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Meshing CAD Models Tolerantly Via Reduction Operations

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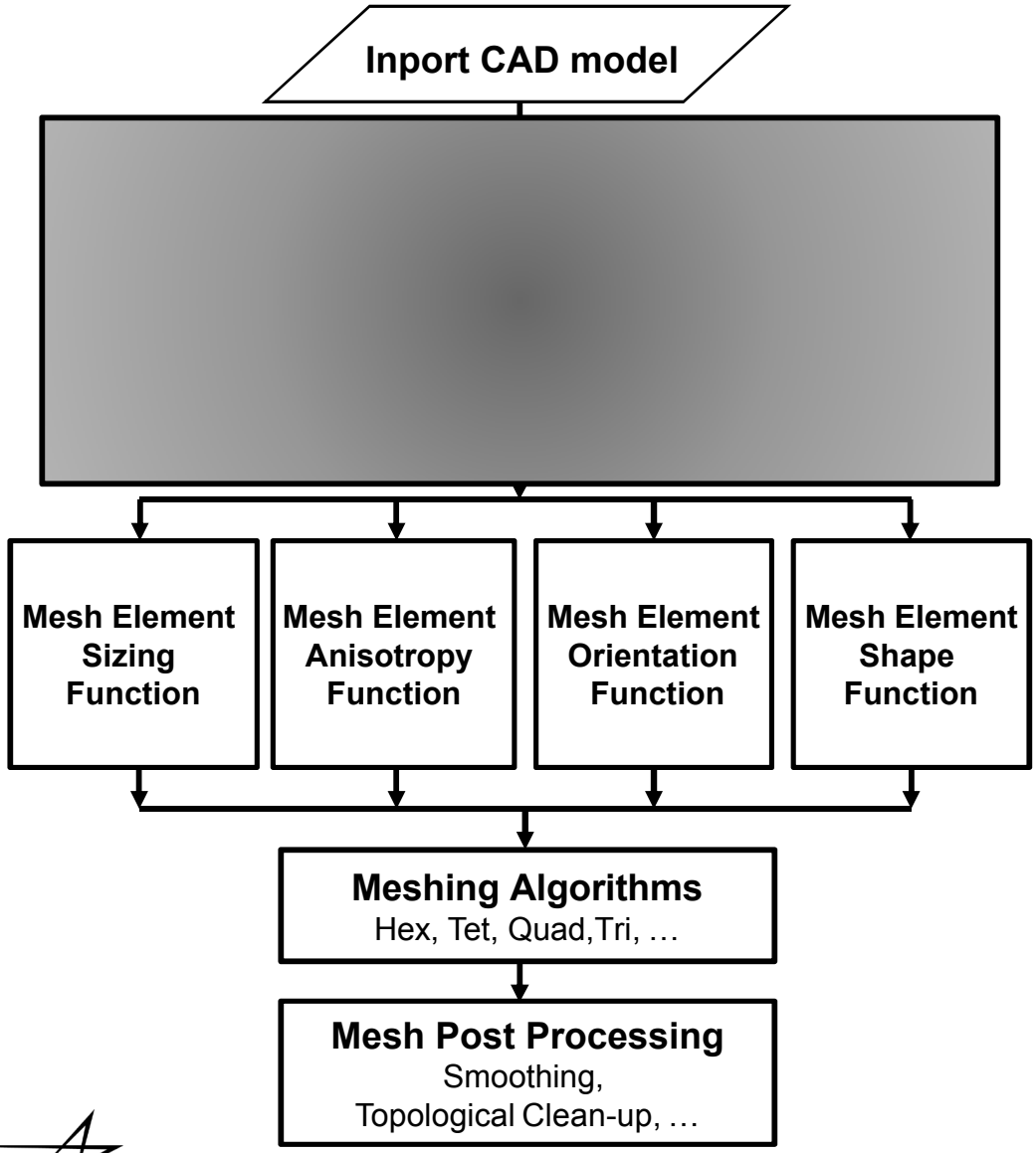
Computer Simulation Infrastructure

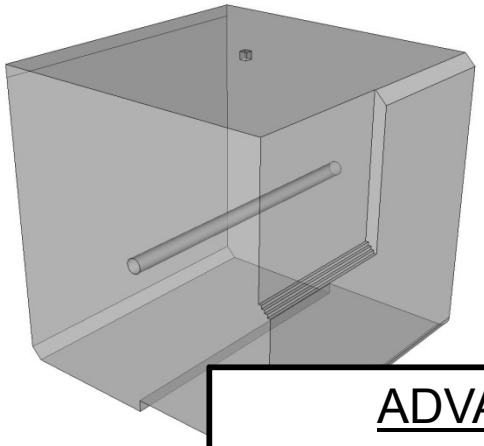
Sandia National Laboratories

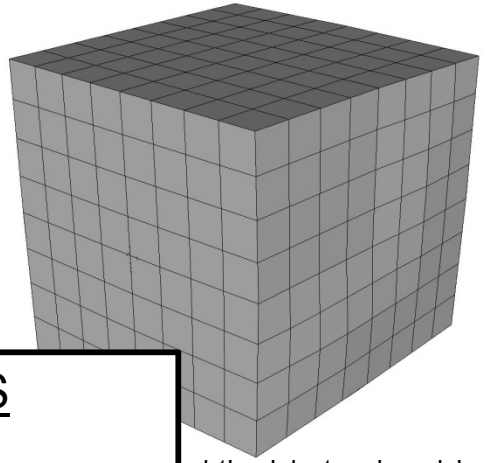
Meshing Technology

GOAL: To automate CAD repair, CAD defeature, and CAD imprint & merge under one geometry tolerant framework



Why is Defeaturing Critical?



