

Technische Universität München

BGCE Project: CAD – Integrated Topology Optimization

BGCE First Milestone Meeting

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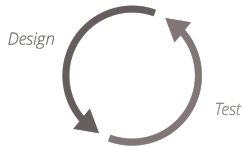
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Motivation

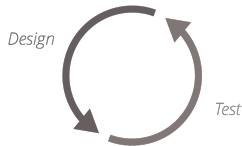
Current Design Process:



- Iterative and redundant
- Time consuming

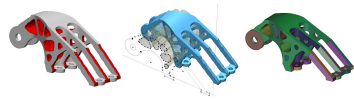
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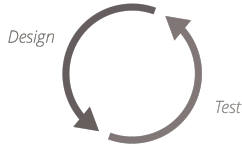
Topology optimization



- Promoted by additive manufacturing

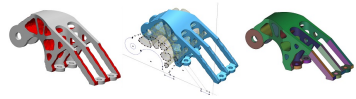
Motivation

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Topology optimization



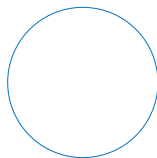
- Promoted by additive manufacturing

Focus:

Convert optimized geometry to **lightweight** and **scalable** CAD formats

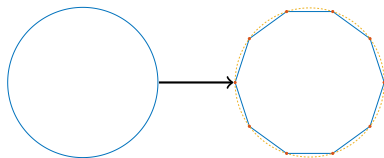
Workflow Overview

CAD design



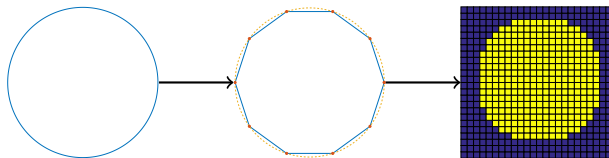
Workflow Overview

STL interface



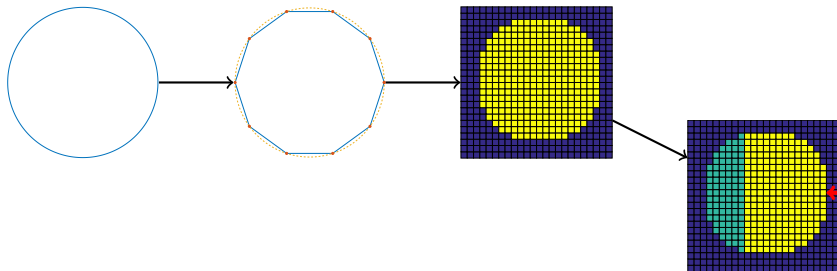
Workflow Overview

Voxelized topology



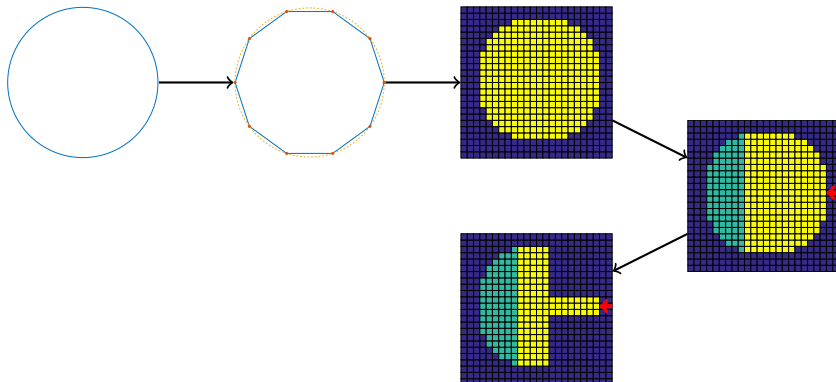
Workflow Overview

Specification of loads and fixtures



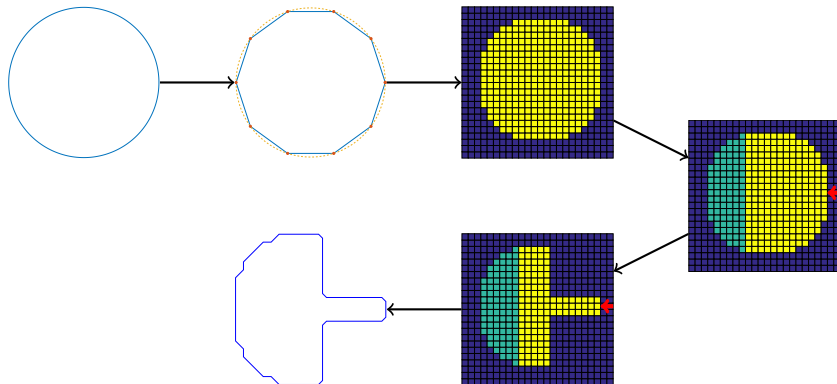
Workflow Overview

Optimized topology



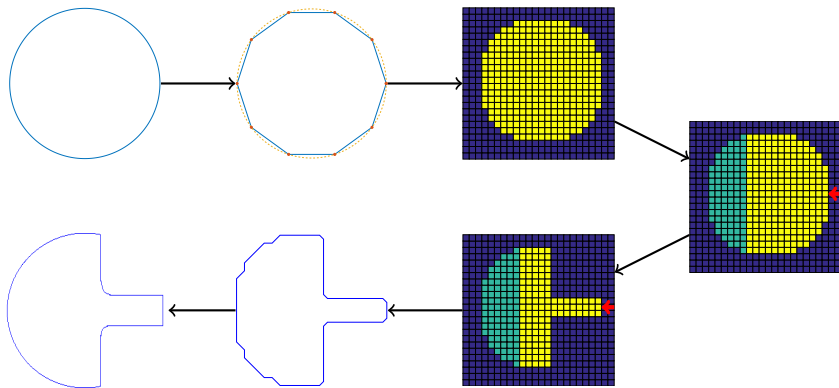
Workflow Overview

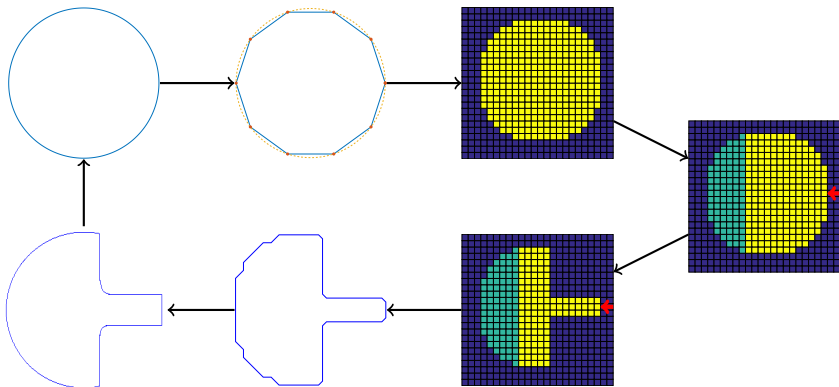
Surface extraction



Workflow Overview

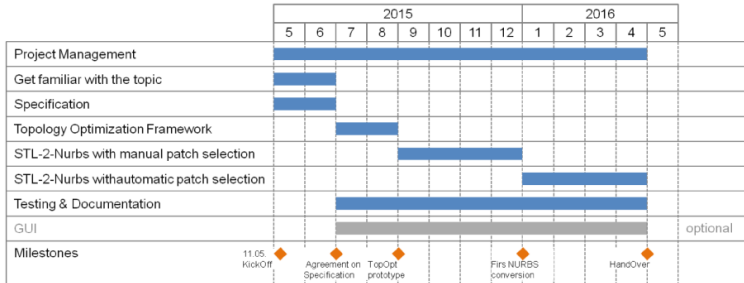
Parametrized CAD-geometries





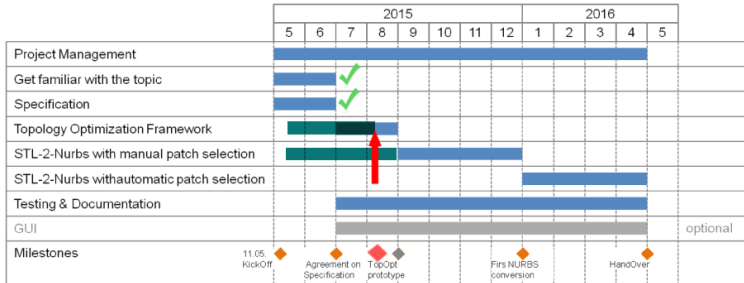
Schedule & Milestones

Schedule:



