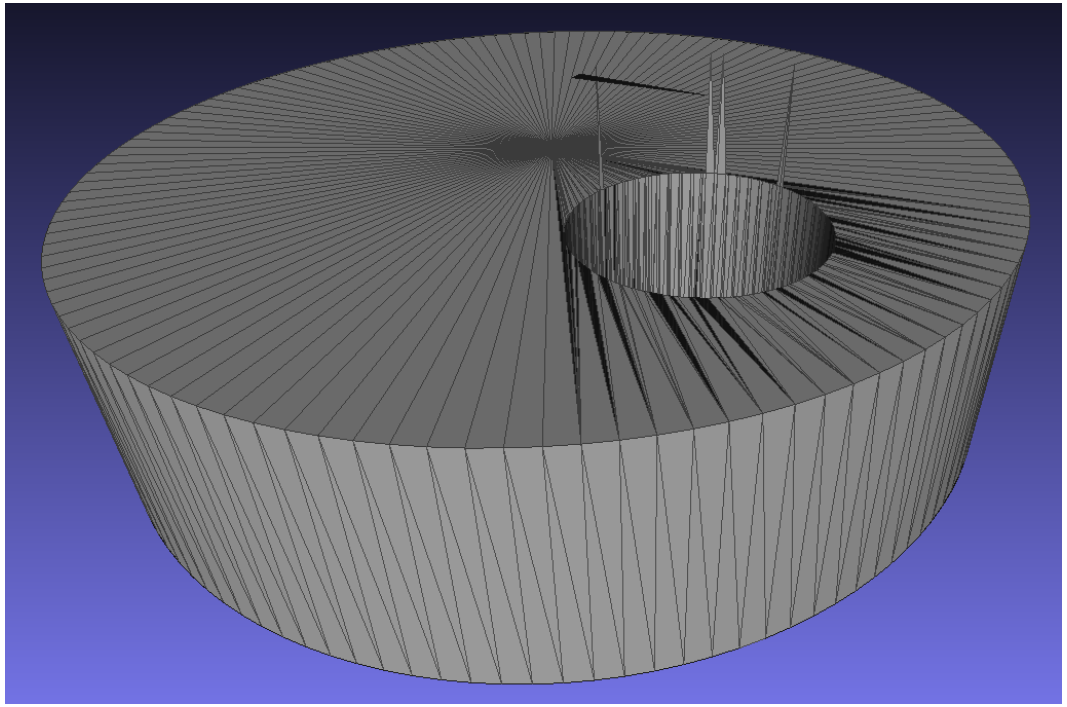
Cube vs. cube



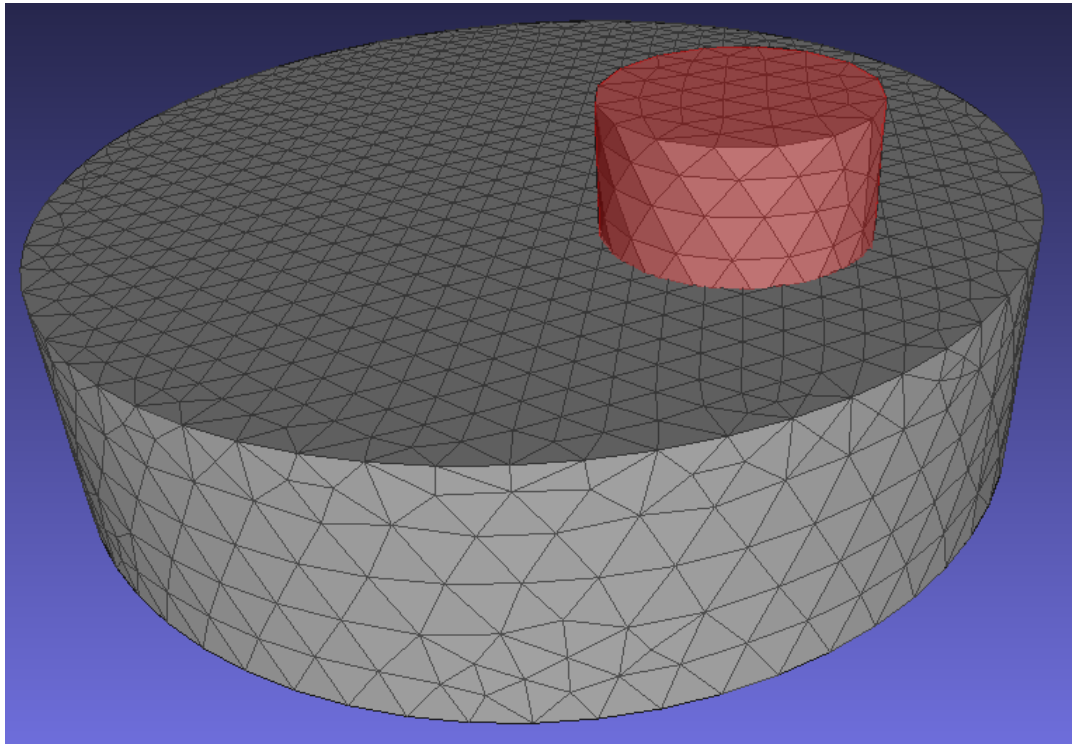







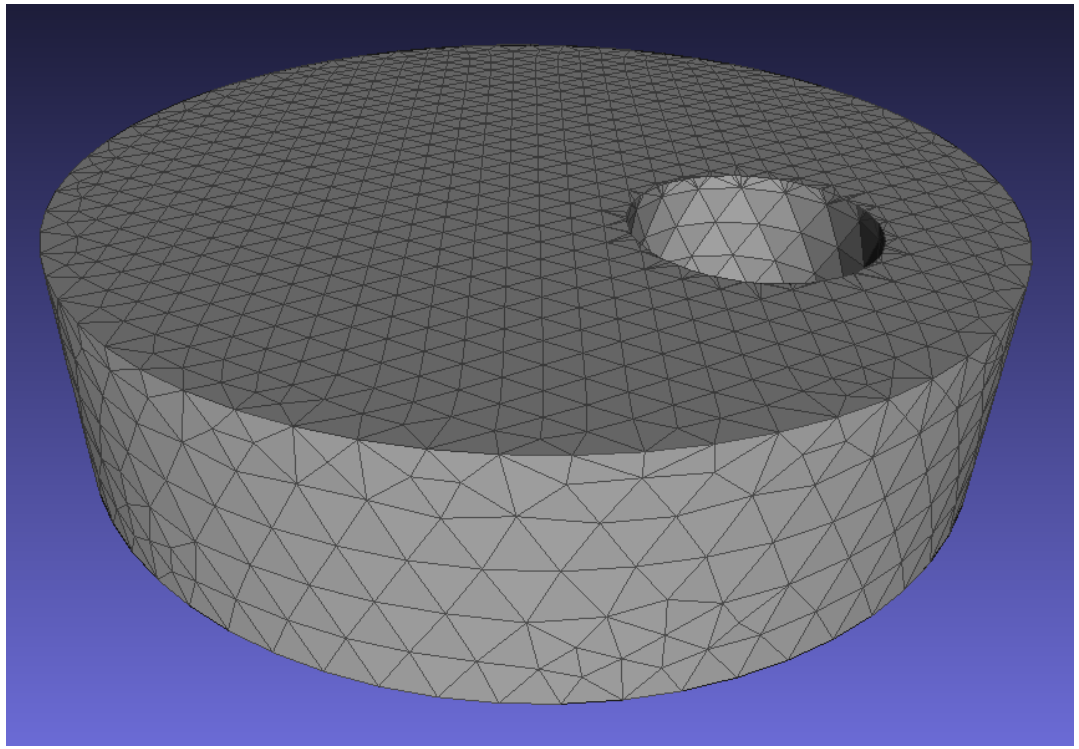