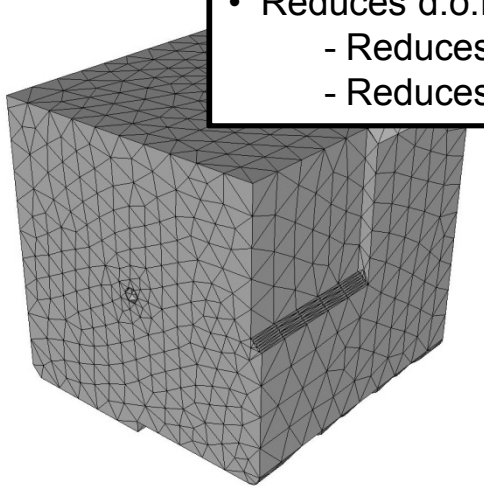


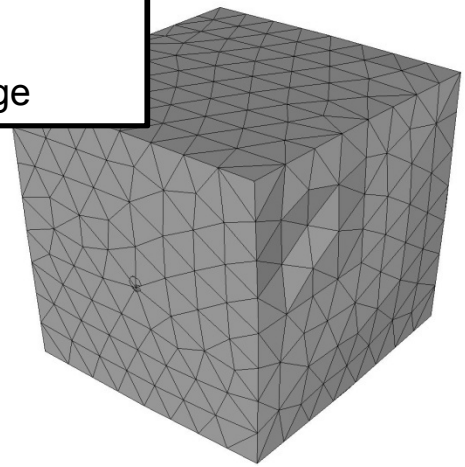
(a) CAD model with c

of the defeatured model

ADVANTAGES

- Reduces user time
- Improves meshing success ratio
- Reduces d.o.f.
  - Reduces analysis time
  - Reduces memory usage



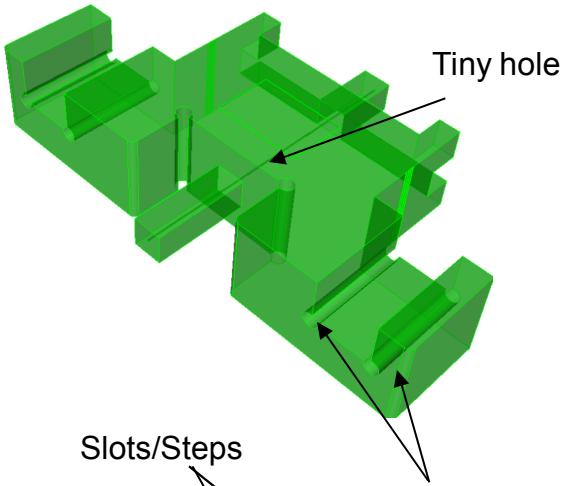


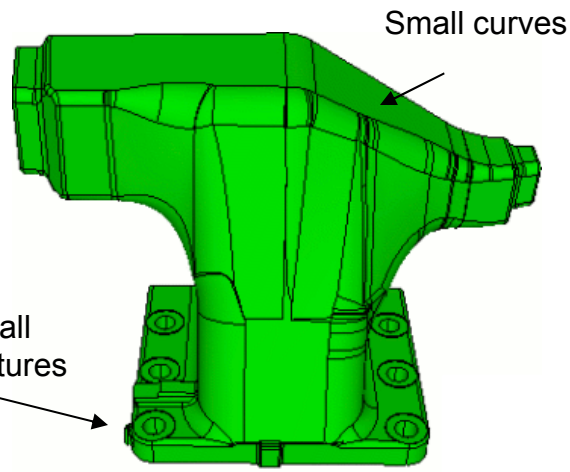
(c) Tet mesh on original model
(27,181 tets; average quality 0.8411)

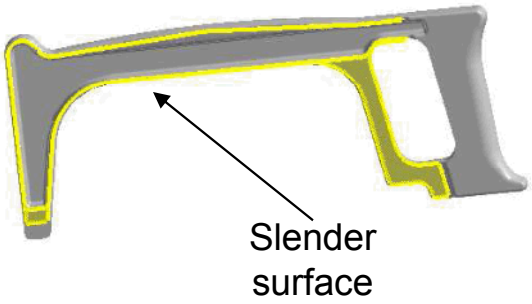
(d) Tet mesh on defeatured model
(3,879 tets; average quality 0.8615)

