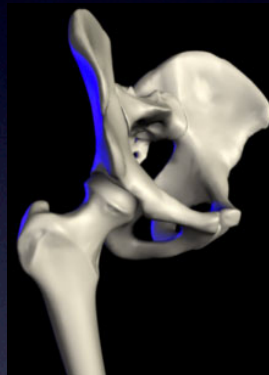
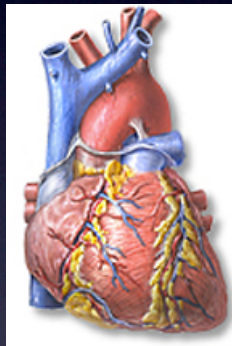


Case Study IV: Geometrical Modeling of the Heart and the Head

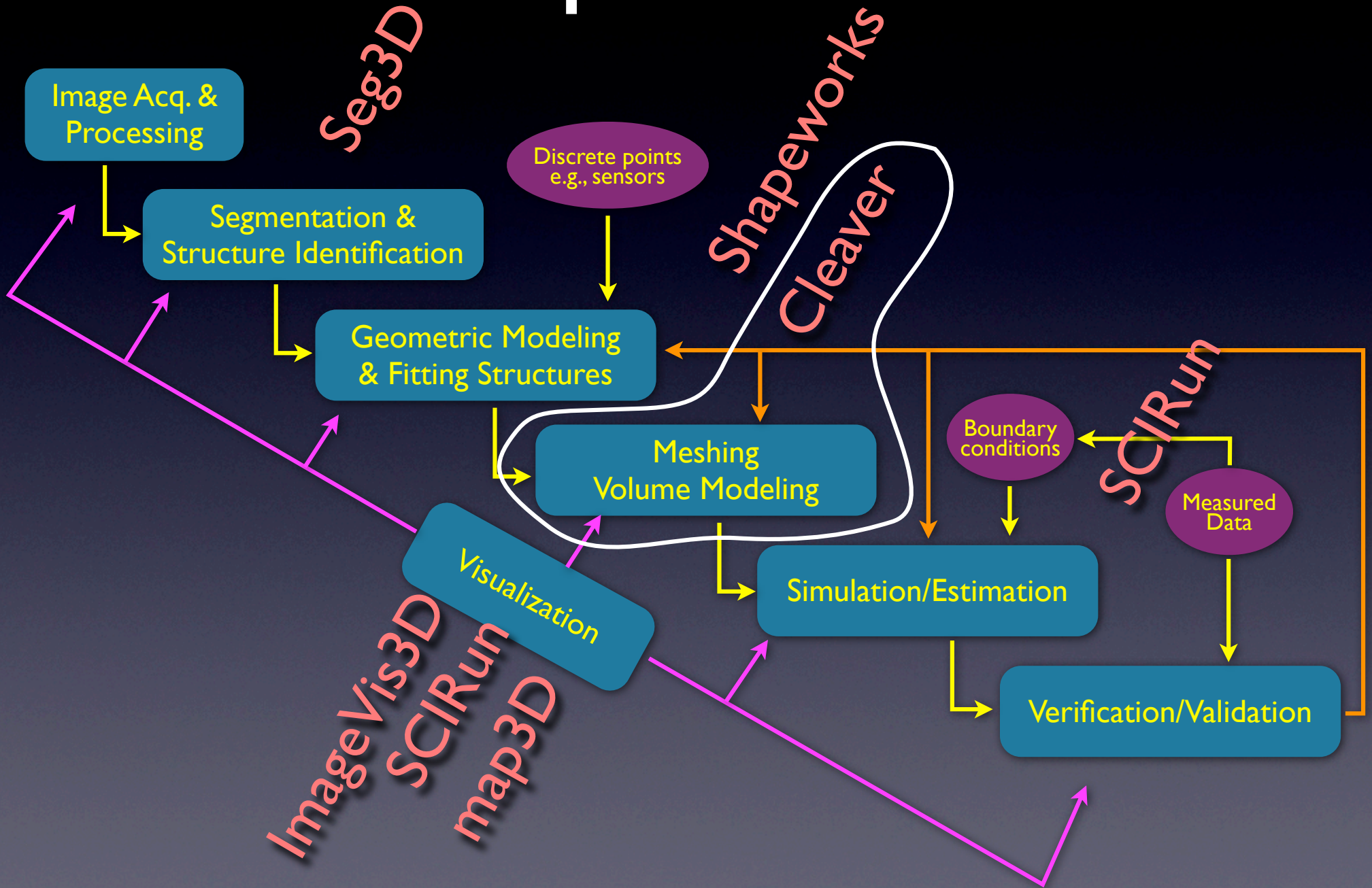
Rob MacLeod, Moritz Dannhauer, Jonathan Bronson