Cylinder vs. cylinder



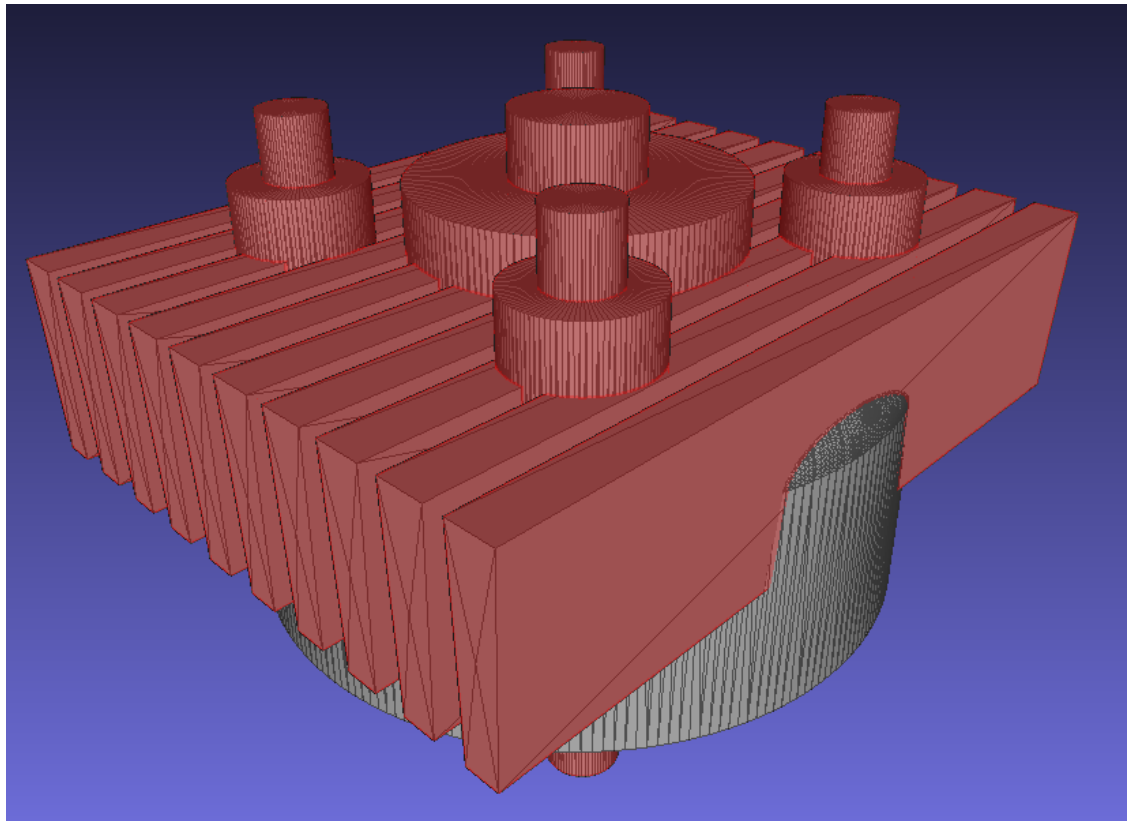


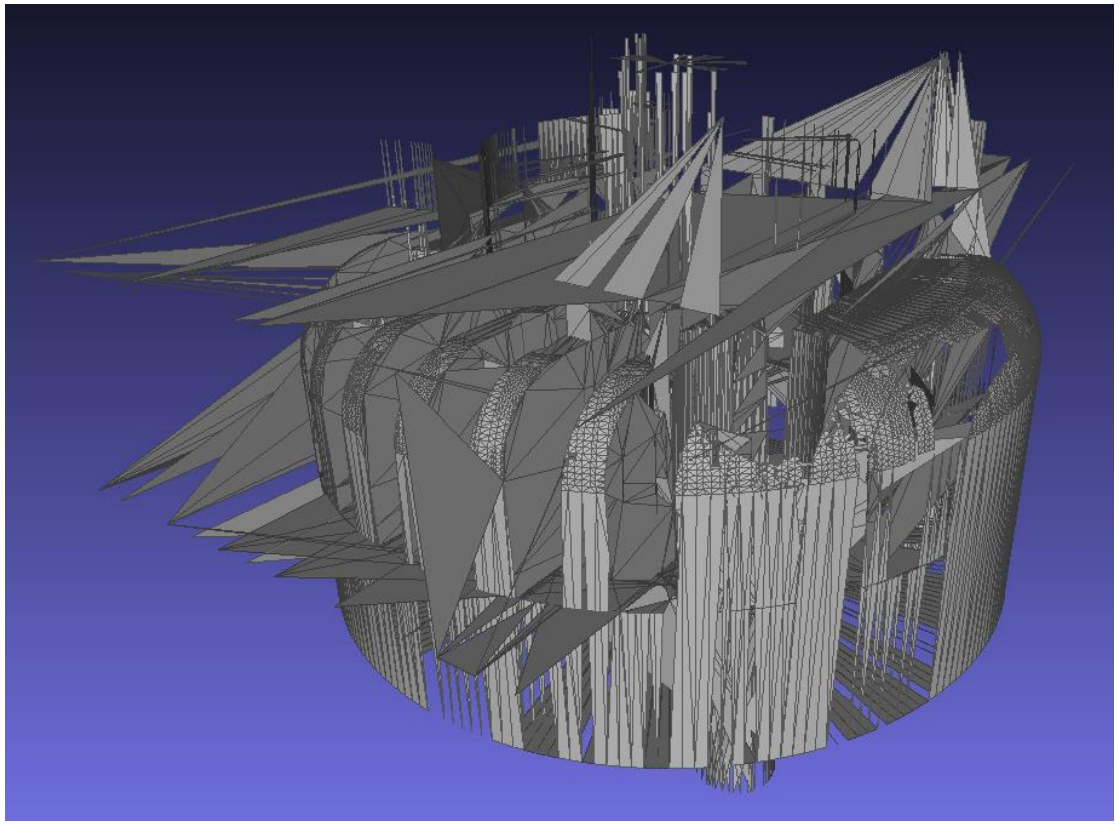