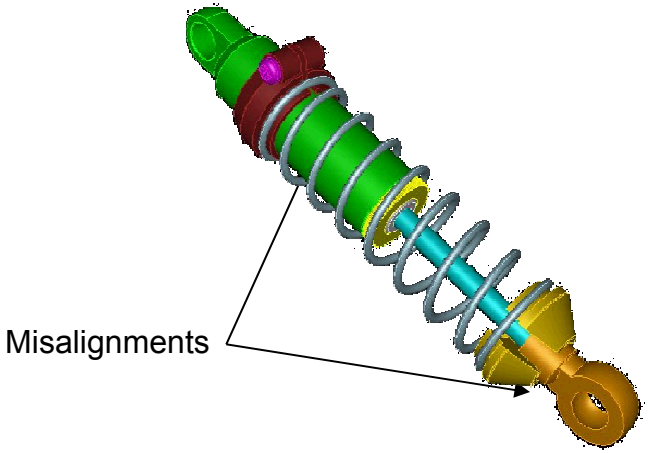
Factors Affecting Defeaturing

- **Mesh Scheme**
- **Mesh Sizing Function**
  - Physics of the problem
  - User-specified boundary conditions
  - Geometric Factors

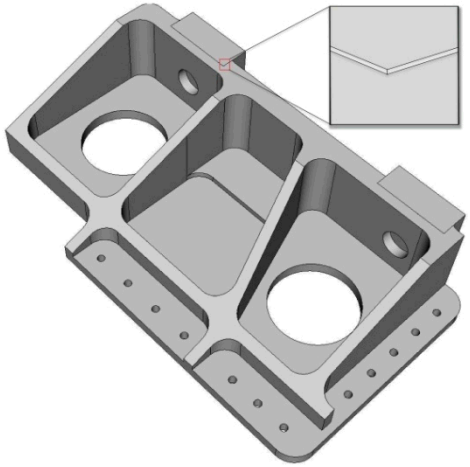




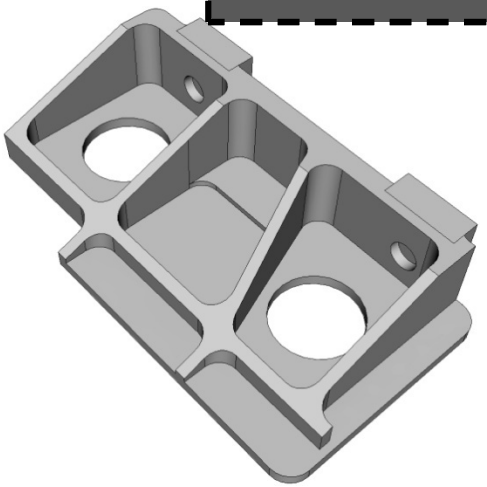




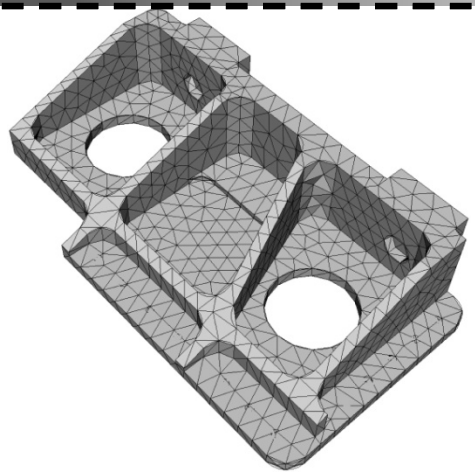
Overview of Geometry Tolerant Framework



(a) Original CAD Model

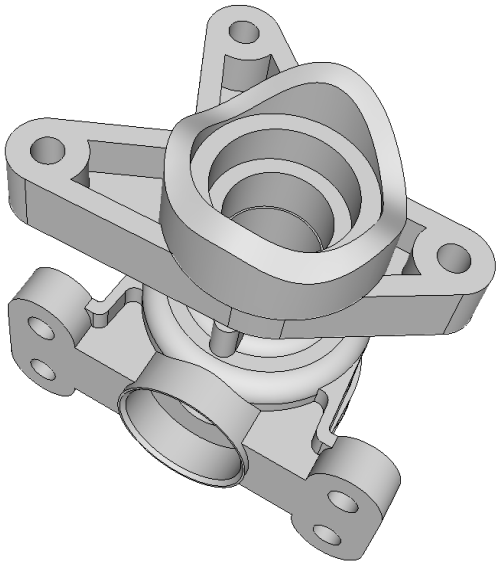


(d) Defeatured CAD Model