Motivation

Geometrical modeling for simulation

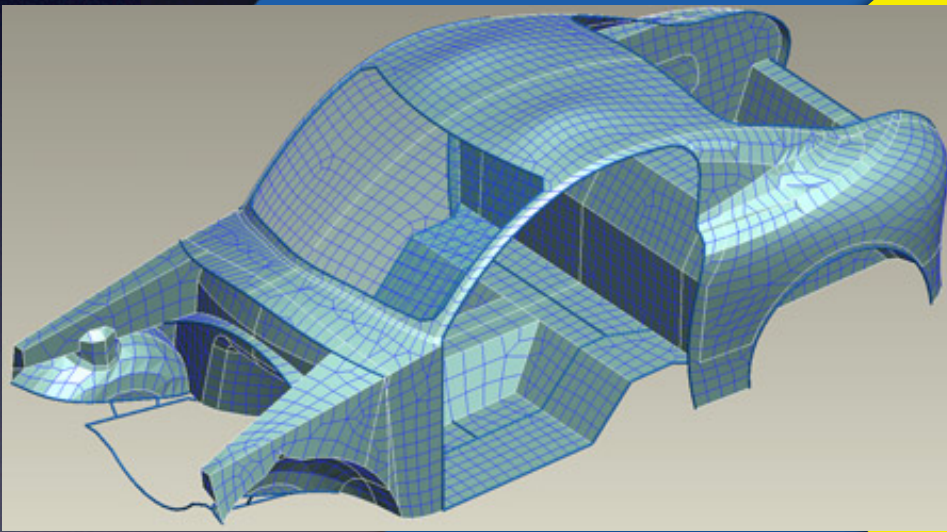


Pipeline



Meshing

Meshing



CAD-based
Meshing

Meshing

Image Based
Modeling

Meshing

Image Based Meshing

Visualization

Low

Complexity

High
Complex Shapes