Cylinder vs. cylinder - Delaunay





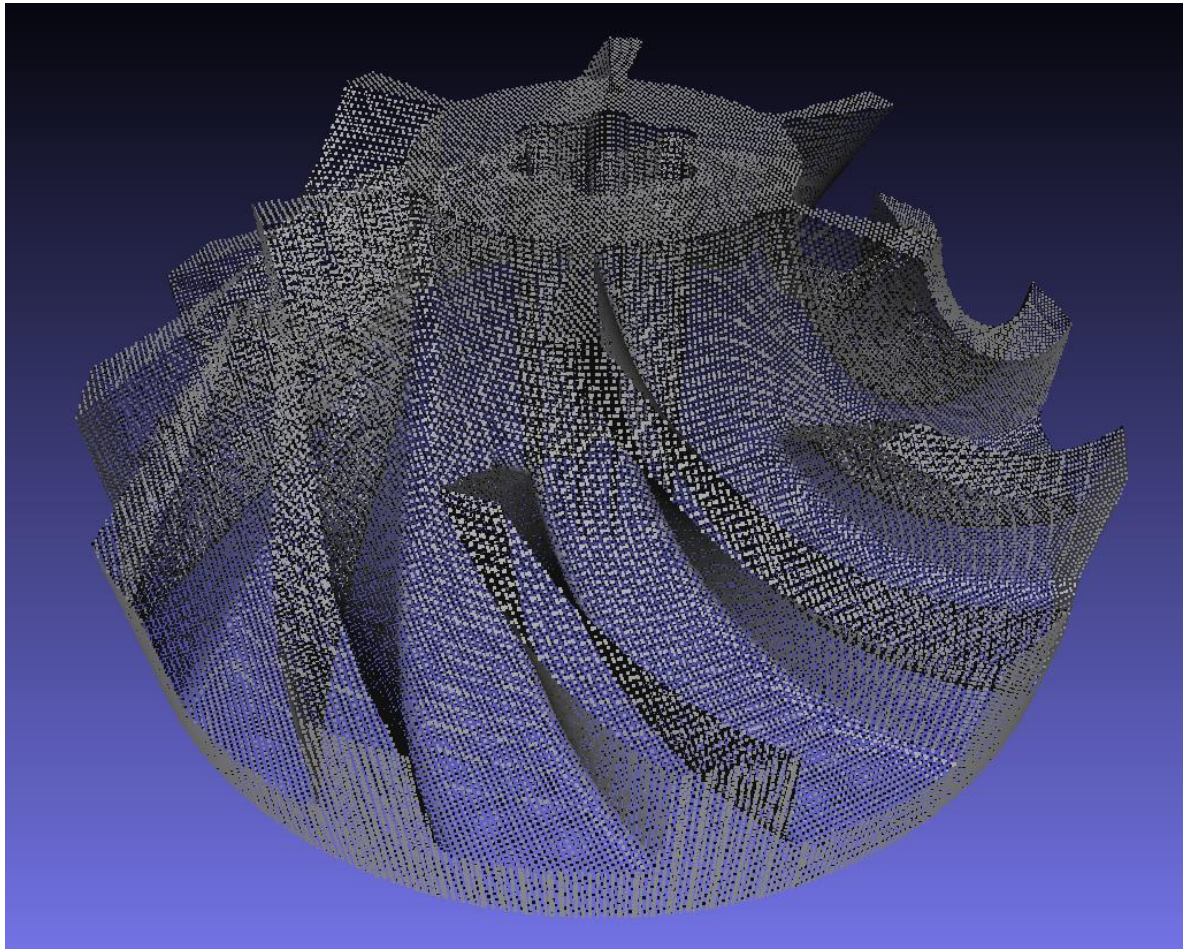
Cylinder head





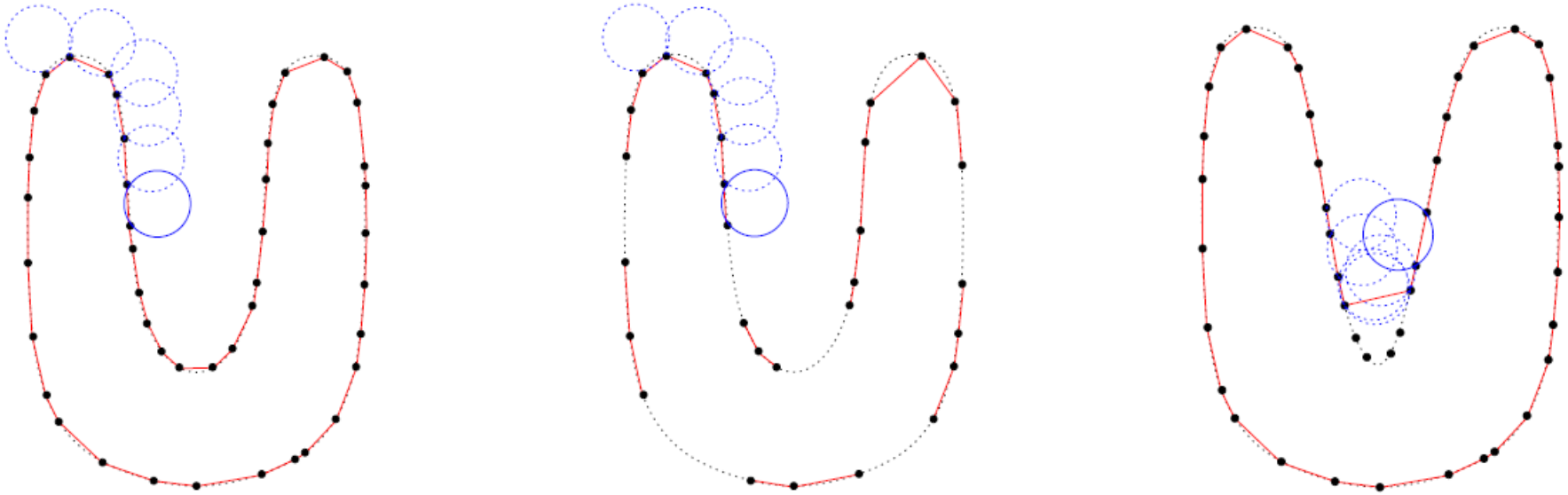