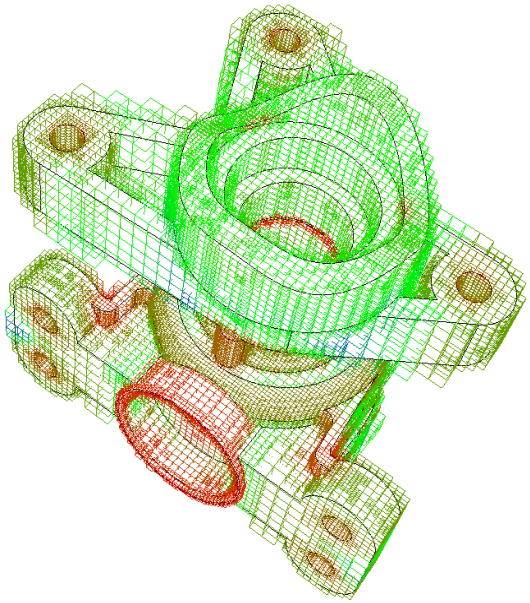


(e) Mesh on Defeatured Model

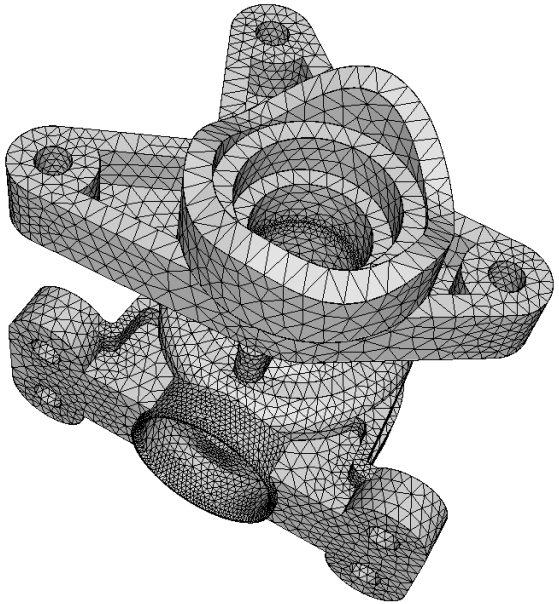
Detect Regions Via Geometric Factors



(a) Input CAD Model



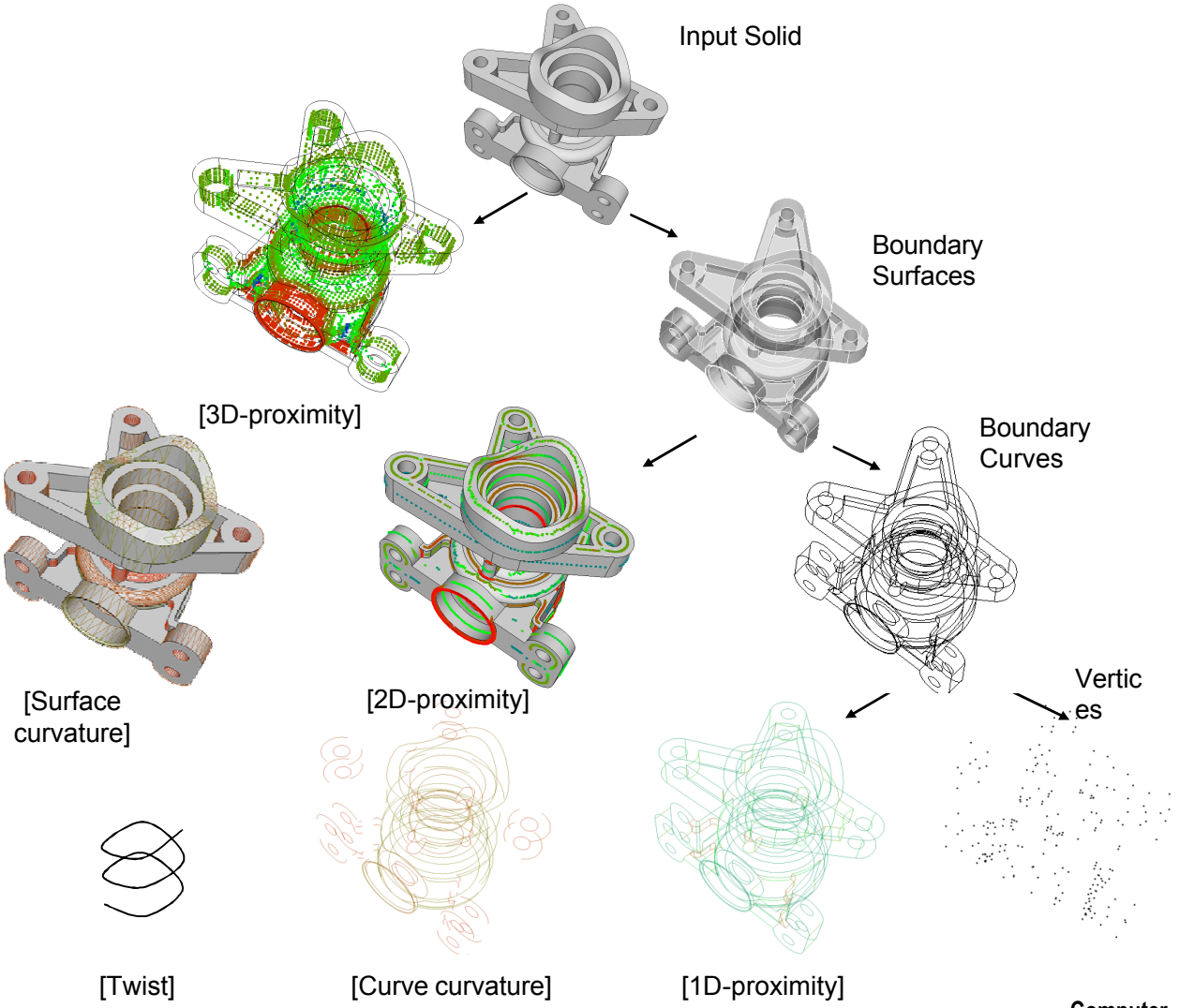
(b) Geometry-based size field



(c) Geometry-adaptive mesh

- Detect regions where the geometry-based mesh size goes below a user specified threshold value
- Evaluate the size field value using geometric factors to mark the facet entities