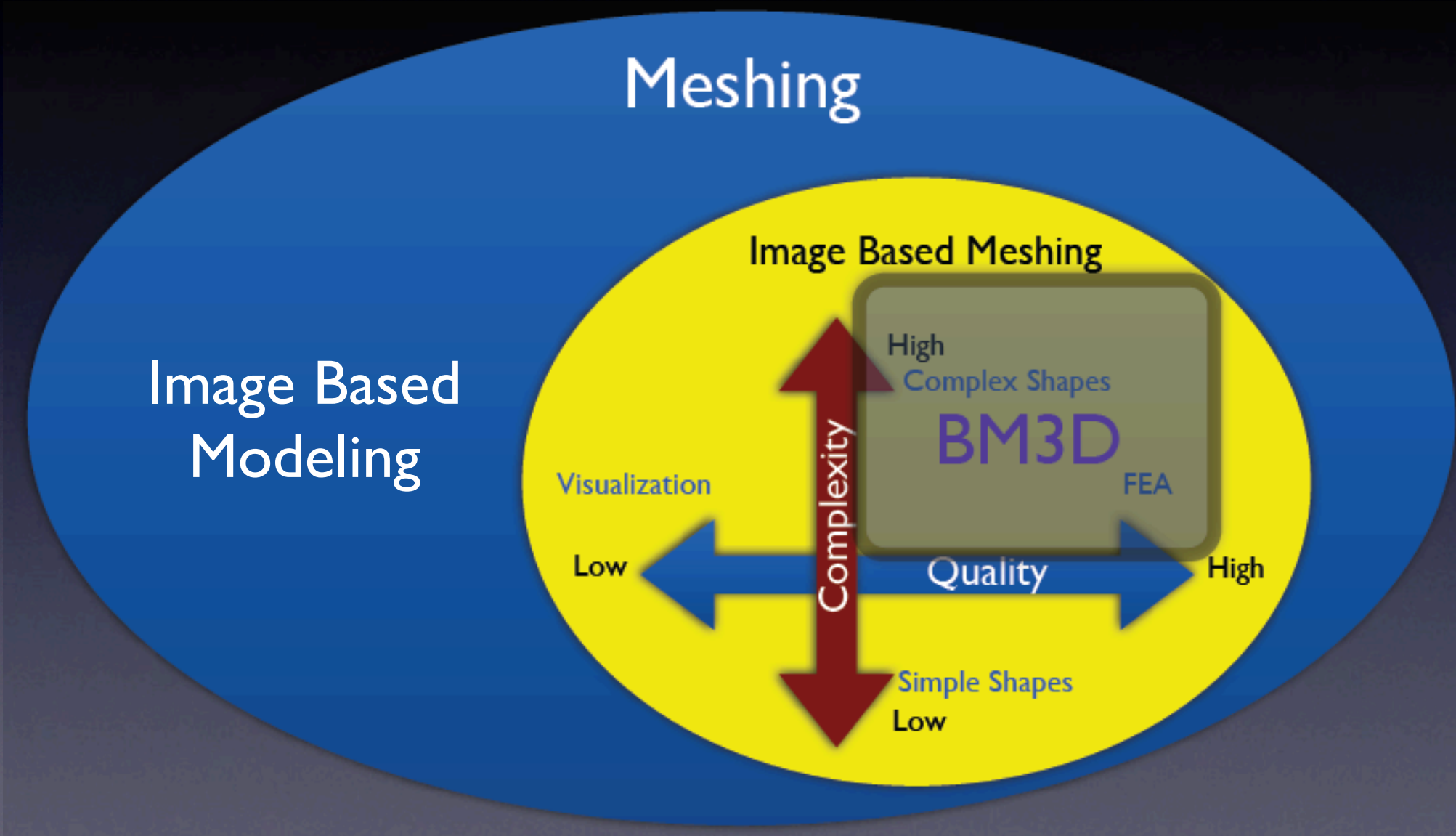
BM3D

FEA

Quality

High

Simple Shapes
Low



Challenges of Meshing

Irregular features

Internal surfaces

Multiple materials

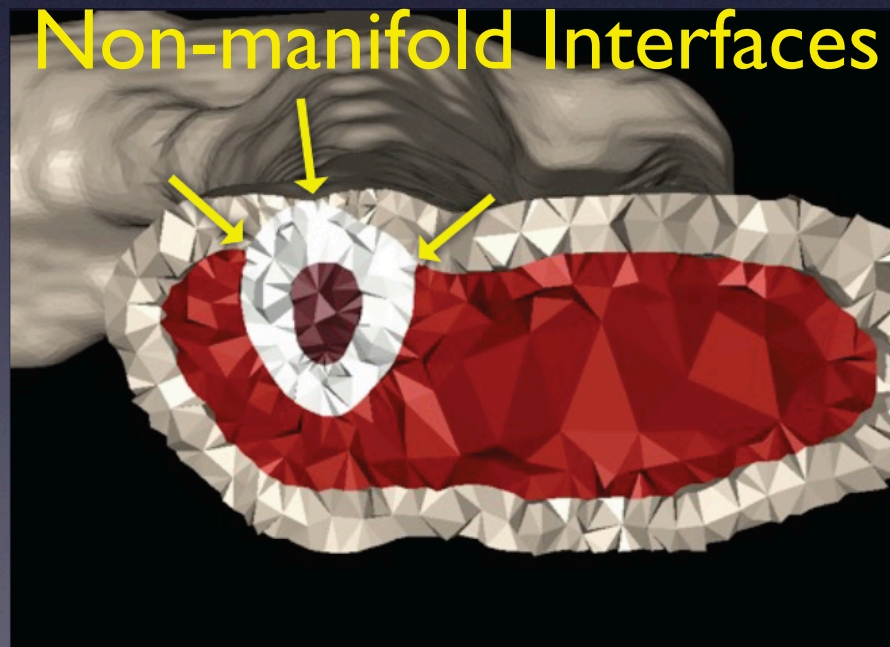
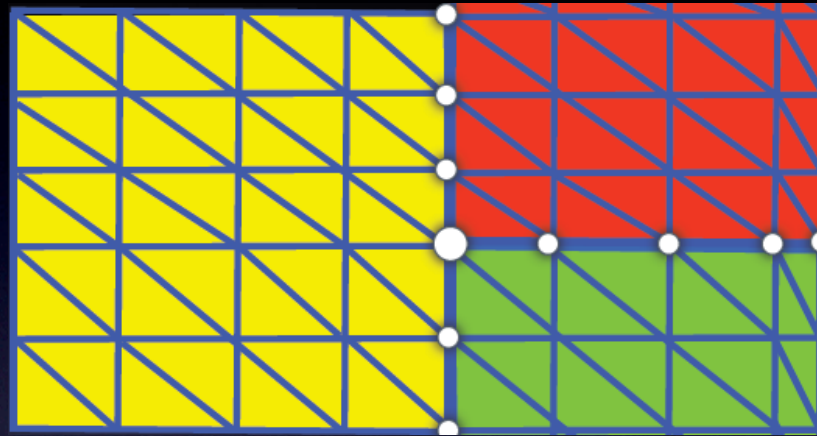
Adaptive mesh