Point cloud based

- Sample surface,
  e.g. 3 orthongal raycasts,
  reconstruct surface from points

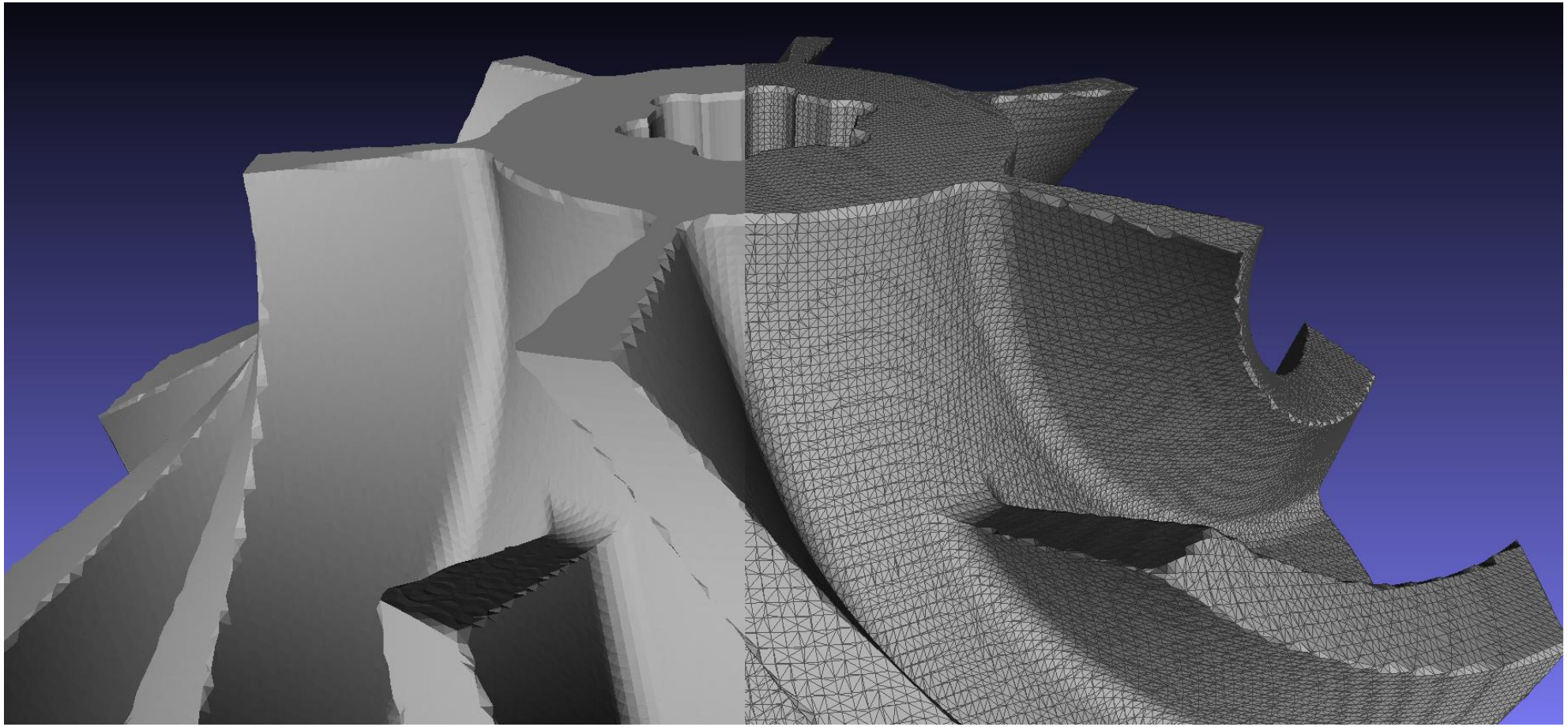