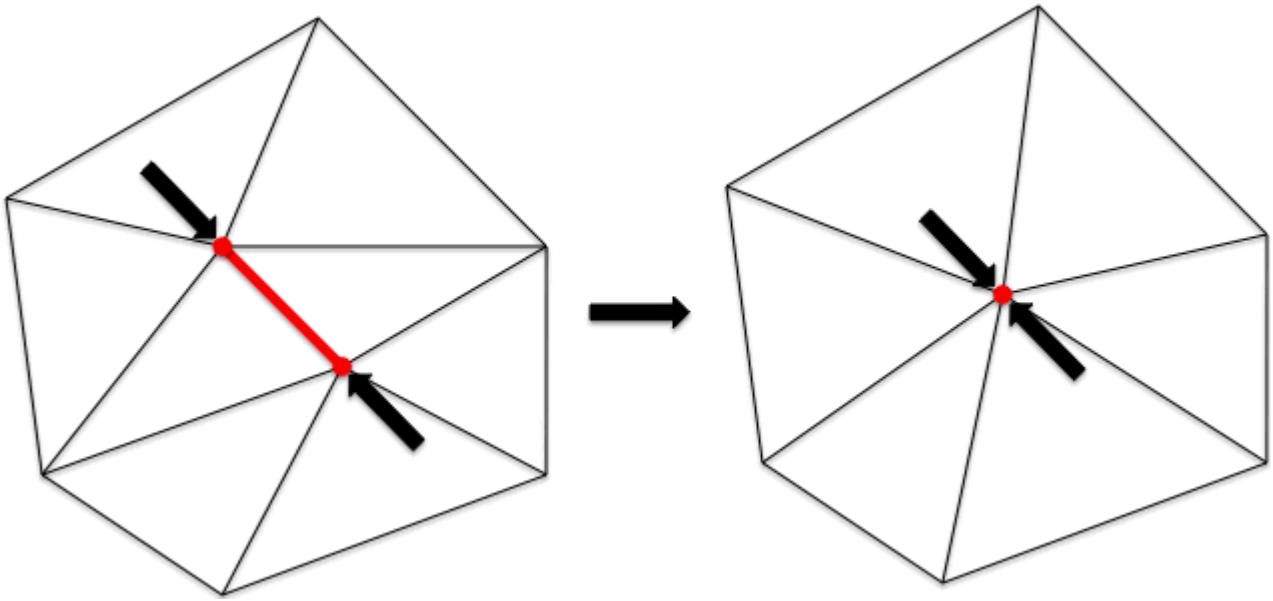
Geometric Factors & Tools to Measure Geometric Factors