Mesh
size

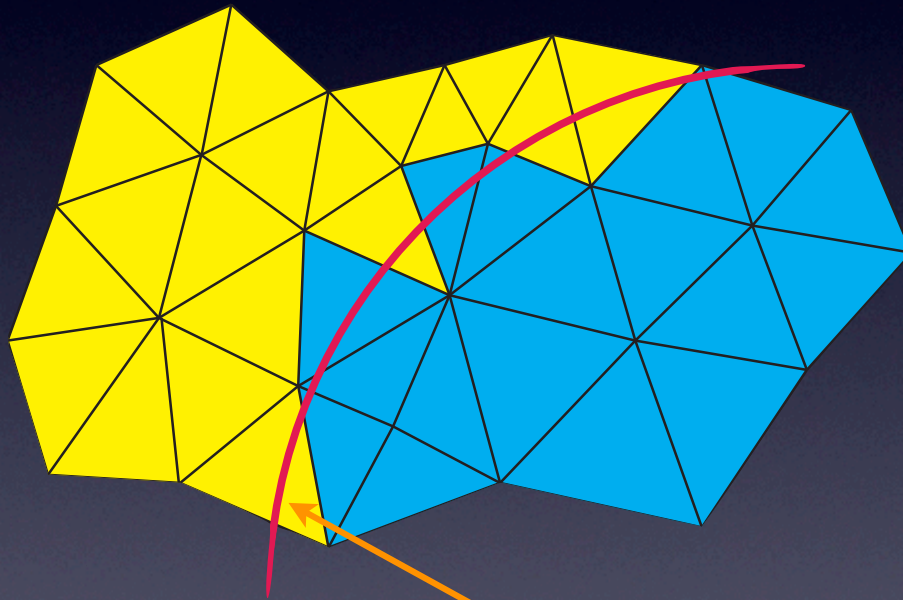
Computational
cost

Examples in Biology

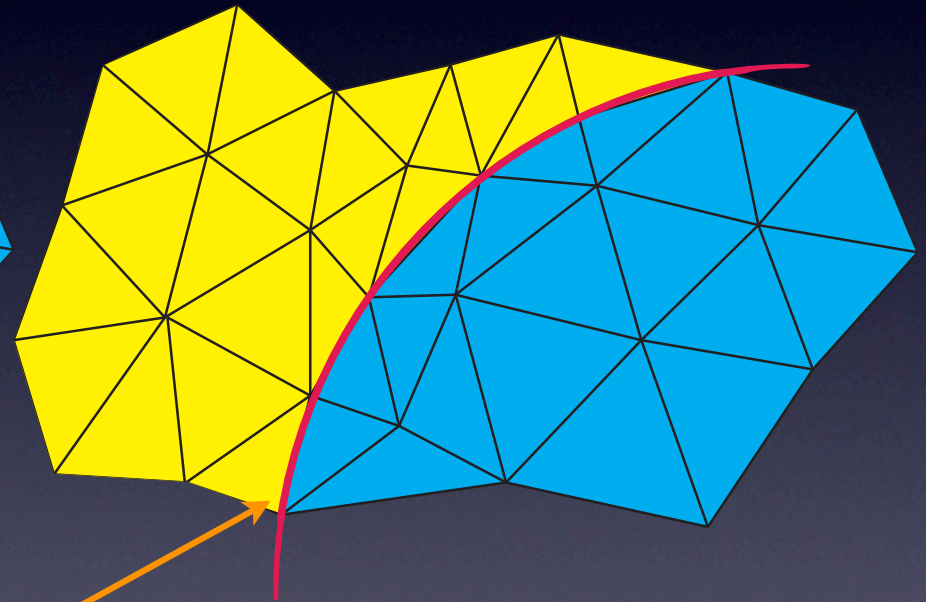


Conforming to Boundaries

Non-Conforming Mesh

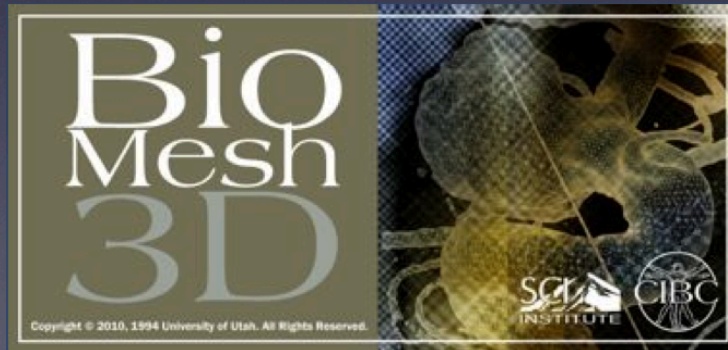
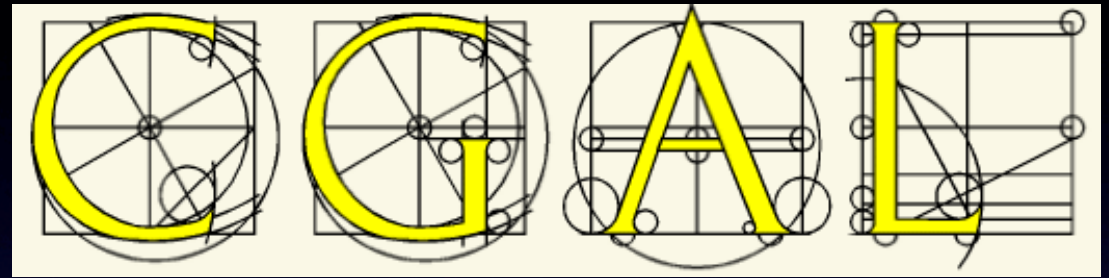
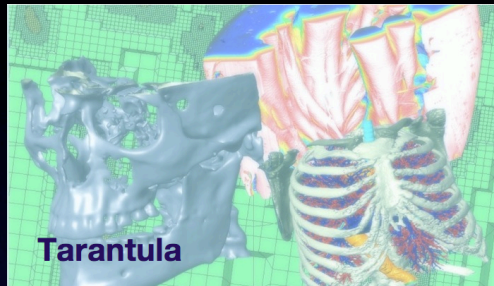