Surface reconstruction from point cloud

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

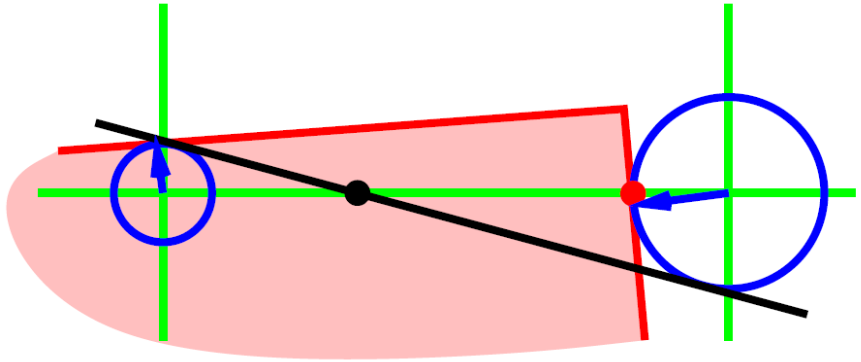


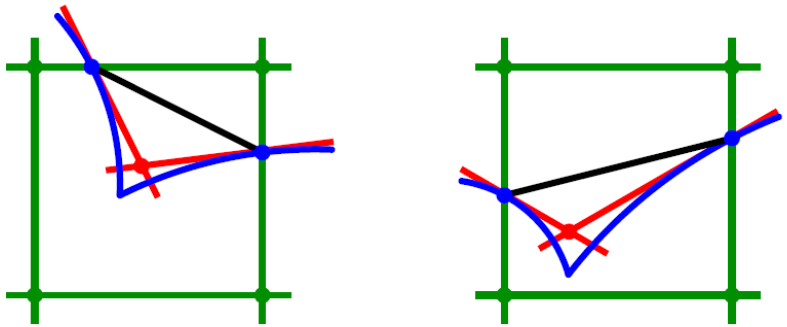
Ball pivoting algorithm

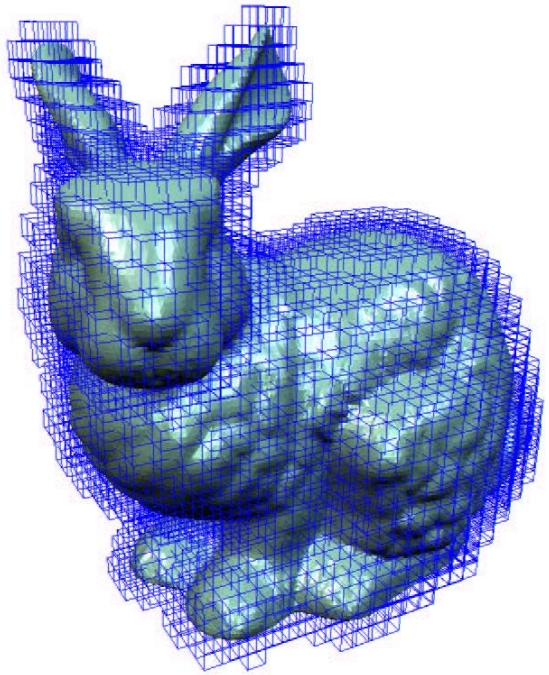