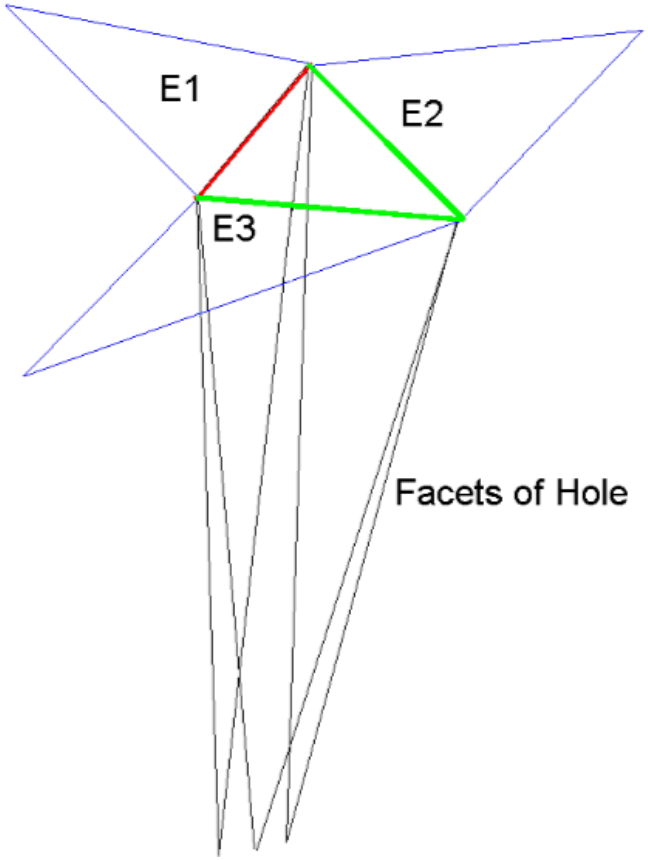
Detecting Irrelevant Features

Subset of CAD Model	Geometric Factors	Tools for Measuring Geometric Factors	Geometric Check
$in(S)$	3D proximity	3D skeleton distance (d_{3D})	$2 \cdot d_{3D} < \varepsilon_{3D}$
$in(F_n)$	2D proximity	2D skeleton distance (d_{2D})	$2 \cdot d_{2D} < \varepsilon_{2D}$
	surface curvature	min. principal radius of curvature (r_{min})	$r_{min} < \varepsilon_{sc}$
$in(C_m)$	1D proximity	curve length (l)	$l < \varepsilon_{1D}$
	curve curvature	radius of curvature (r_c)	$r_c < \varepsilon_{cc}$
	curve twist	torsion (t)	$f(t, r_c) < \varepsilon_t$

