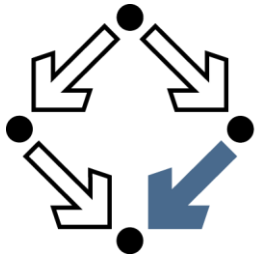
enlight

An optimized raycasting approach for subtractive manufacturing simulation and visualization



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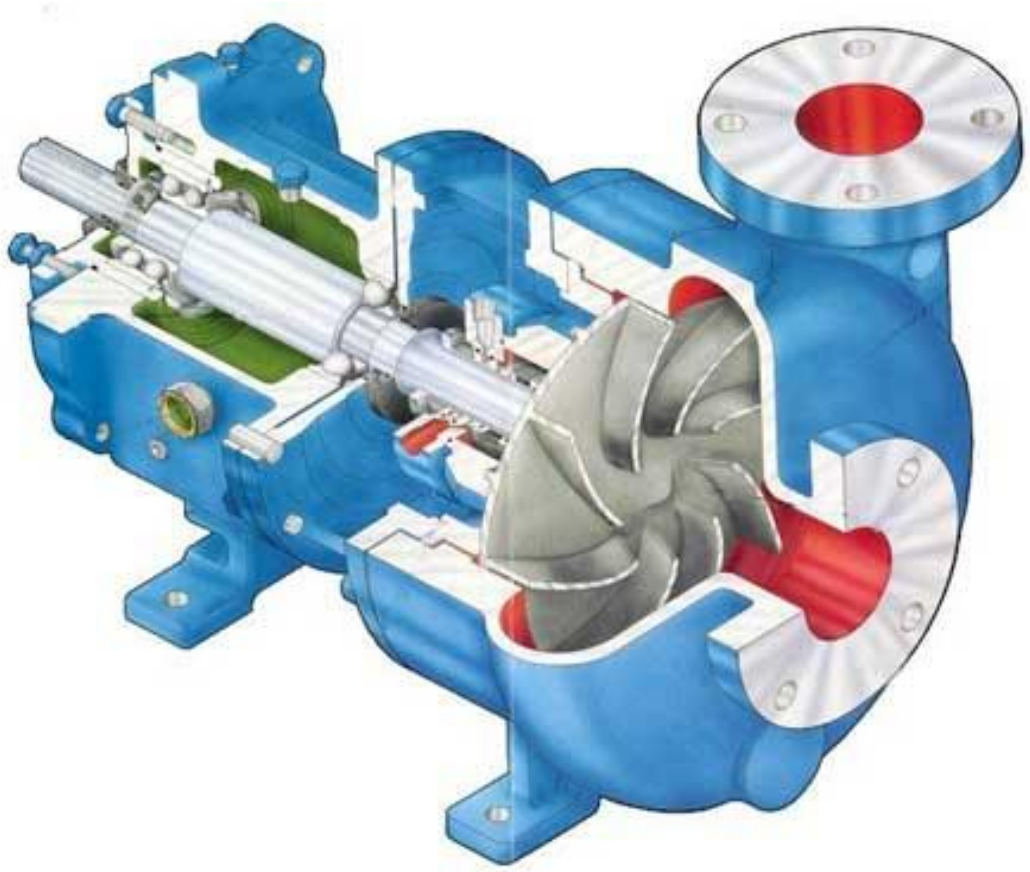
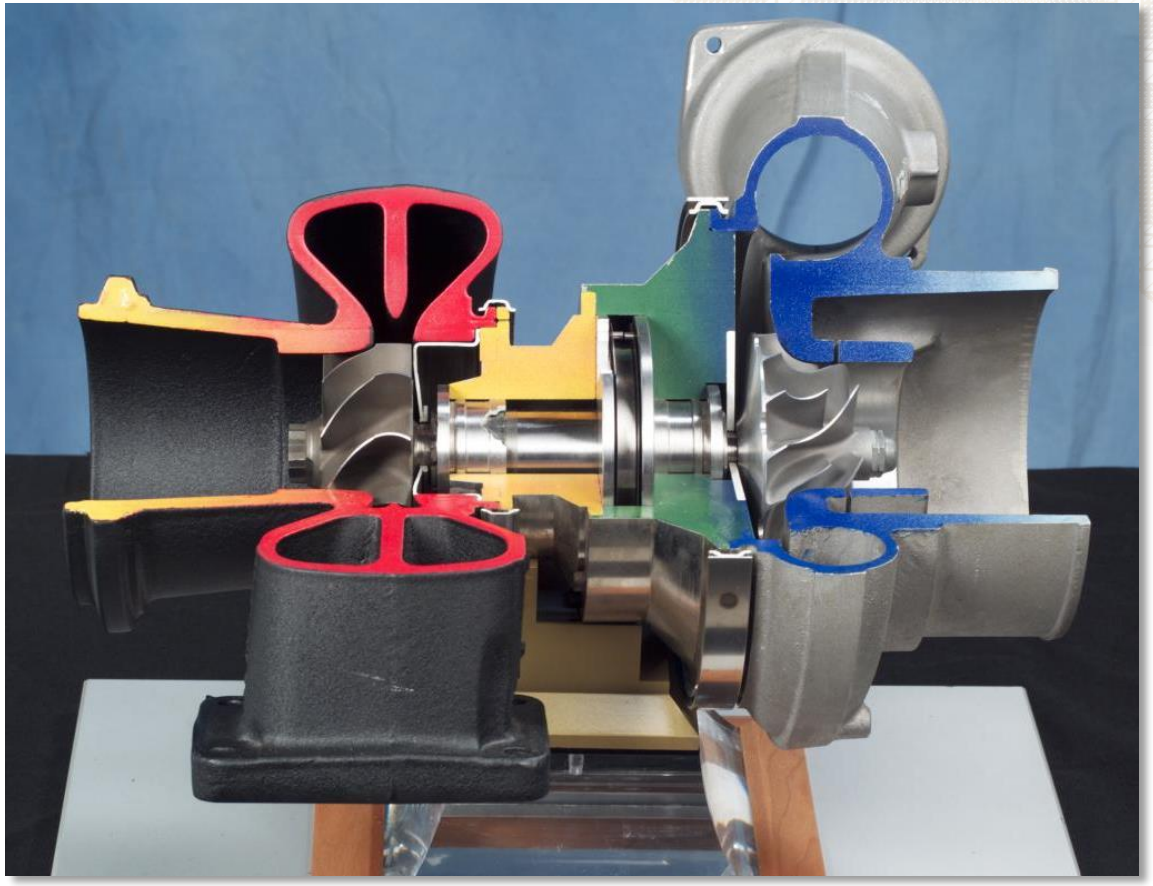
Regio 13
Impulse für OÖ
Regionale Wettbewerbsfähigkeit OÖ 2007–2013

Industrial components – e.g. impellers





http://www.globalpumps.in/matherplatt.html
http://en.wikipedia.org/wiki/File:Turbocharger.jpg

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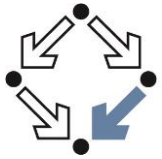
Milling - Subtractive manufacturing

Adapted from: https://www.youtube.com/watch?v=P0ImcDi_B0o



Overview

- Problem specification
- Basic visualization approach
- Optimization I, II, III
- Results

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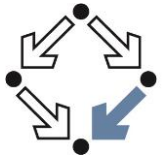

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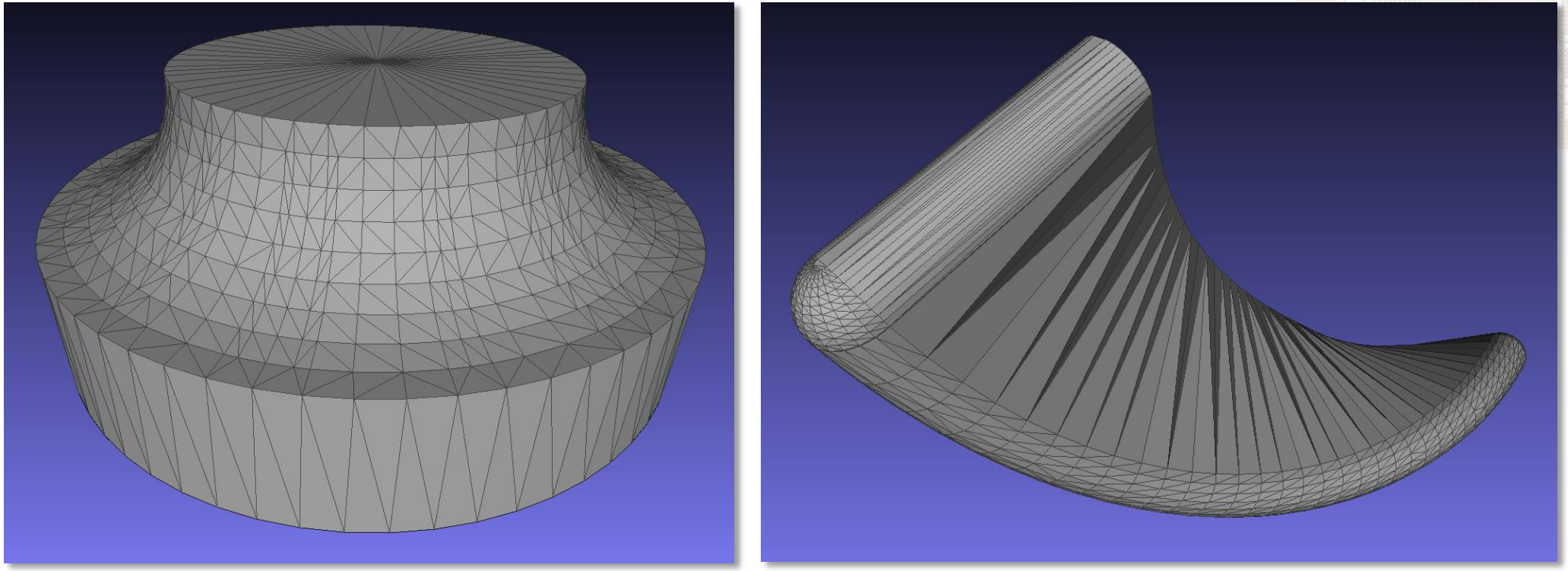
Problem specification