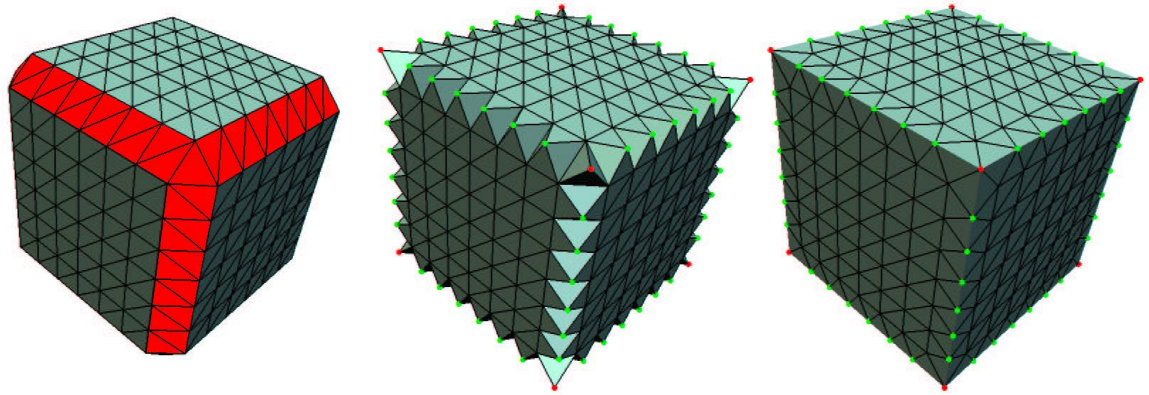
Voxel based

- Leif Kobbelt et al.,
  Feature sensitive surface extraction from volume data, 2001