Conforming Mesh

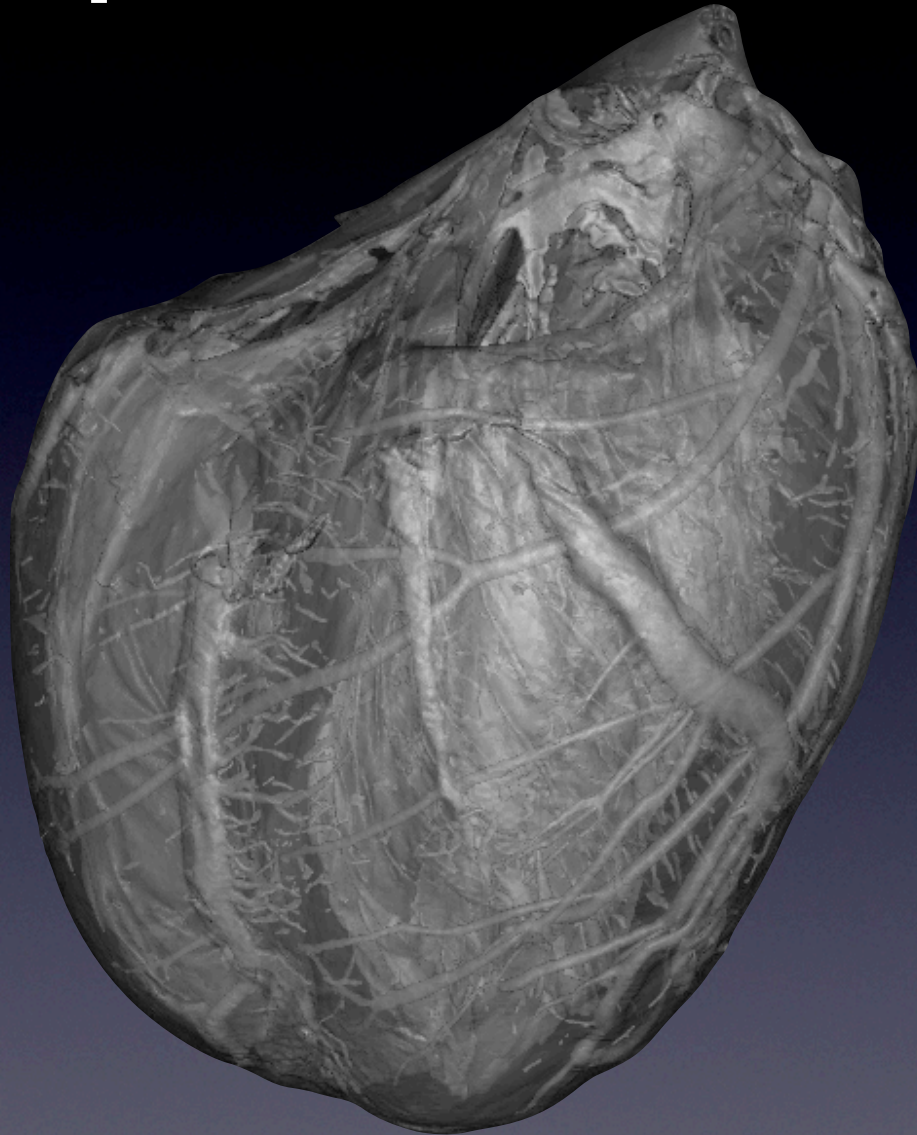


Internal surface

Meshing packages