Input for digital simulation



MeshLab screen shots of low resolution input meshes

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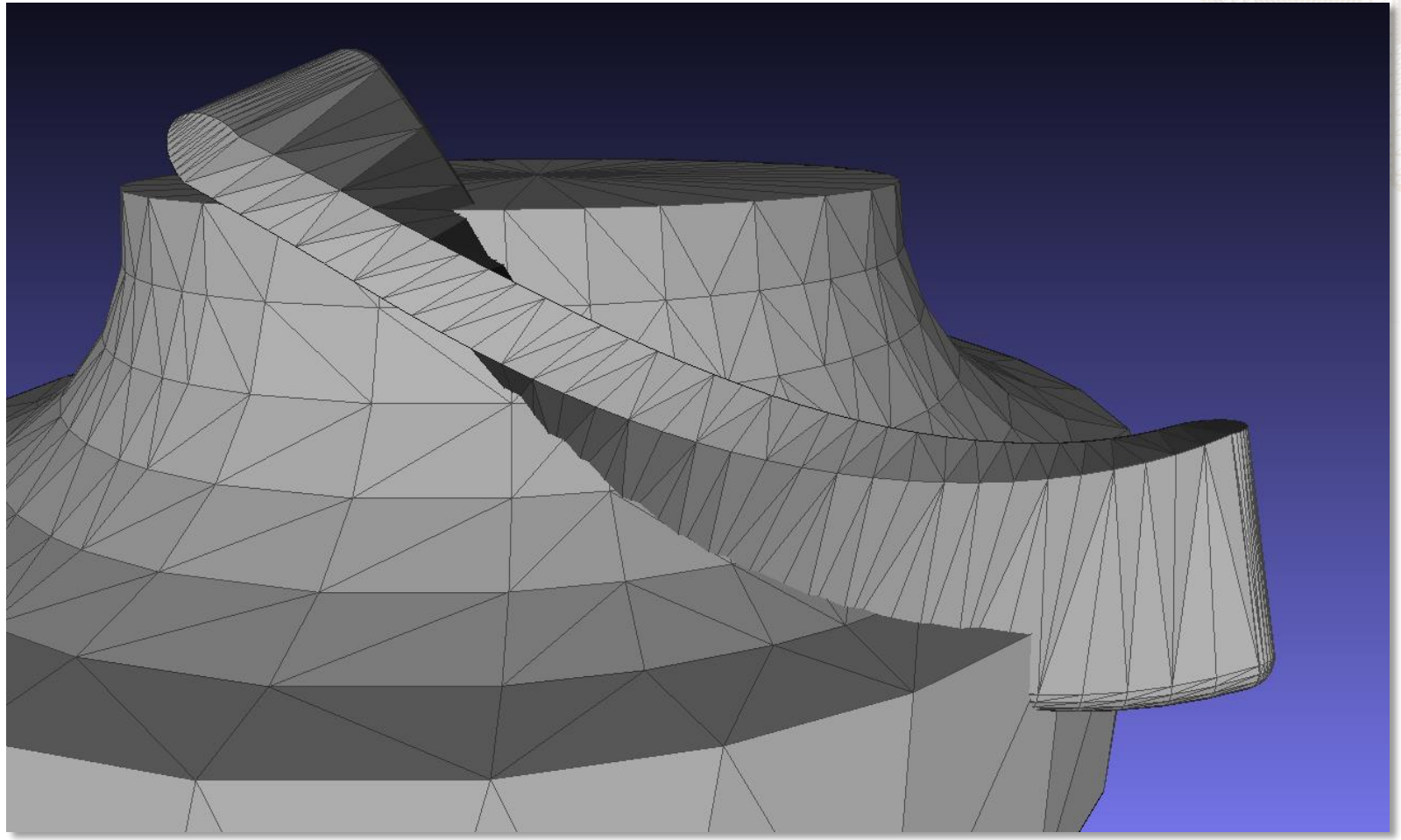
Problem situation



MeshLab screen shots of low resolution input meshes

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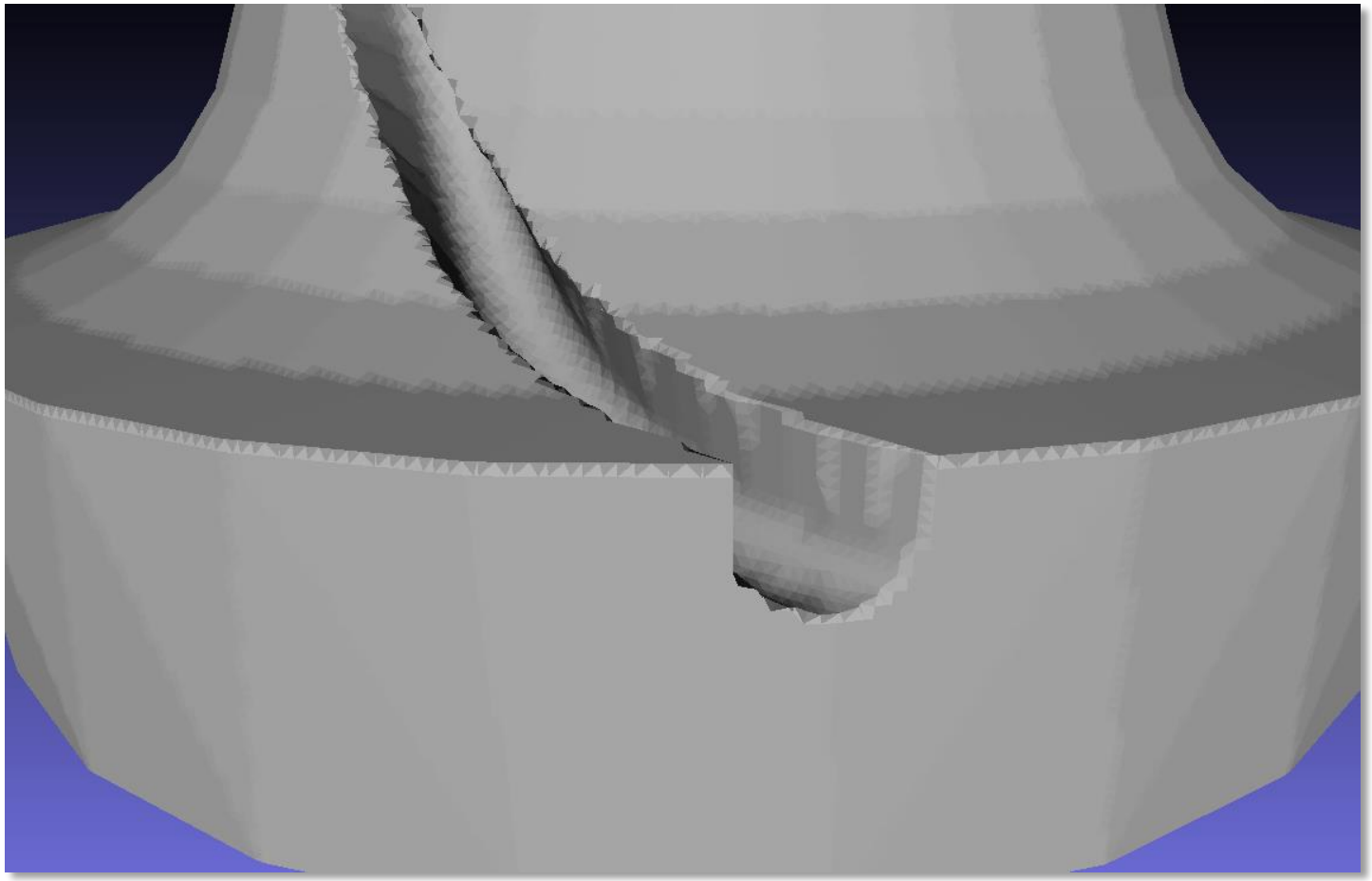
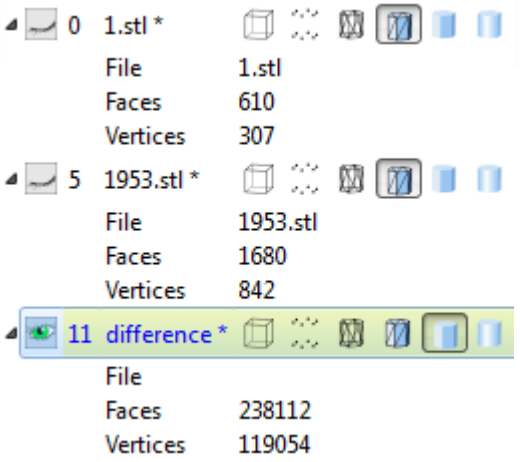
Existing methods – e.g. marching cubes





Explicit surface calculation using MeshLab

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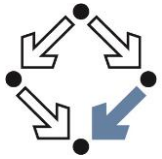
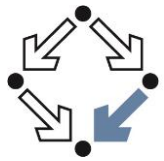


Basic visualization approach



Rendering 3D geometry

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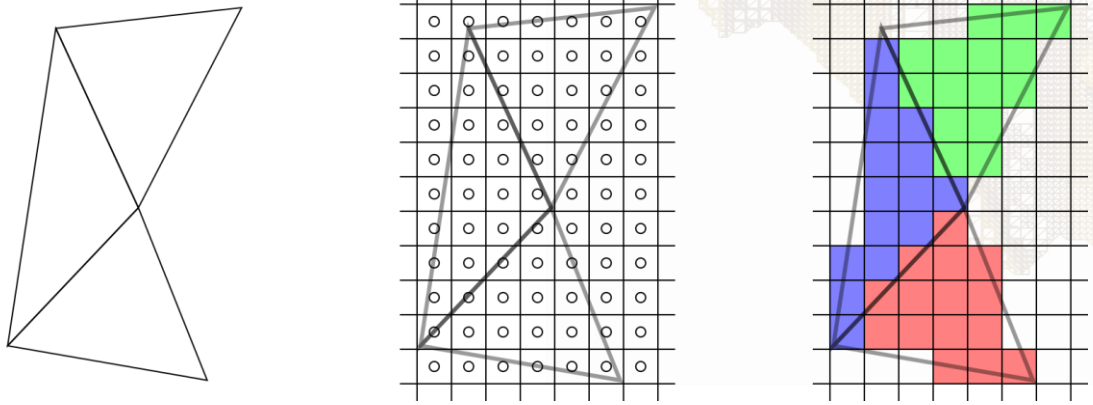
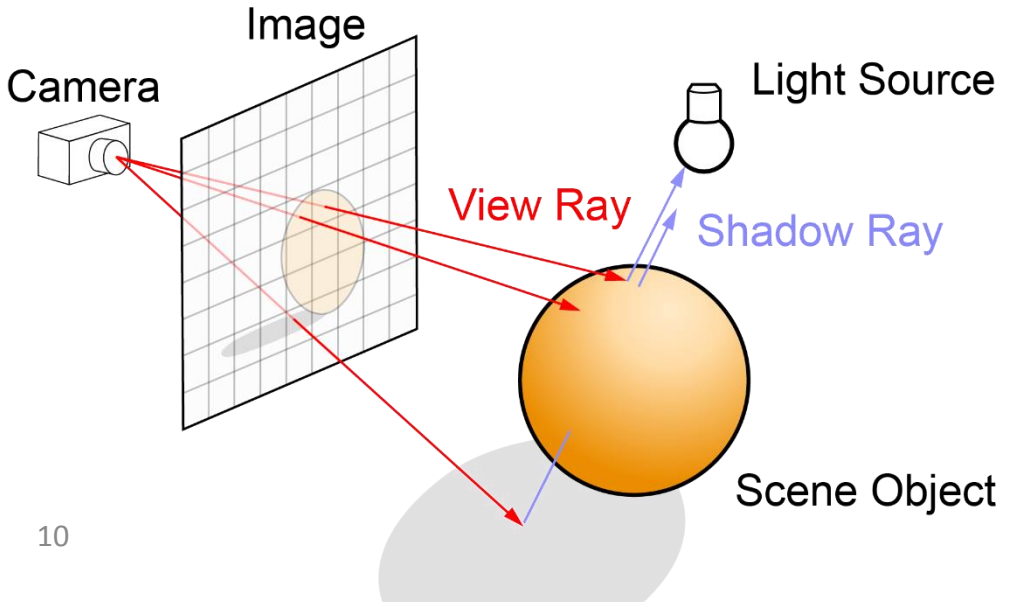
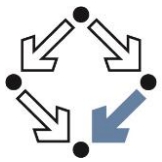
- Rasterization (OpenGL, DirectX)



- Ray tracing/casting



http://www.arcsynthesis.org/gltut/basics/Intro%20Graphics%20and%20Rendering.html
http://en.wikipedia.org/wiki/Ray_tracing_(graphics)#mediaviewer/File:Ray_trace_diagram.svg