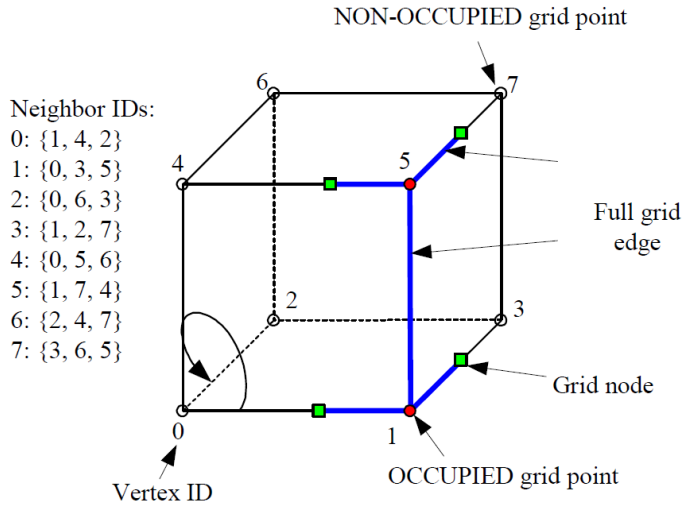


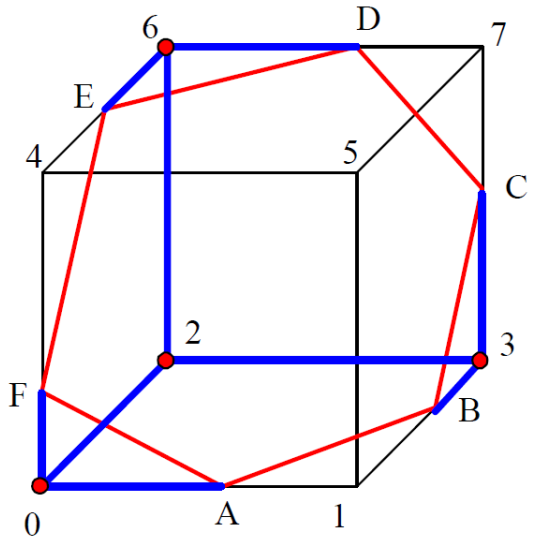


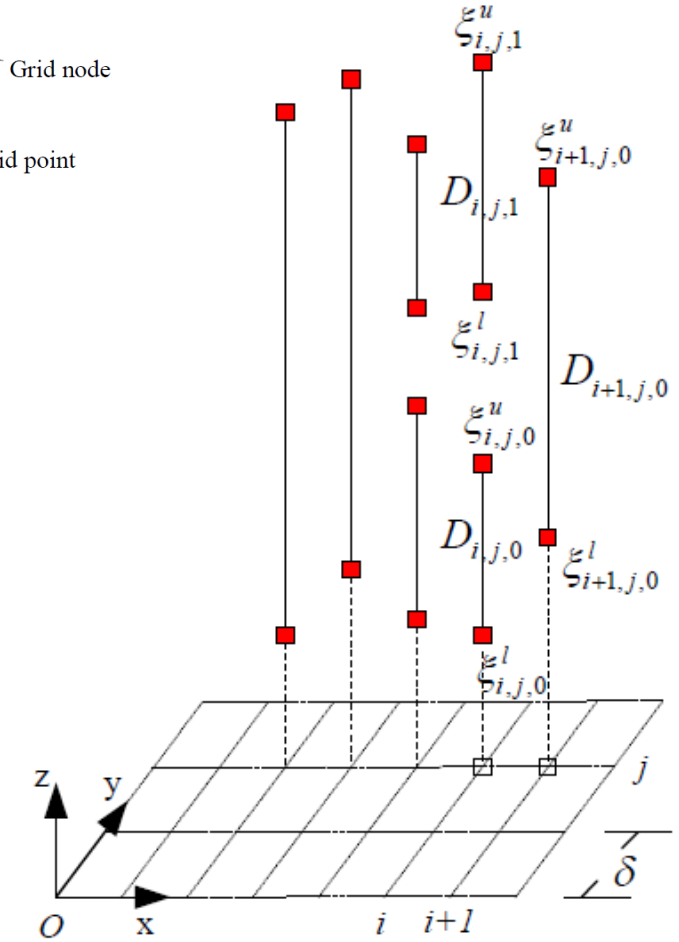


Dexel based

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







Goal

- Implement presented approaches
- Create appropriate test suite (models)
- Evaluate algorithms
- Try to find "best" algorithm or hybrid

- Development on "best" algorithm will be continued at RISC …

Schedule

Time	Milestone
October	DPR3: Technical lecture, infrastructure code, some test models
November	Exposè, direct triangle-triangle intersection
December	DPR3: Thesis introduction, point cloud based approaches
January	Voxel based approaches
February	Dexel based approaches
March	Comparing implementations, introductory and fundamental chapters
April/May	Implementation chapters, adjusting implementations, more test models
June	Finishing touches and submission

Thank you!

Questions?