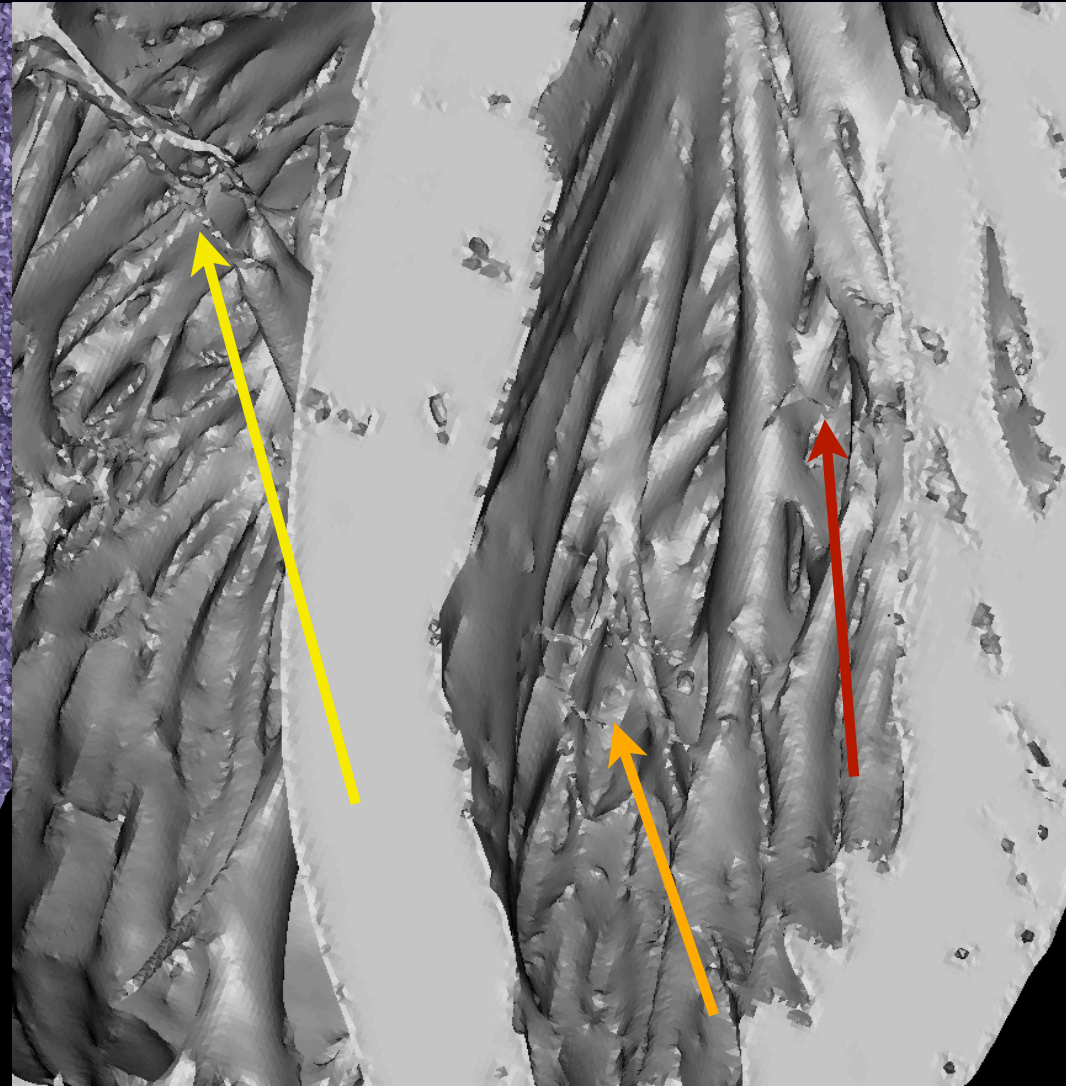
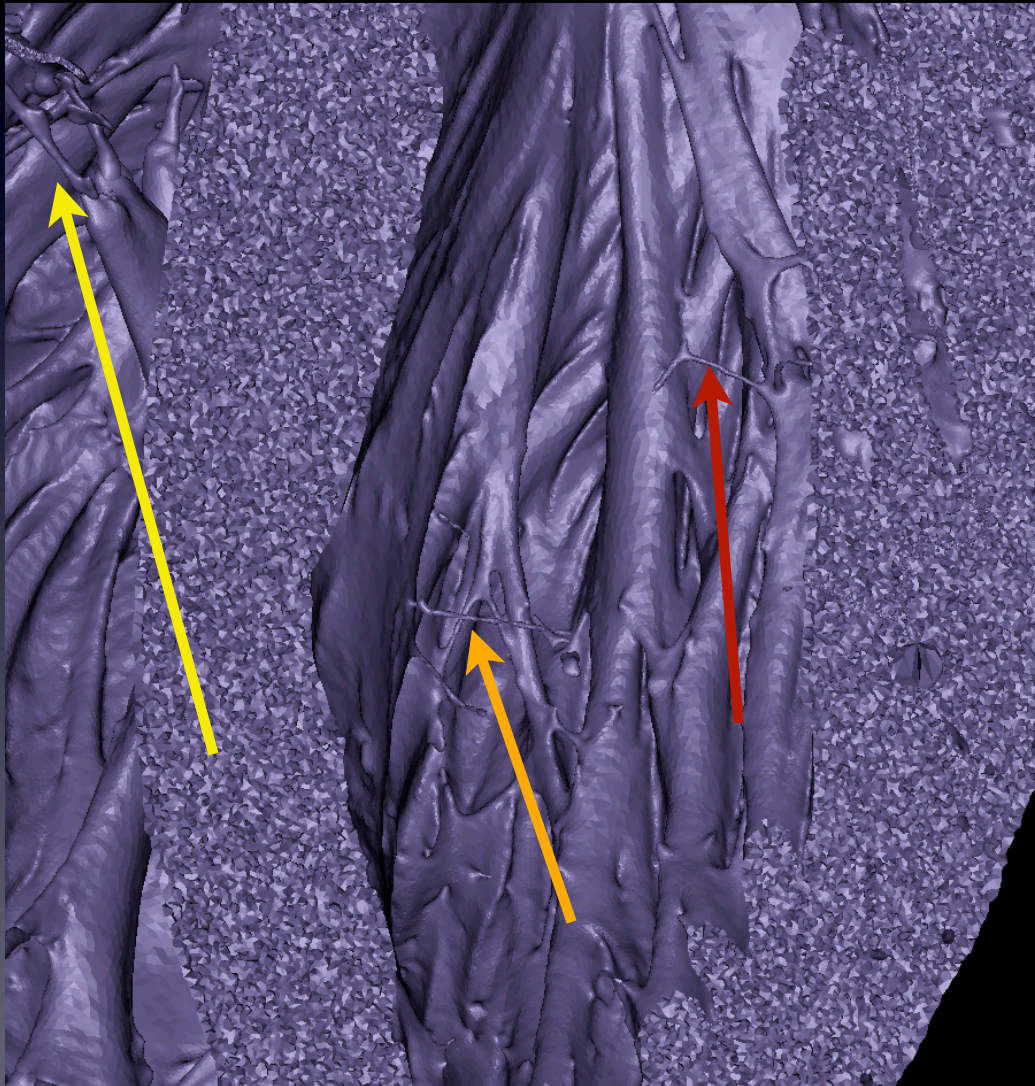
Example: Oxford Heart