Ray casting

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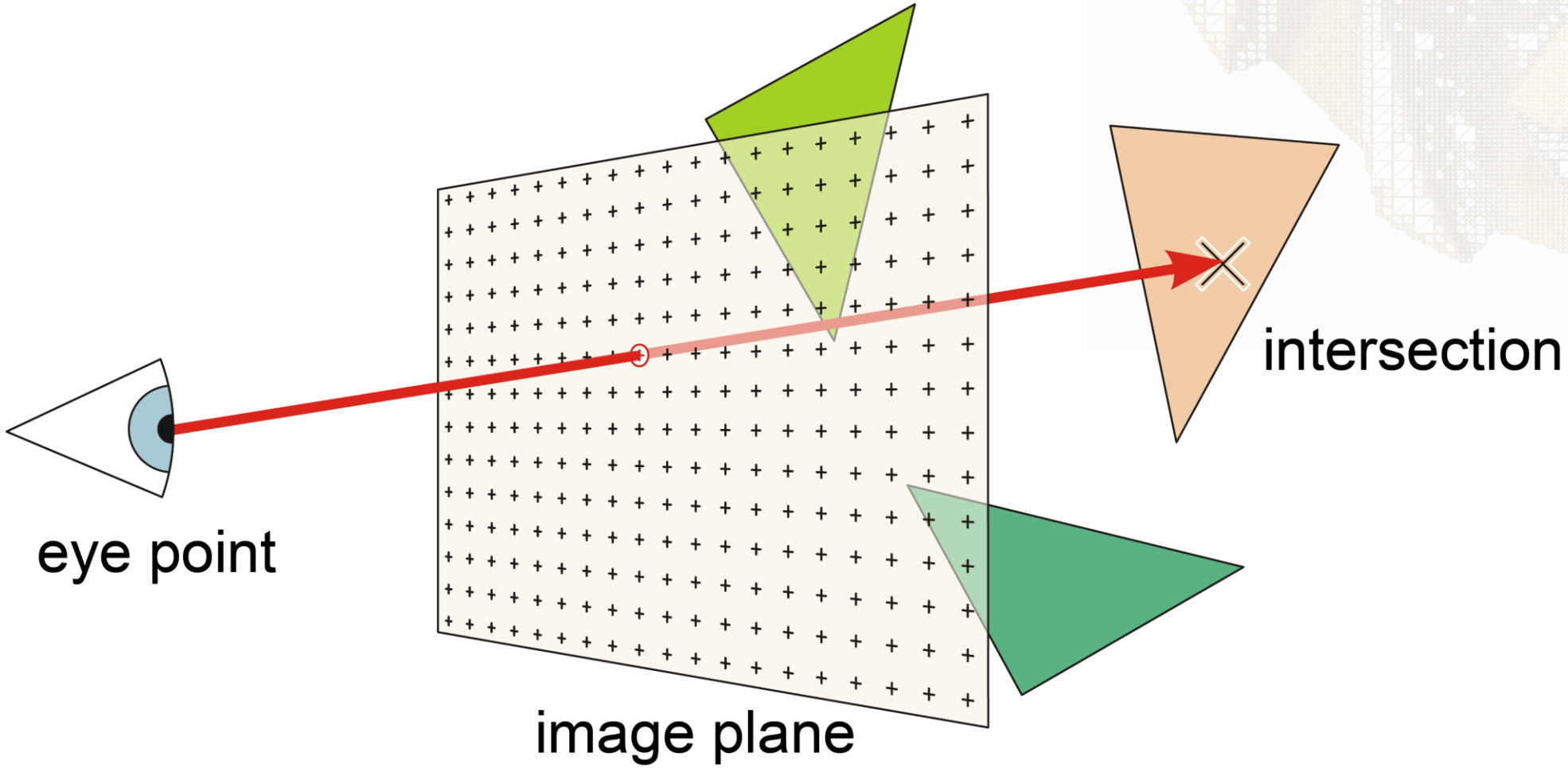
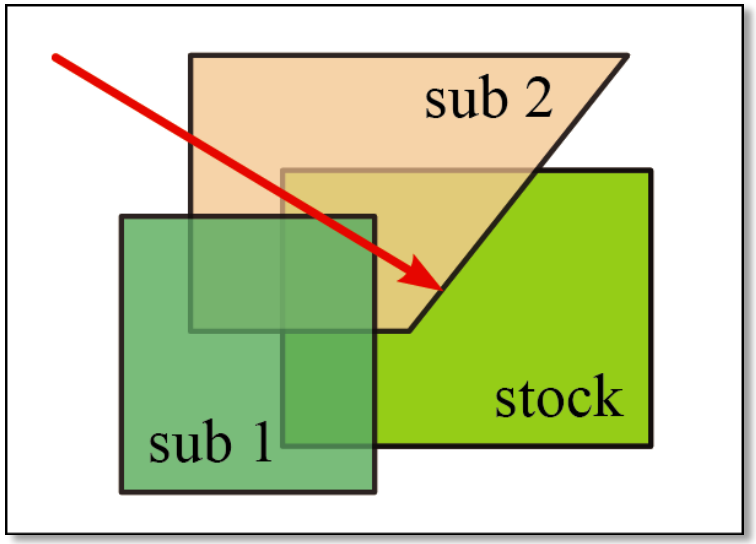
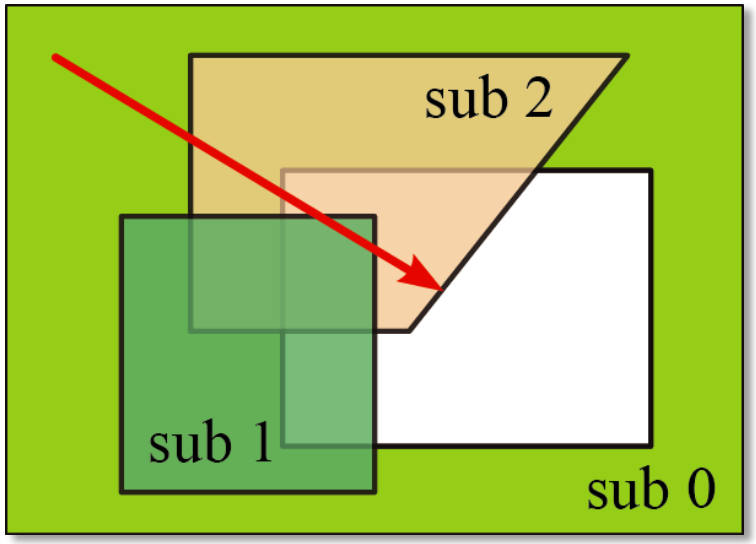
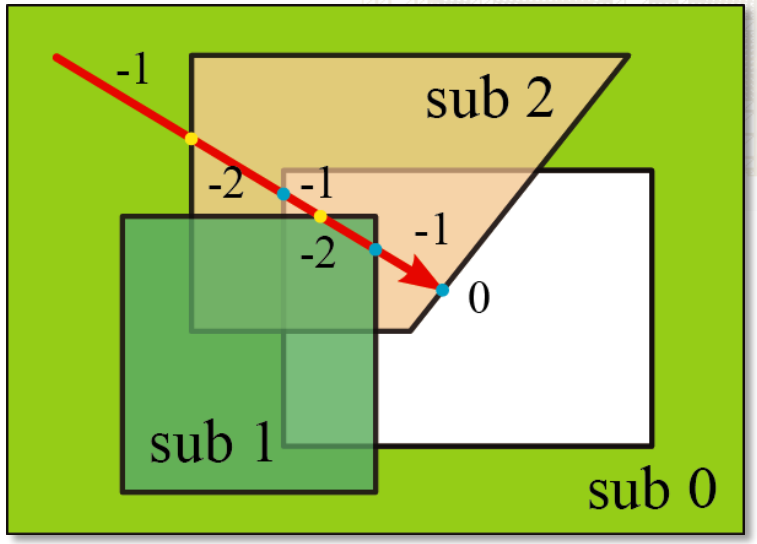


http://de.academic.ru/dic.nsf/dewiki/1163221

Swept volumes - entry/exit counting







Triangle ray intersection

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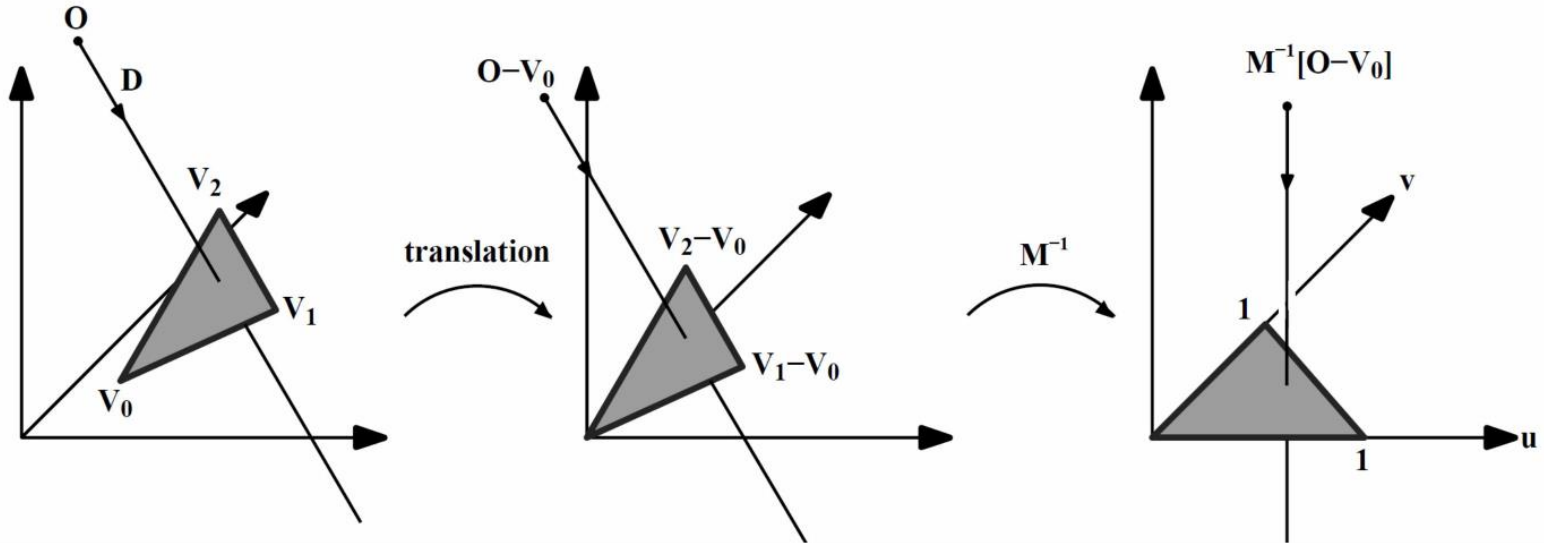
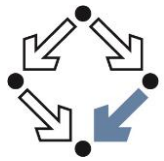
Fast, Minimum Storage Ray/Triangle Intersection, Möller & Trumbore, 1997



$$[-D, V_1 - V_0, V_2 - V_0] \begin{bmatrix} \mathbf{t} \\ u \\ v \end{bmatrix} = O - V_0$$