Schedule & Milestones

Schedule: (current)



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Status

Last milestone

- ✗ Automatic patch selection
- ✗ Parametrization of obtained patches
- ✓ B-spline fitting using least squares
- 🕒 Smooth connection of patches
- ✗ Conversion back to CAD

Today

- ✓ Automatic patch selection – moved to the surface extraction part
- ✓ Parametrization of obtained patches – moved to the surface extraction part
- ✓ B-spline fitting using least squares
- ✓ Smooth connection of patches
- ✗ Conversion back to CAD

Long way to smoothness

Peters' scheme:

Given the control mesh M_x

1. Refine the *control mesh* 2 times using Doo-Sabin refinement
2. Construct a tensor product Bezier patches (biquadratic or bicubic) centred on the each vertex of the refined *control mesh*

According to Peters obtained surface is G^1 smooth

Long way to smoothness

- Use the mesh obtained from Dual Contouring as a *control mesh*
- Modify the fitting step to take advantage of the **Peters' scheme**



$$E_{dist}(V_x) = \sum_{i=1}^N \| p_i - y_i V_x \|_2^2 \rightarrow \min \quad (1)$$

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What is done?

- First part of the pipeline from CAD model to optimized voxel model:
 - ✓ CAD to STL with e.g. FreeCAD
 - ✓ STL to Voxels with CVMLCPP
 - ✓ Voxels to ToPy input with custom script
 - ✓ Topology optimized geometry with ToPy
 - ⌚ Surface reconstruction with VTKToolbox
- B-spline fitting
 - ✗ Automatic patch selection
 - ✗ Parametrization of obtained patches
 - ✓ B-spline fitting using least squares
 - ⌚ Smooth connection of patches
 - ✗ Conversion back to CAD

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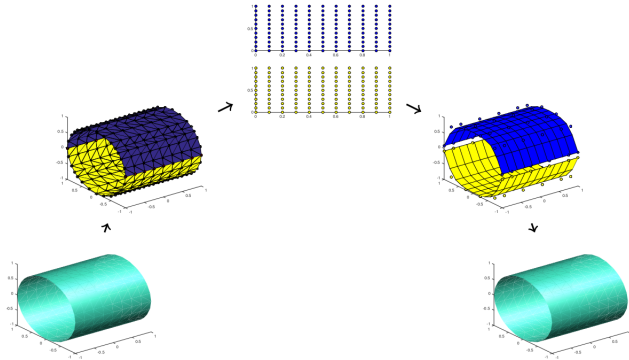
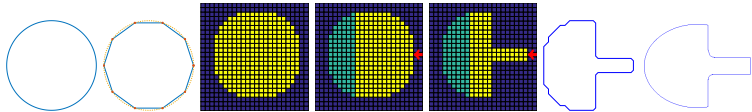
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What is next?

- Automation of the first part of the pipeline
- Integration of boundary conditions handling
- Implementation of remaining B-spline fitting steps (based on work of M.Eck & H.Hoppe)
- Further research on algorithms considering voxel geometry

Thank you for your attention!



Literature

- **William Hunter.** "Predominantly solid-void three-dimensional topology optimisation using open source software"
- **Gerrit Becker, Michael Schäfer, Antony Jameson.** "An advanced NURBS fitting procedure for post-processing of grid-based shape optimizations"
- **Matthias Eck, Hugues Hoppe.** "Automatic Reconstruction of B-Spline Surfaces of Arbitrary Topological Type"