Cross Section of Heart

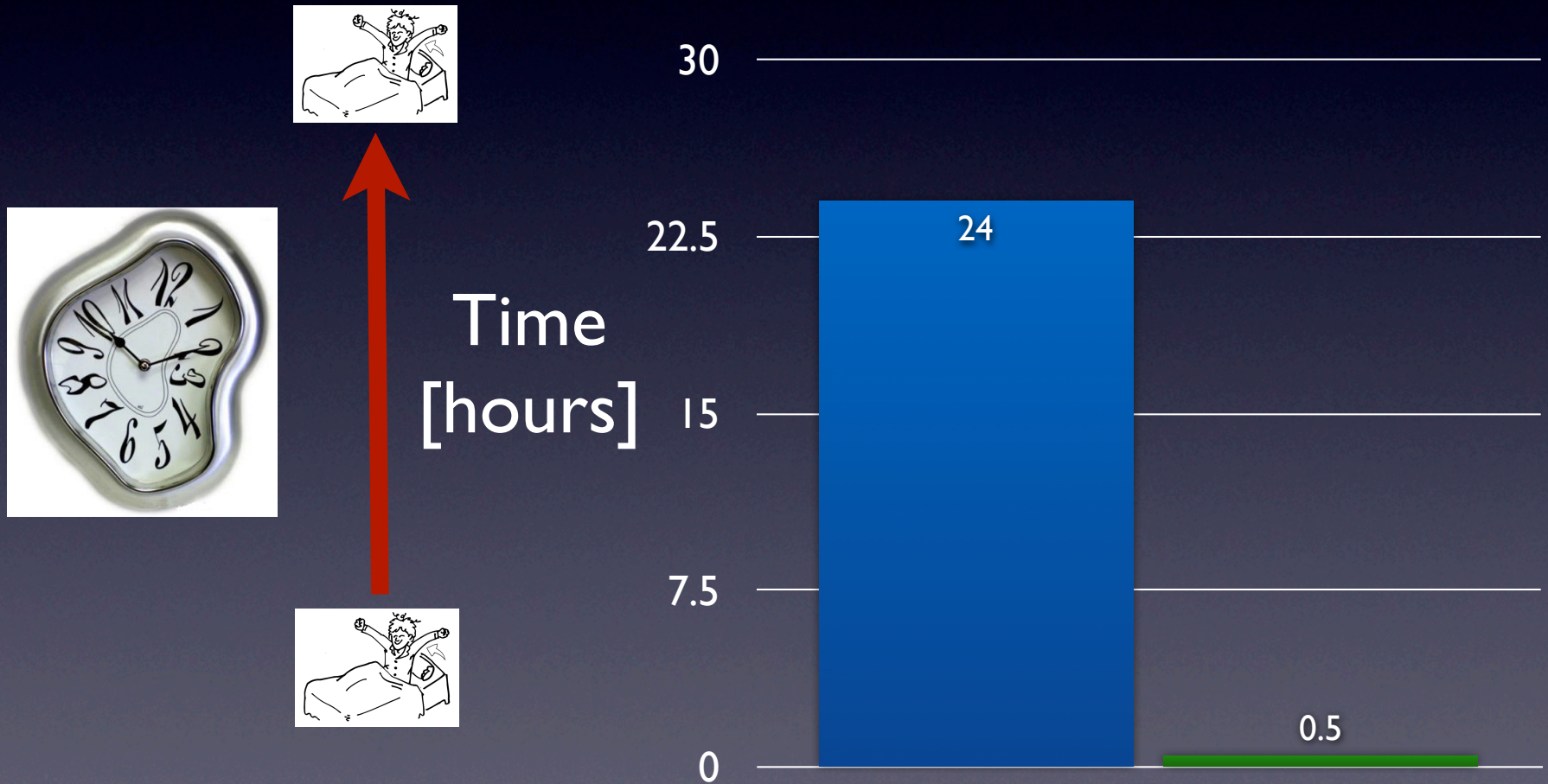
BioMesh3D

Tarantula

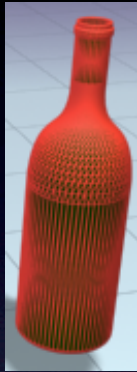