Image: Torsten Welsch



Ray casting result and coloring

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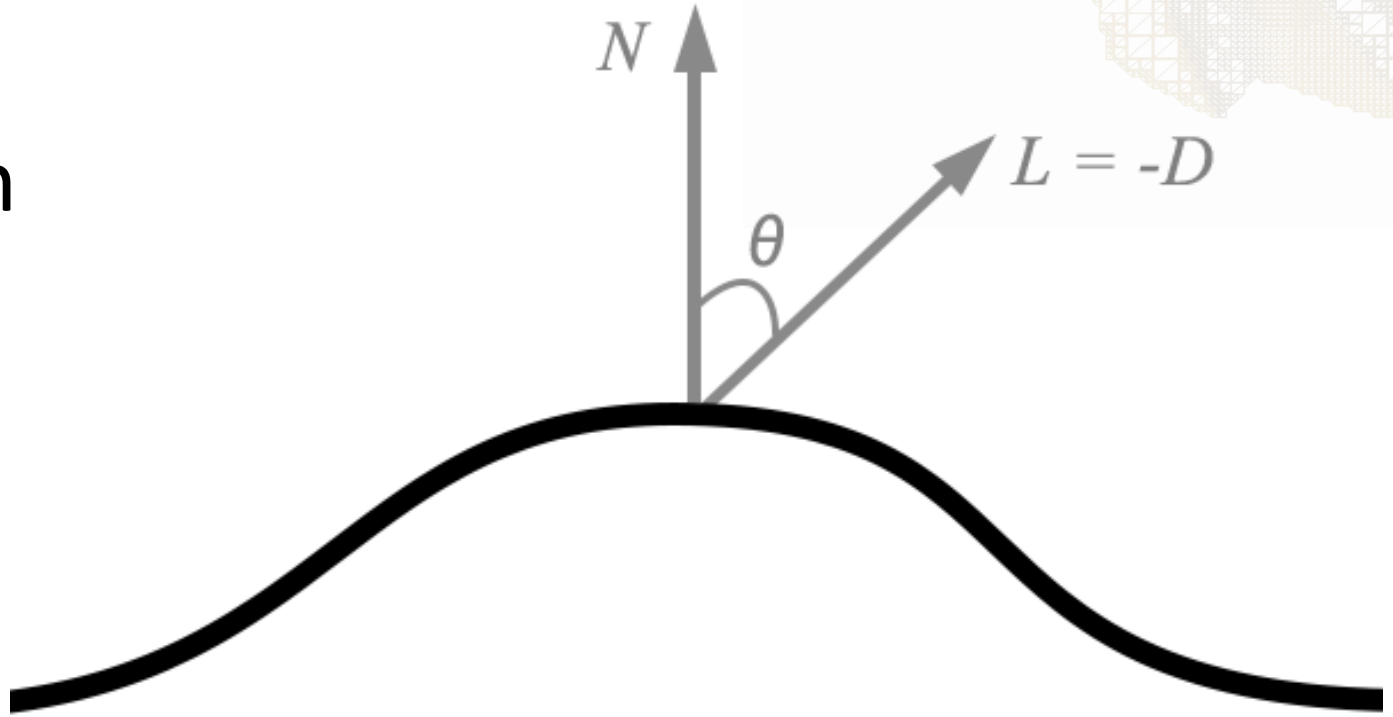
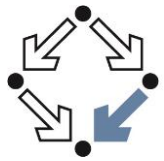
Per ray/pixel

- Distance/position
- Normal vector of hit triangle

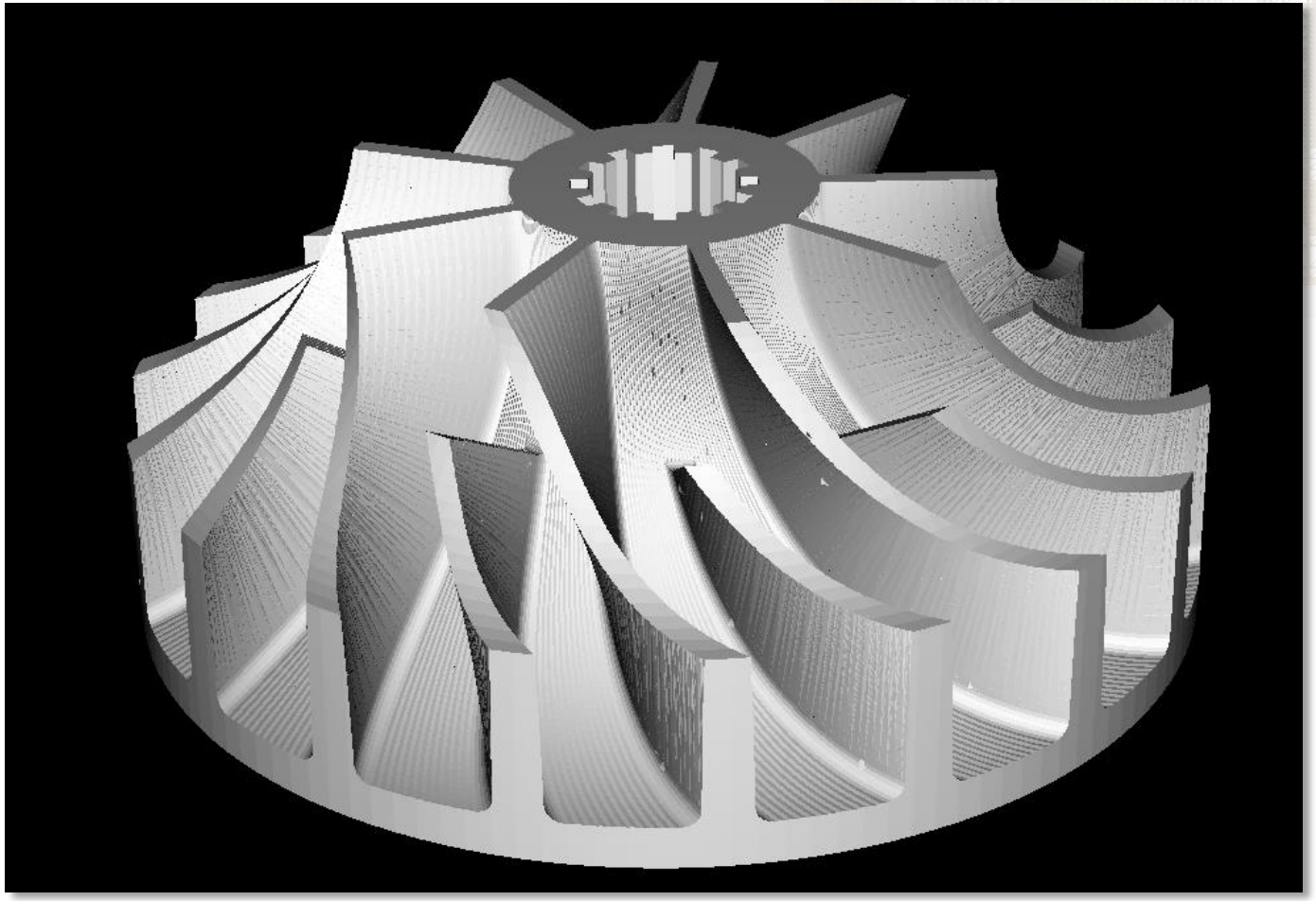


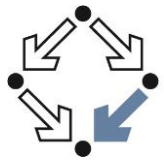
http://metalbyexample.com/up-and-running-3/



OpenGL integration - Composition

- Write calculated color values directly to frame buffer (glDrawPixels)
- Fast
- Color calculation entirely on CPU





OpenGL integration - Retriangulation

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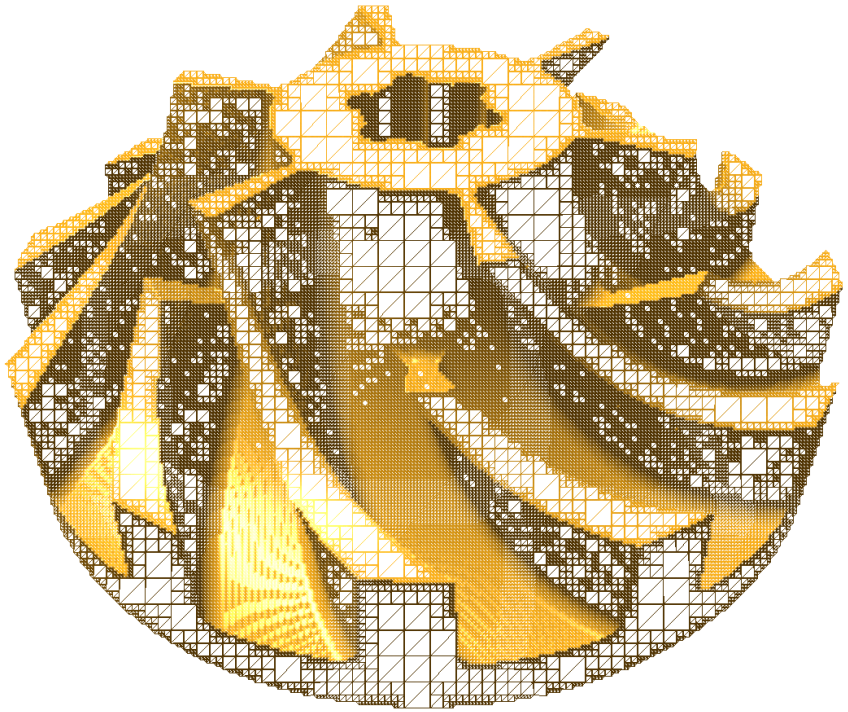
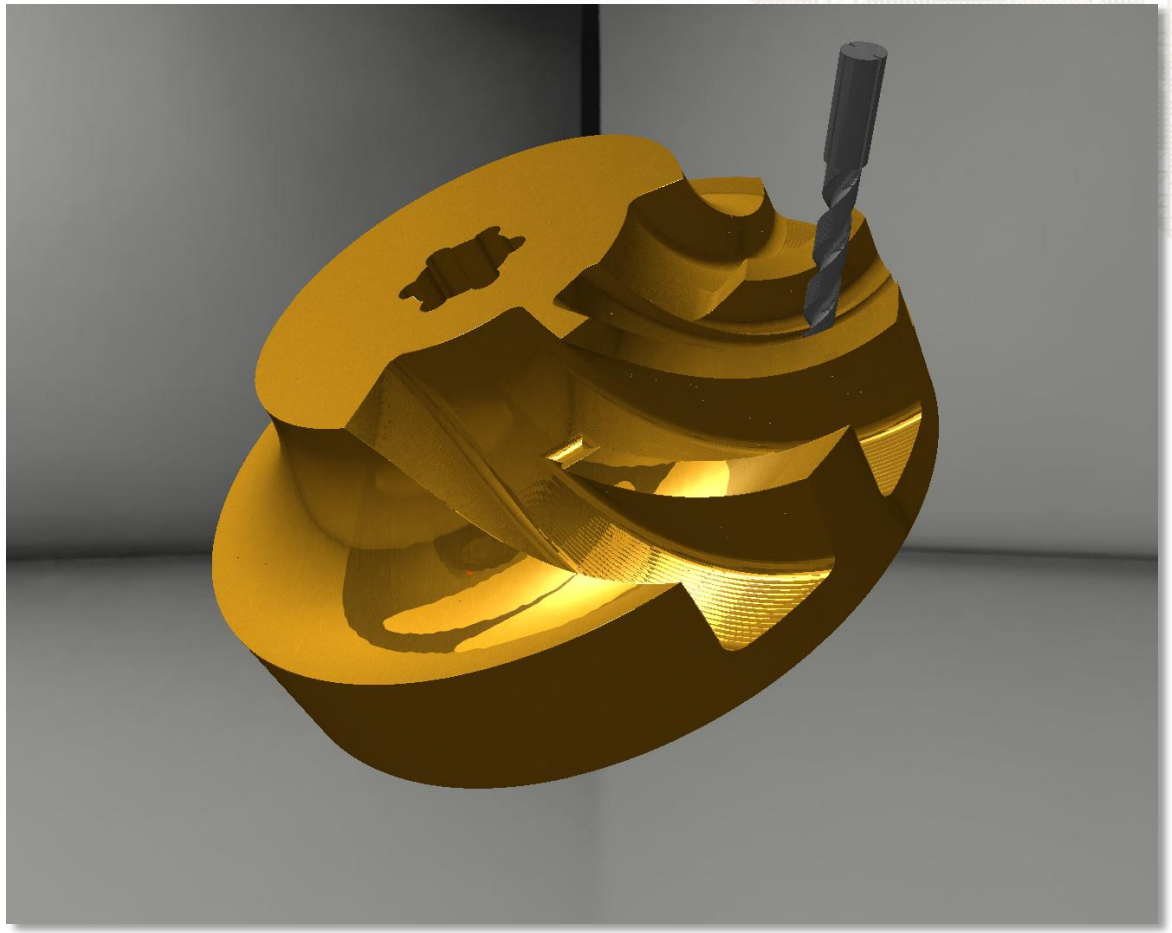
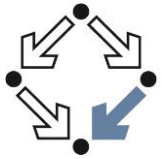
- Triangulation on CPU
- Full graphics pipeline on GPU