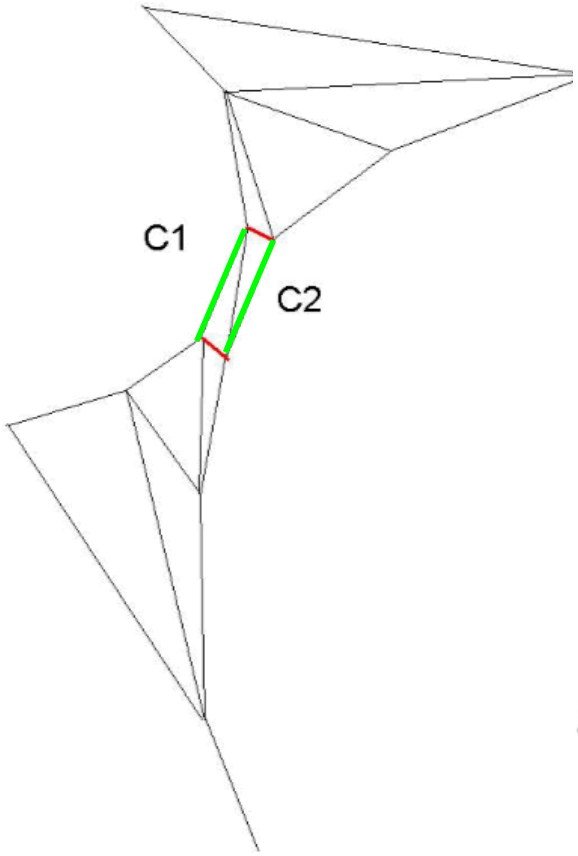
Simple Edge-Collapse Operator



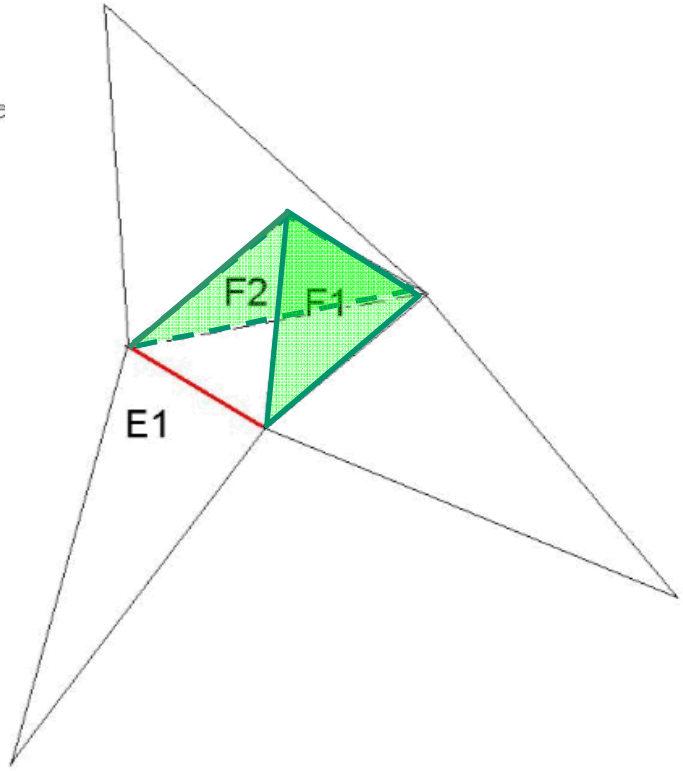
Post-processing Operations



(a) Single curve overlaps

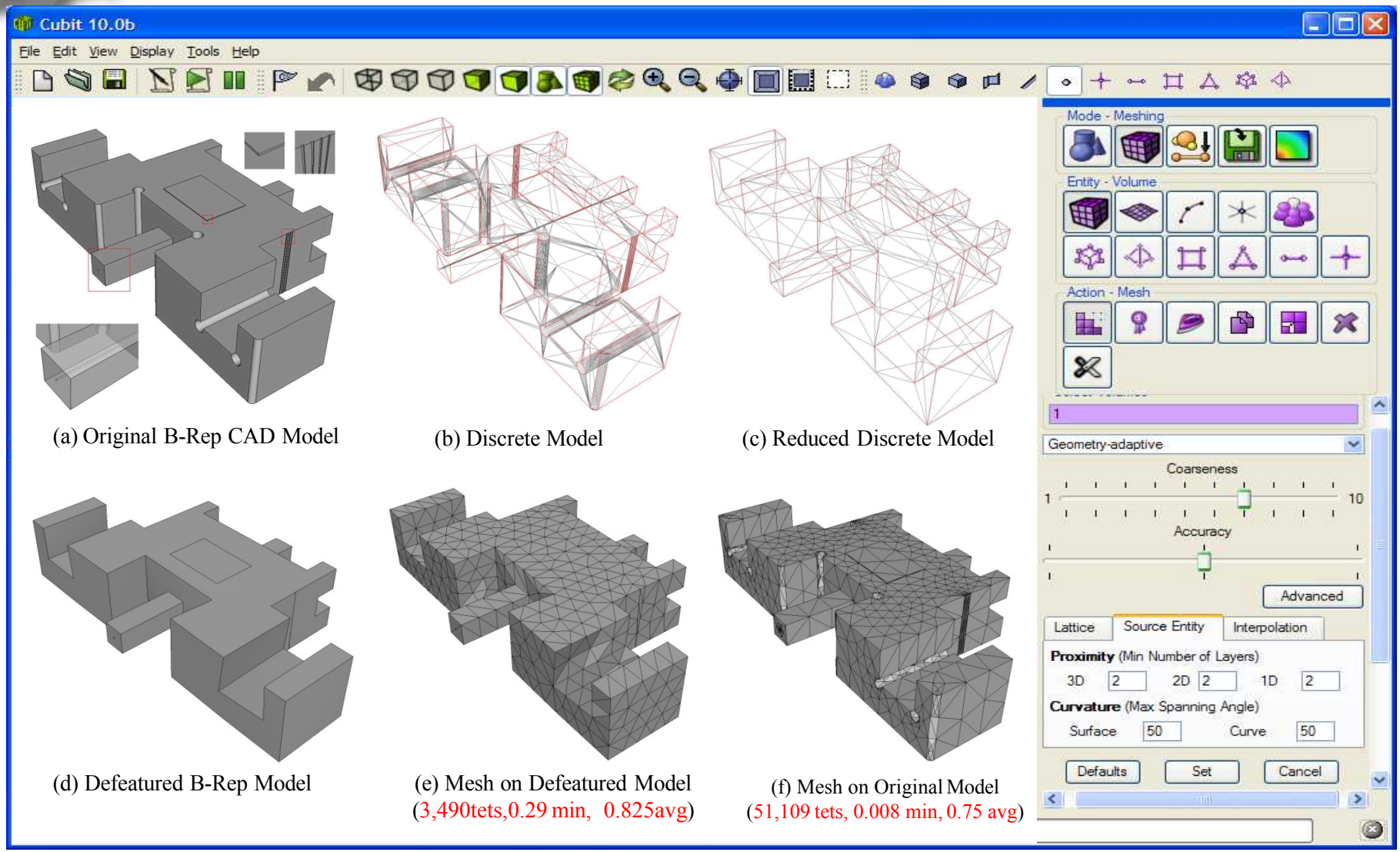


(b) Two curves overlap



(c) Single surface overlaps

Results (with demo)