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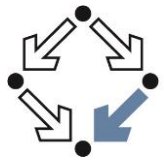
Optimization I

Reducing intersection tests



Acceleration structures

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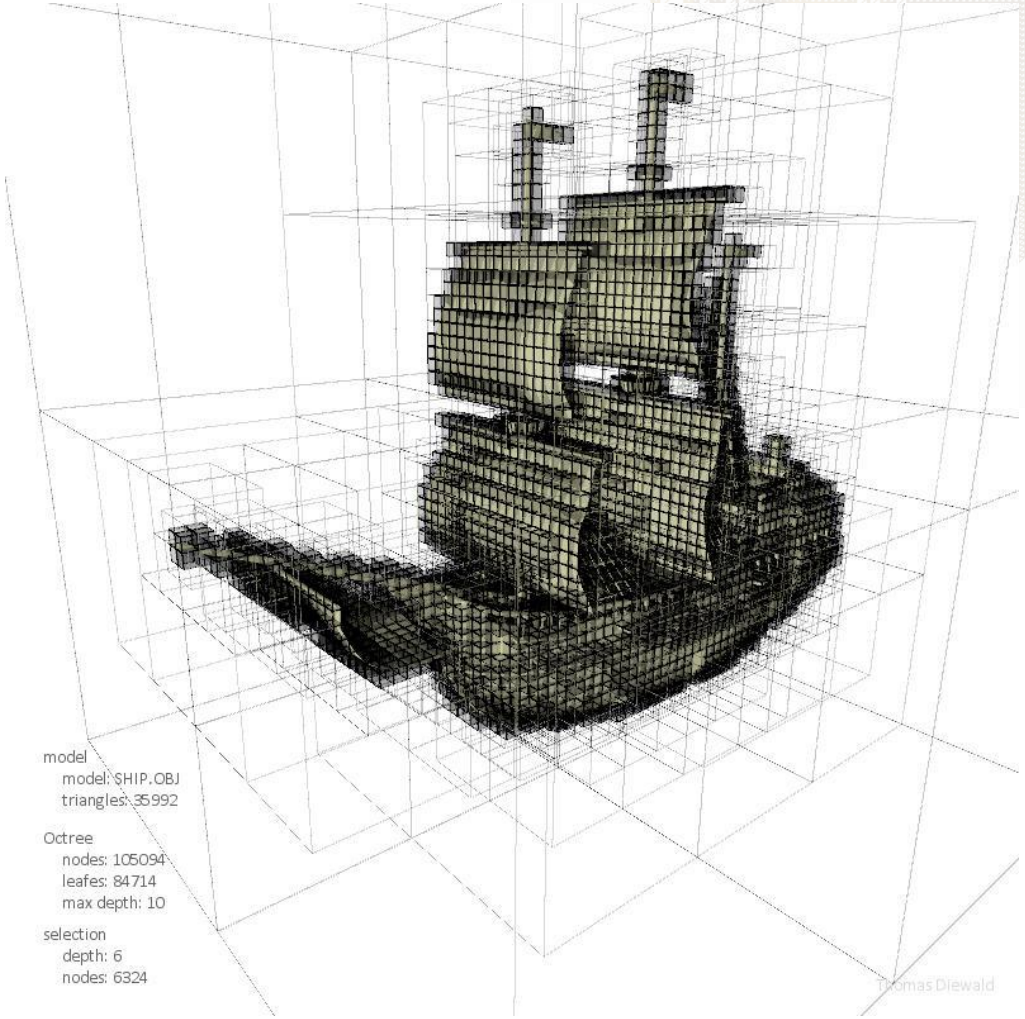
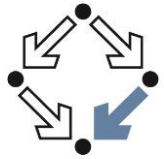
- Trees
  - K-d trees
  - Octrees
  - Bounding volume hierarchy
- Regular grids

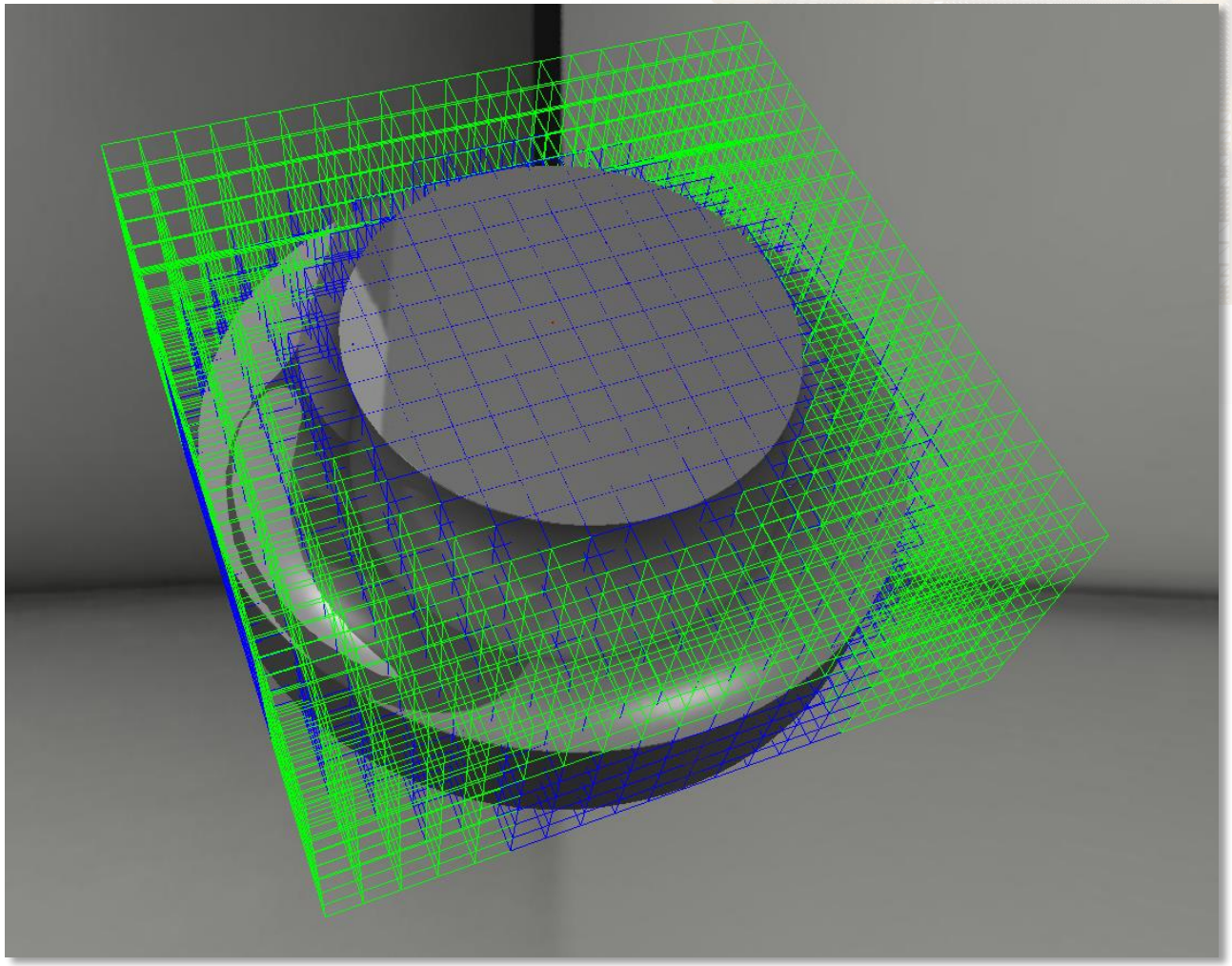


http://thomasdiewald.com/blog/?p=1488



Regular grid

- Simple
- Fast modifications



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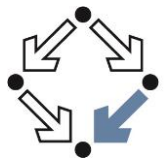
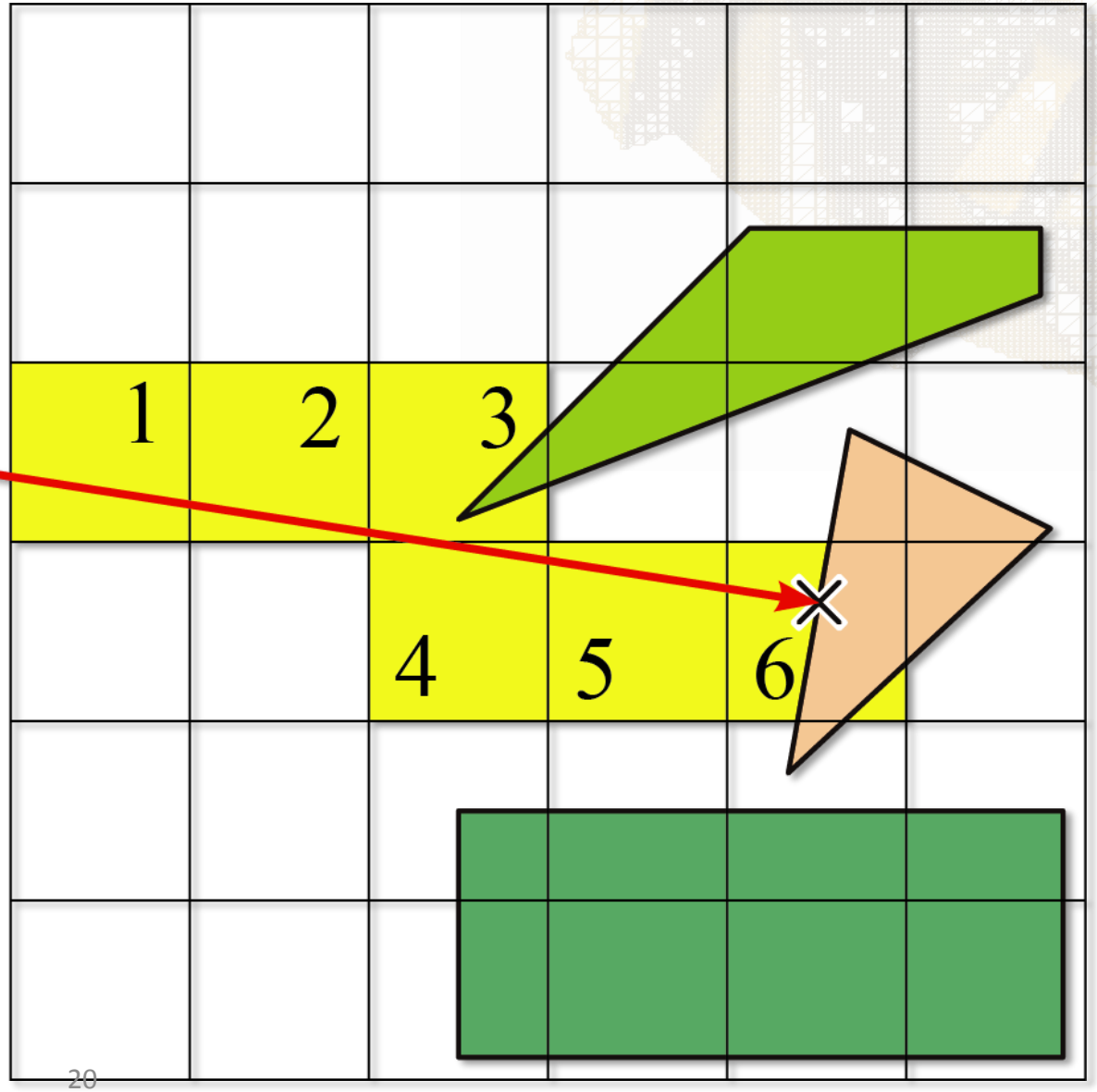


Traversal – 3D DDA

- A fast voxel traversal algorithm for ray tracing, John Amanatides and Andrew Woo, 1987



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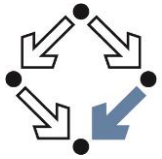
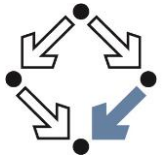
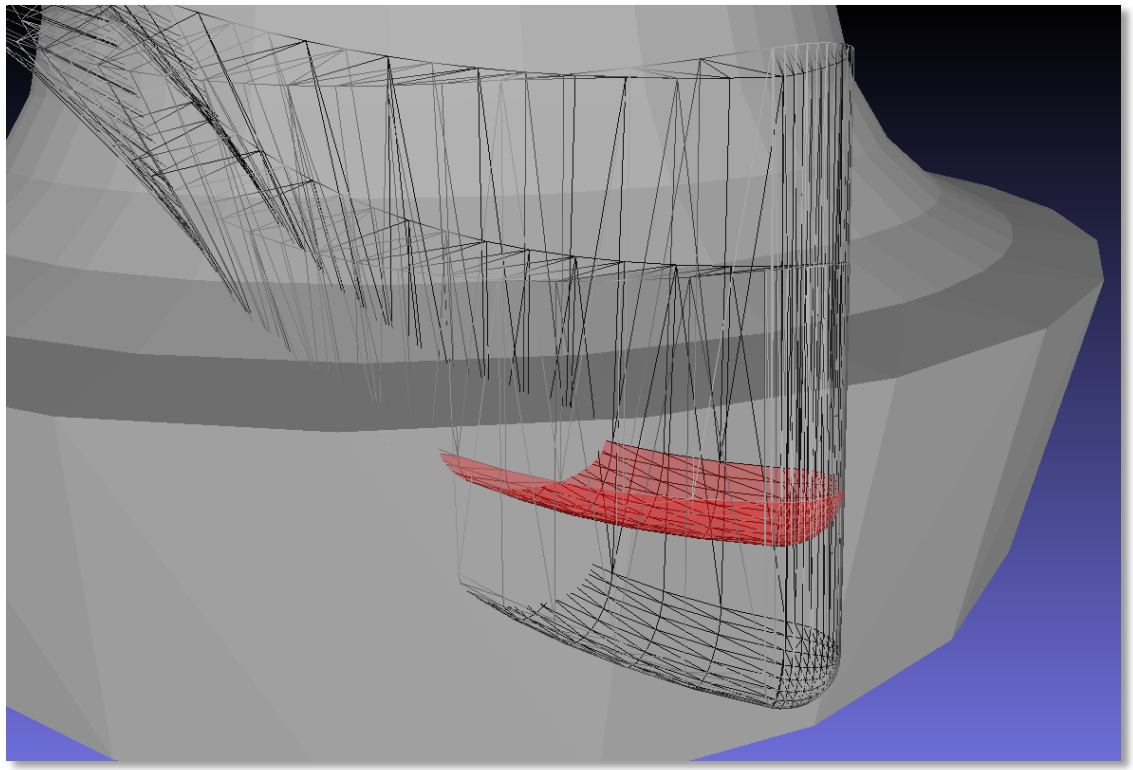


Optimization II

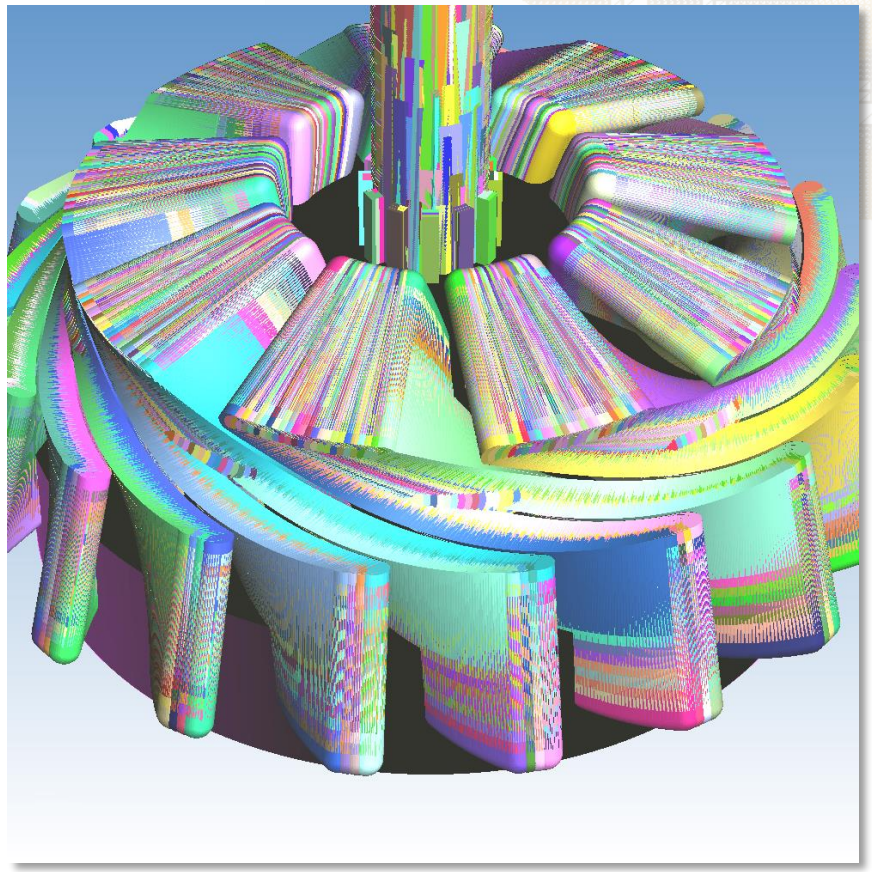
Reducing triangle count

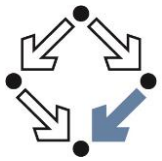


Optimizing triangle count

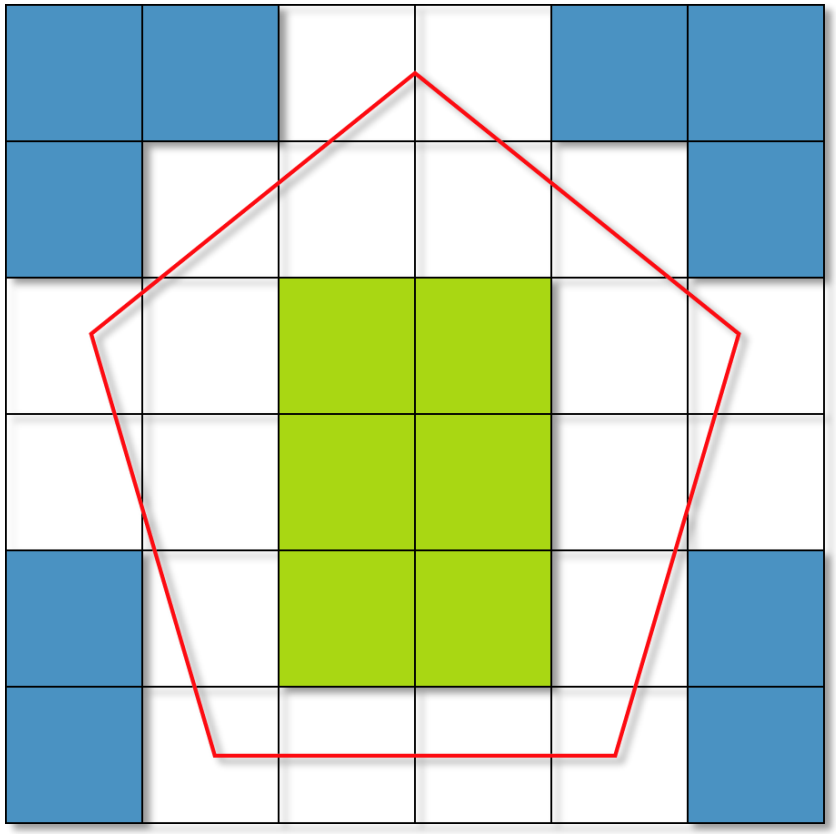


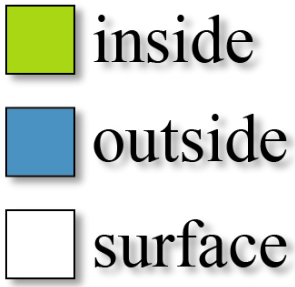
Screen shot of selected triangles in MeshLab