(a) Original B-Rep CAD Model

(b) Discrete Model

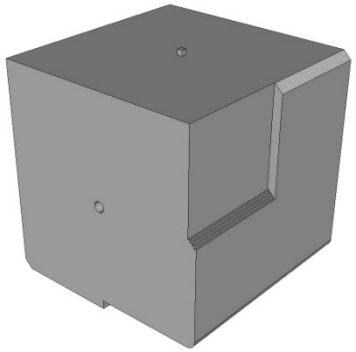
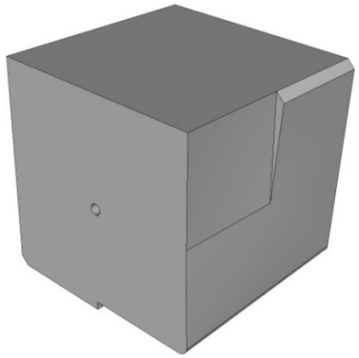
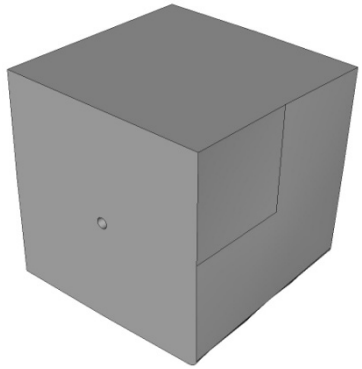
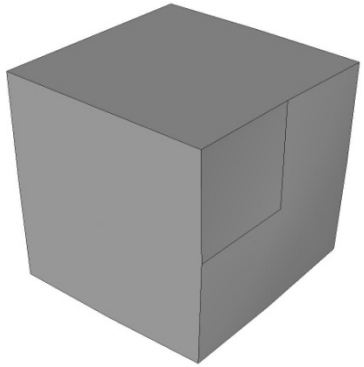
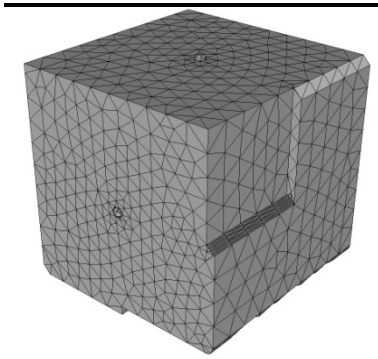
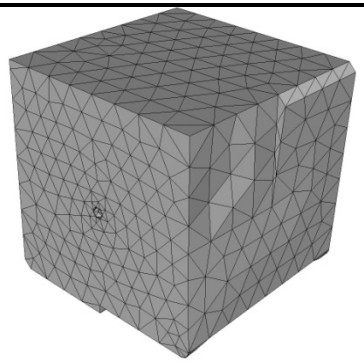
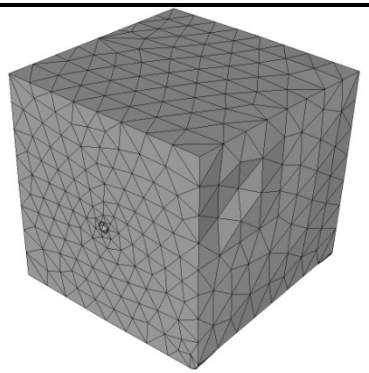
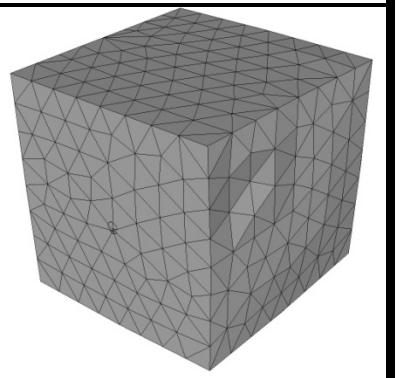
(c) Reduced Discrete Model

(d) Defeatured B-Rep Model

(e) Mesh on Defeatured Model
(3,490tets,0.29 min, 0.825avg)

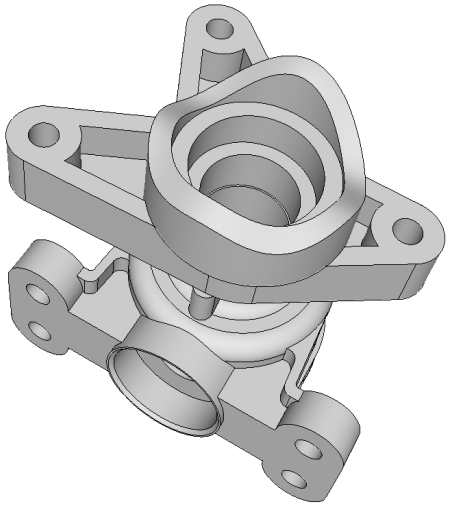
(f) Mesh on Original Model
(51,109 tets, 0.008 min, 0.75 avg)

User Control on Defeaturing

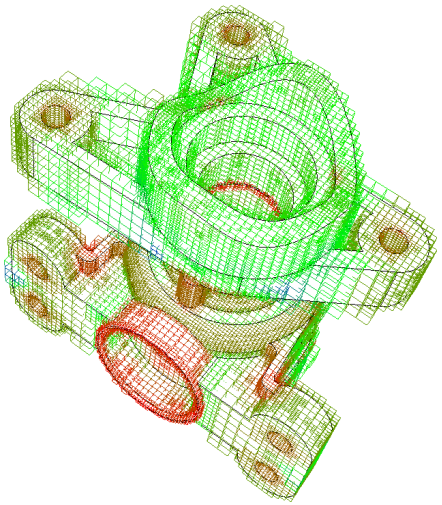
	No Features Removed	Small Curves Removed	Chamfer Removed	Hole & Fillet Removed
Geometric model				
Mesh				
Geometric Factors	None	Curve Length	Curve Length 2D Proximity	Curve Length 2D Proximity Curve Curvature Surface Curvature

Future Work

- **Extend the current approach to assembly models**
- **Extend the current approach to volume defeaturing via 3D skeleton**
- **Extend the current framework to physics-based adaptive defeaturing**

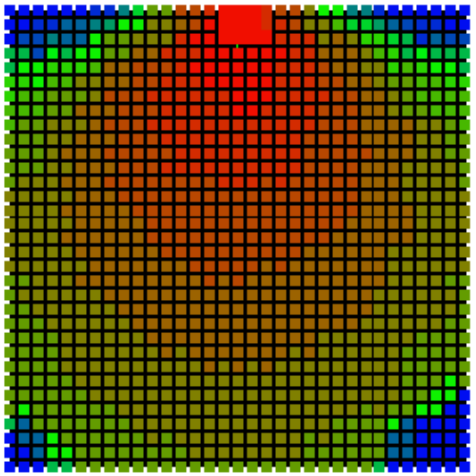


Input CAD Model



Geometry-based size field

Firmness Level = Soft



Physics/BC-based size function

Firmness Level = Hard

Thank You

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