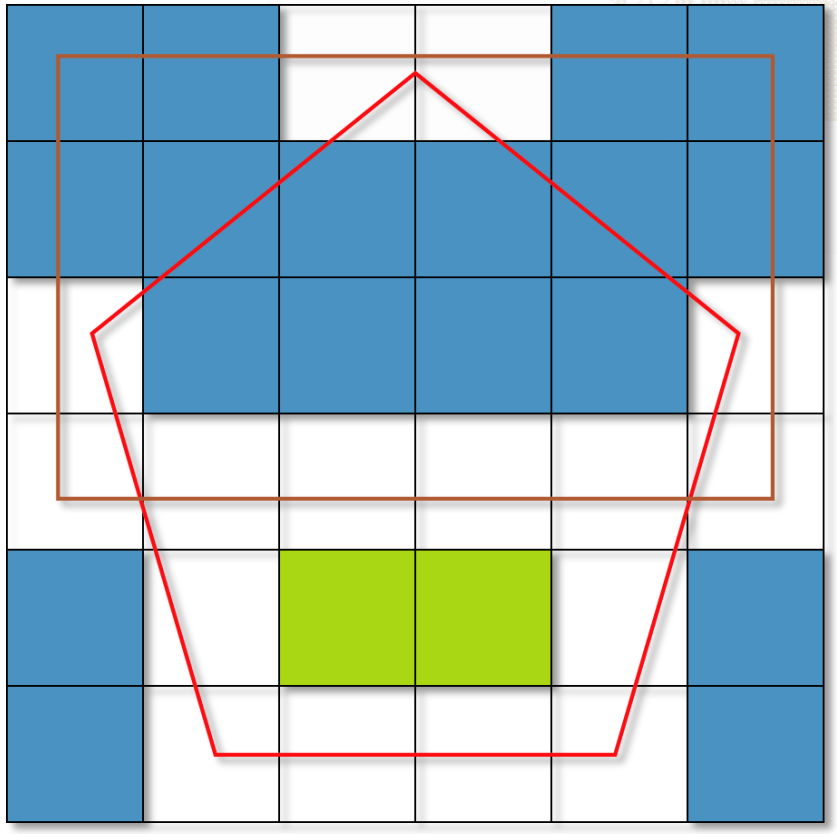




Cell classification







Open volumes

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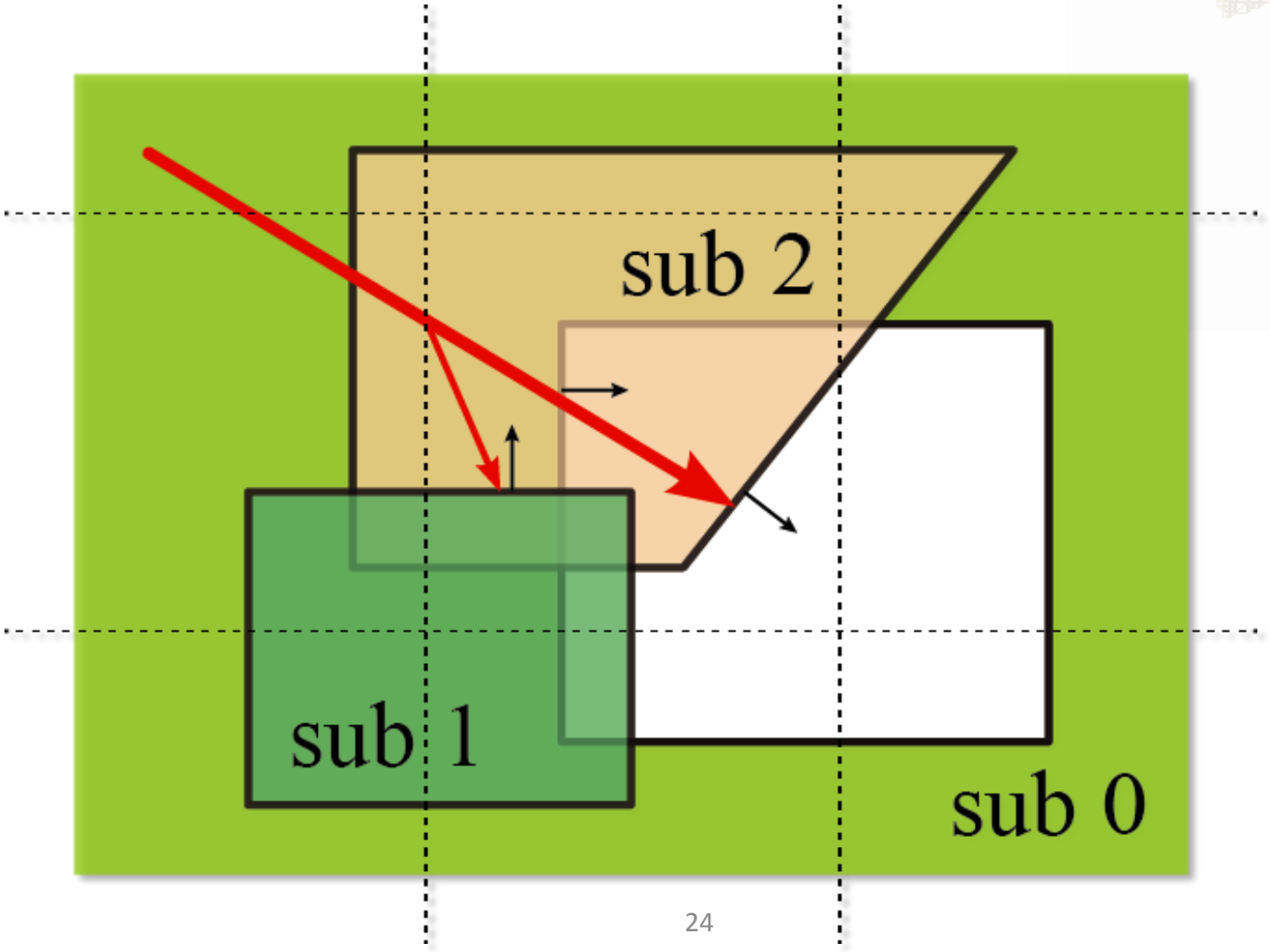

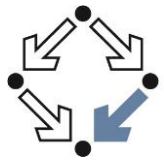

Triangle reduction

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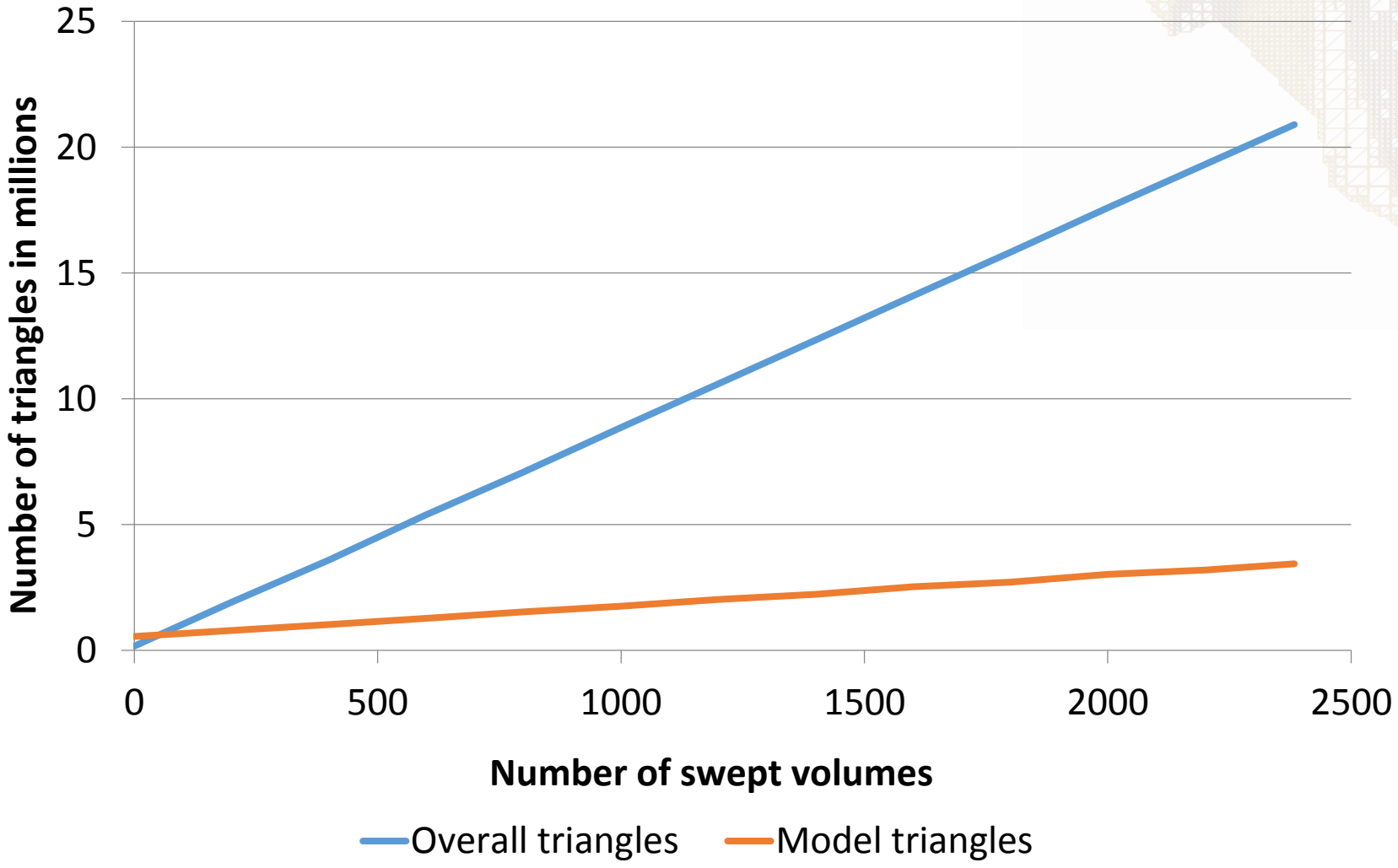

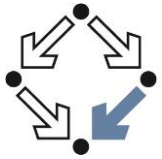

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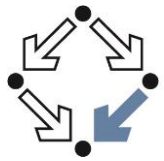
Optimization III

Hardware architecture



Vectorization and memory locality - Packets

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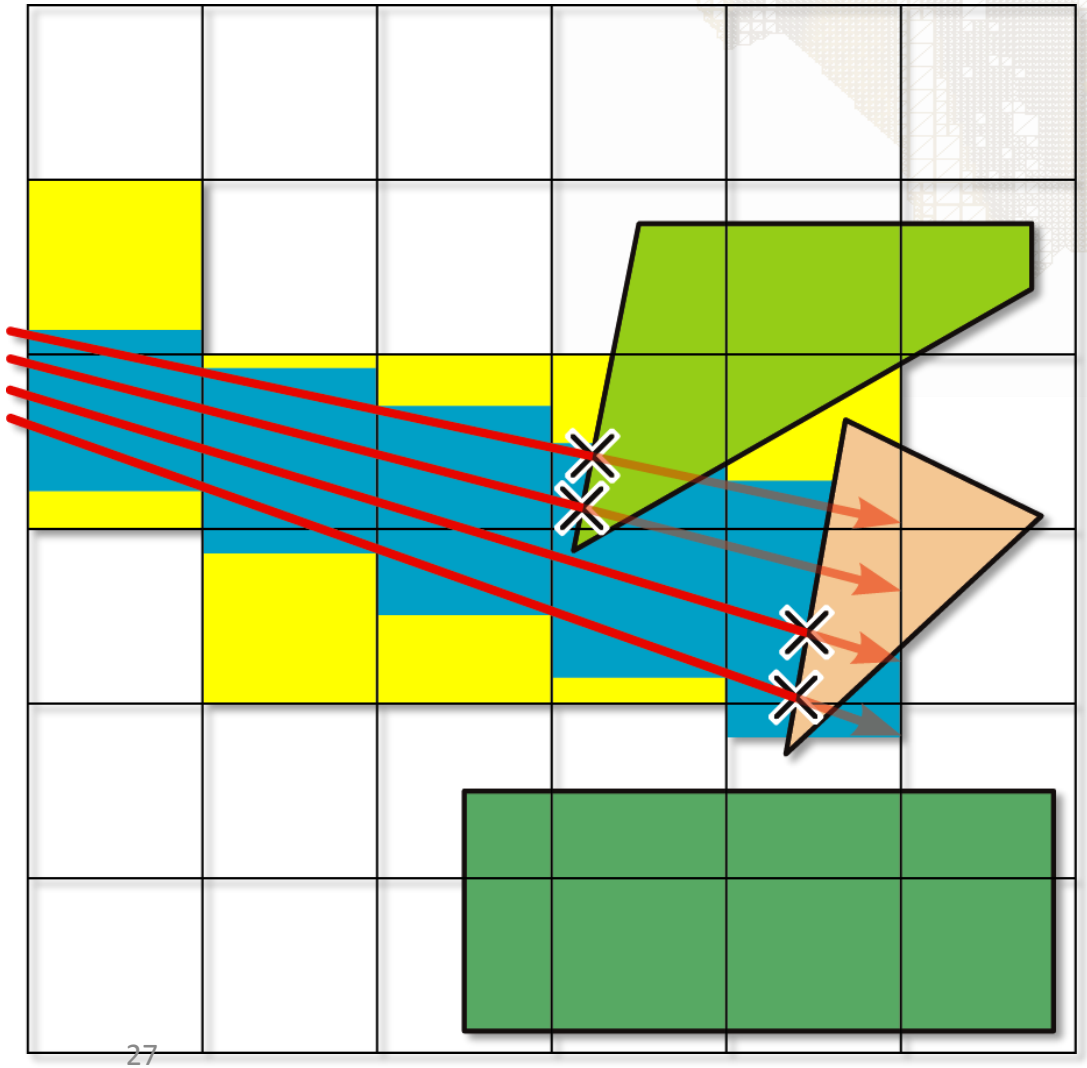
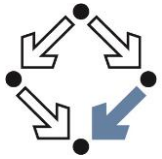
- Ray tracing animated scenes using coherent grid traversal,
  Ingo Wald et al., 2006





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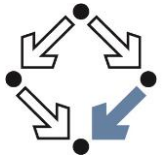
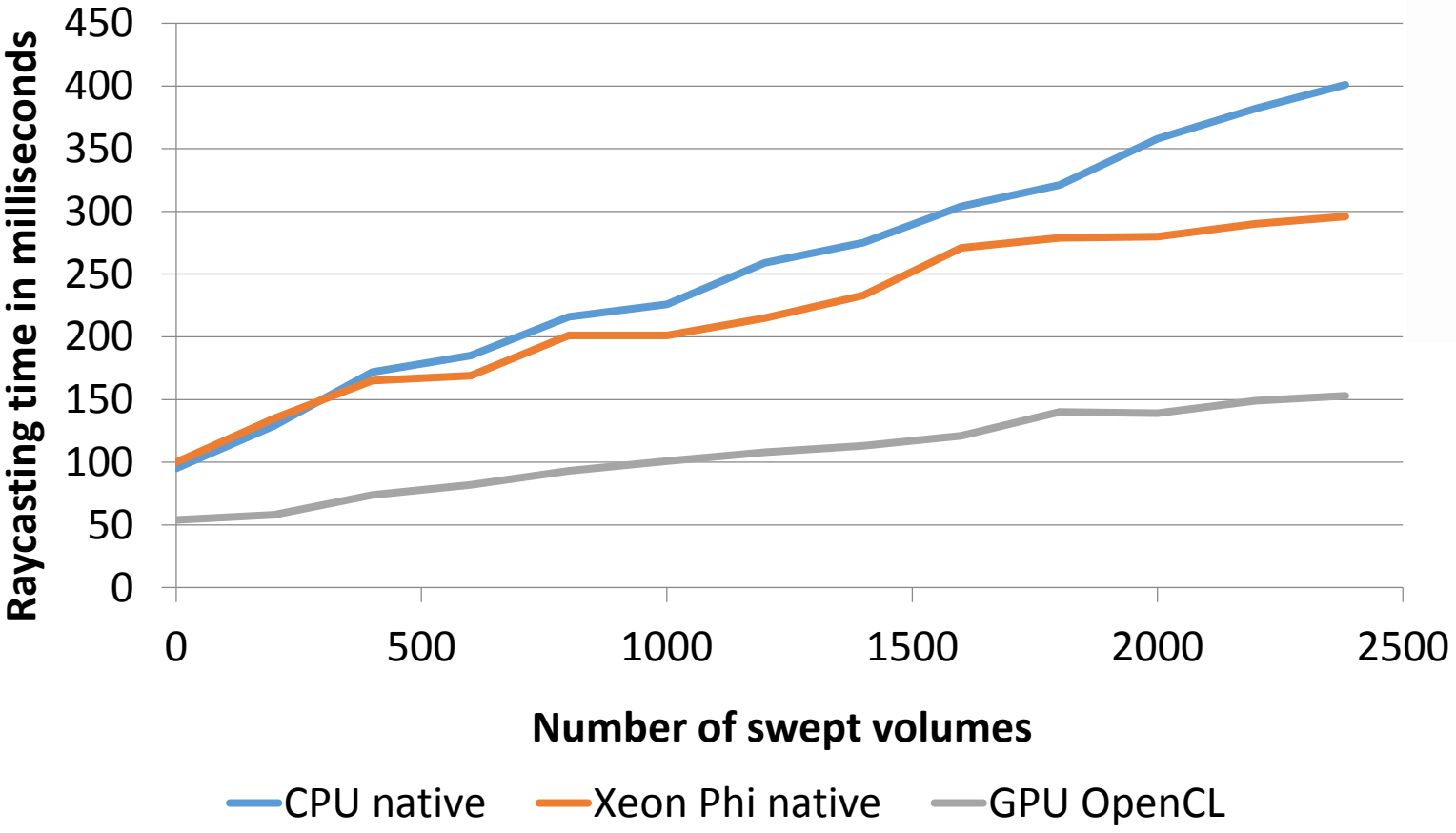
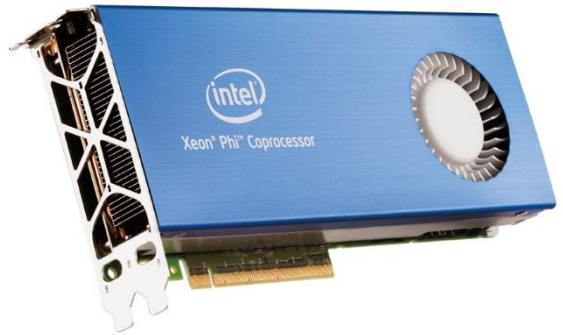
Results



Runtime benchmark





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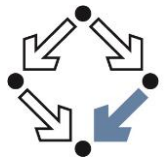
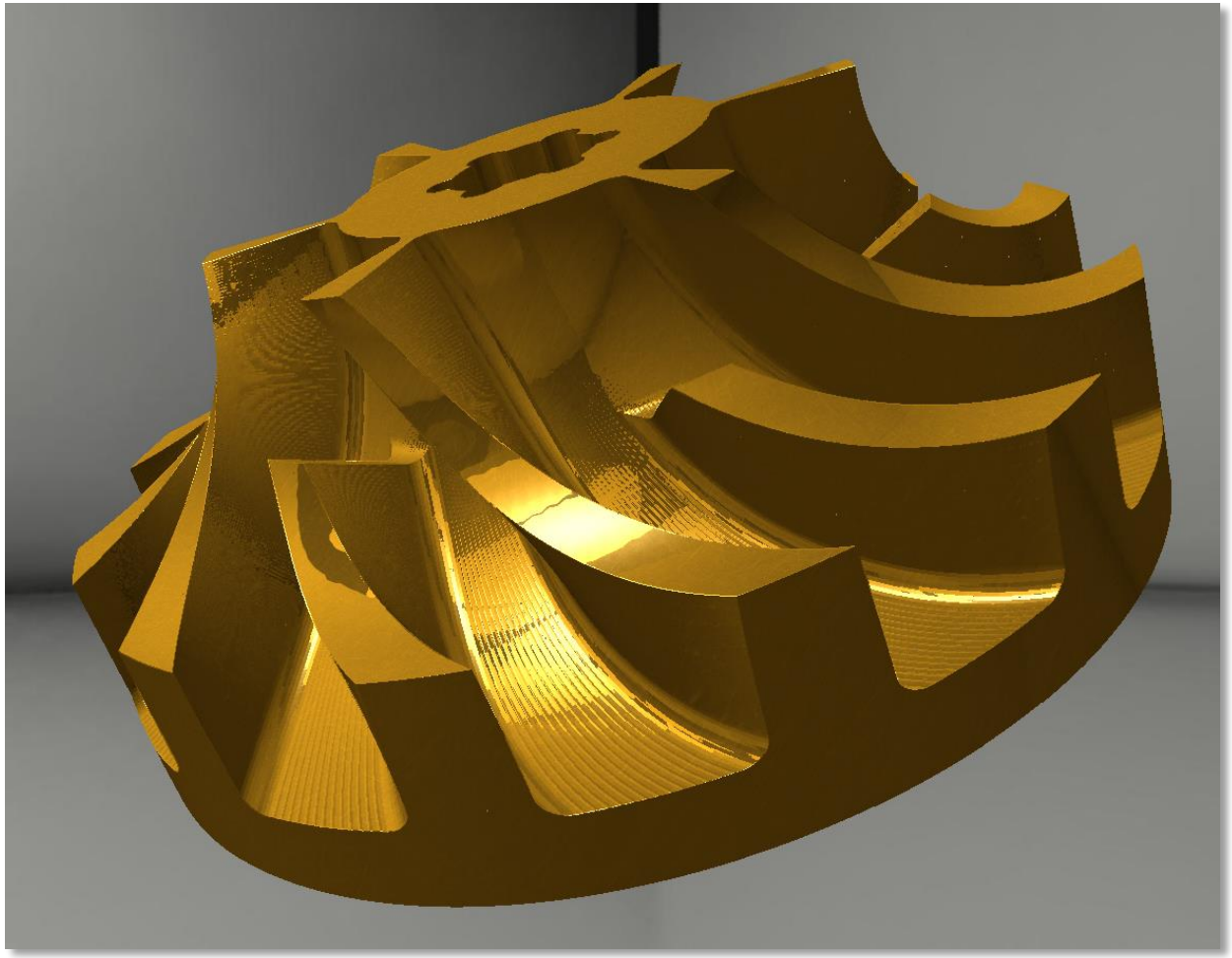
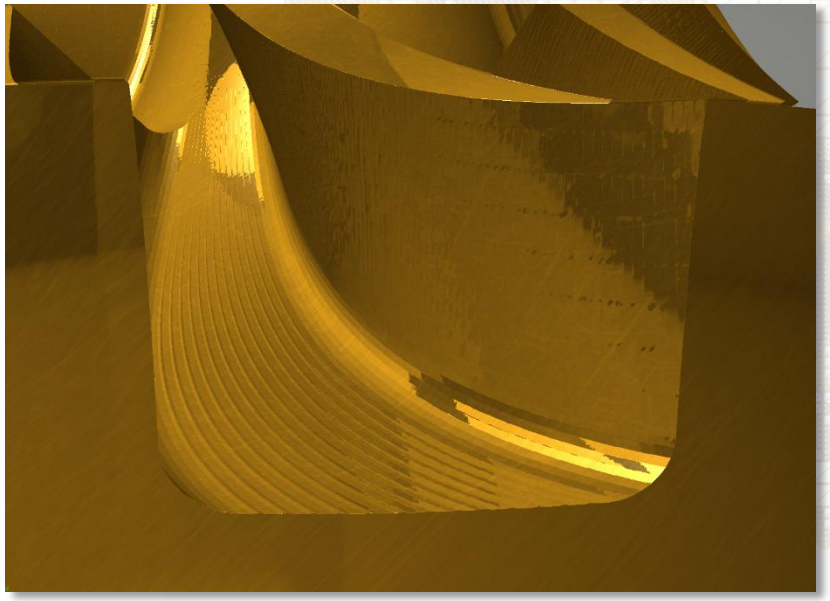
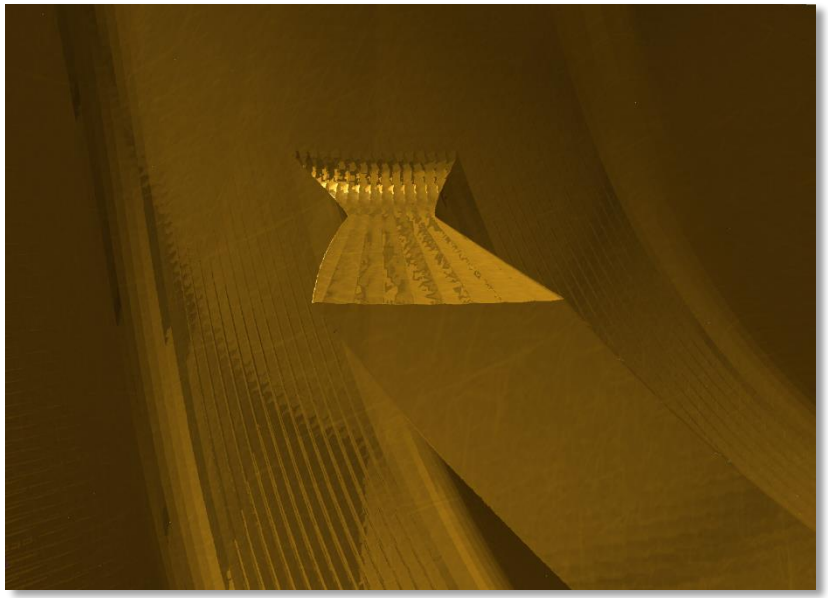
http://www.pcper.com/reviews/Mobile/Intel-Core-i7-3720QM-Ivy-Bridge-Mobile-Review-Monster-Kill
http://www.anandtech.com/show/6265/intels-xeon-phi-in-10-petaflops-supercomputer
http://www.bit-tech.net/hardware/graphics/2013/11/07/nvidia-gtx-780-ti-3gb-review/1



Visual quality







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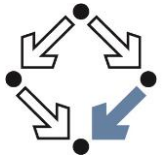

Master thesis

- "Detailed and adaptive surface reconstruction of implicitly defined geometries"
- Regular grid with swept volumes as input
- Will (hopefully) calculate exact surface as triangle mesh
- See you in December ;)

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