Comparison - Run Time

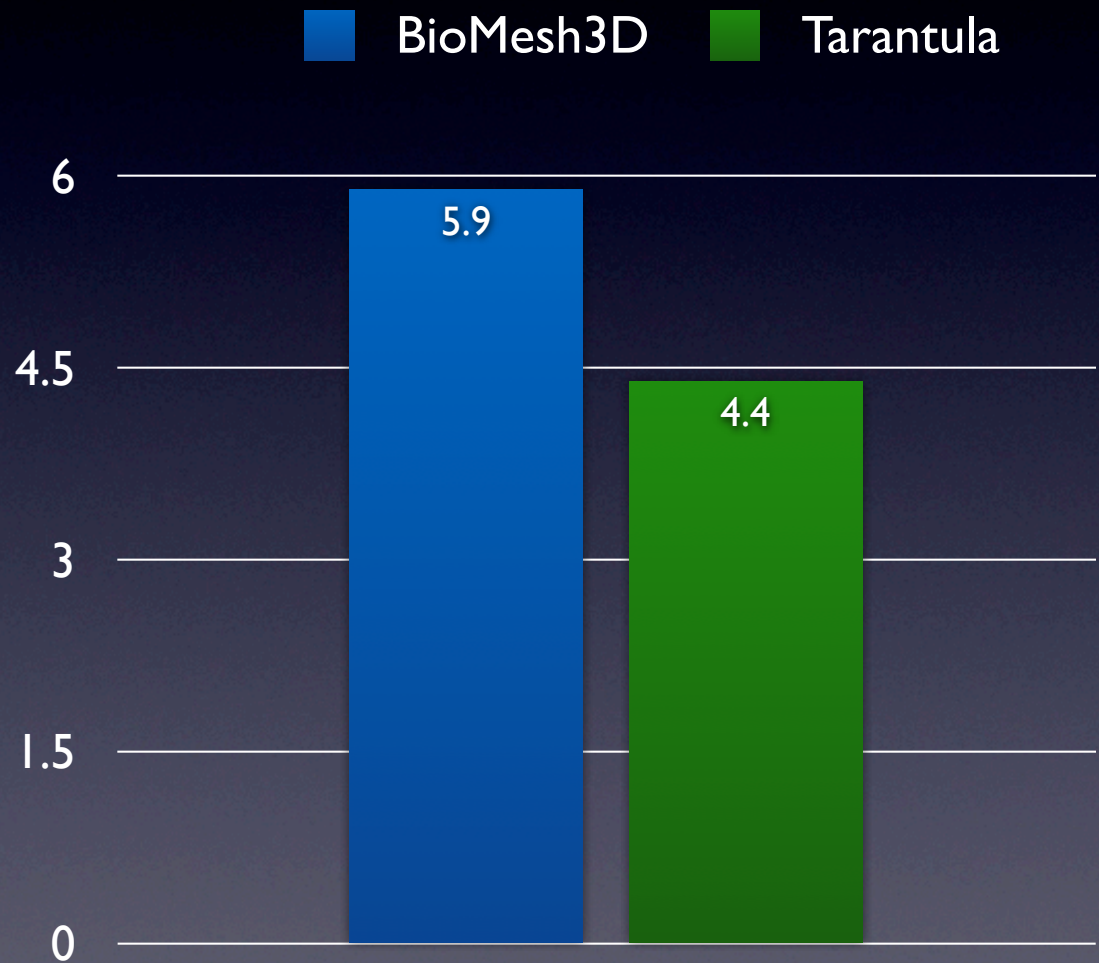
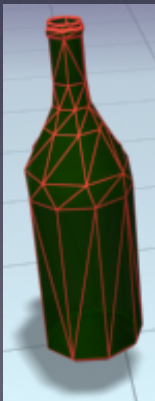
BioMesh3D Tarantula



Comparison - Complexity

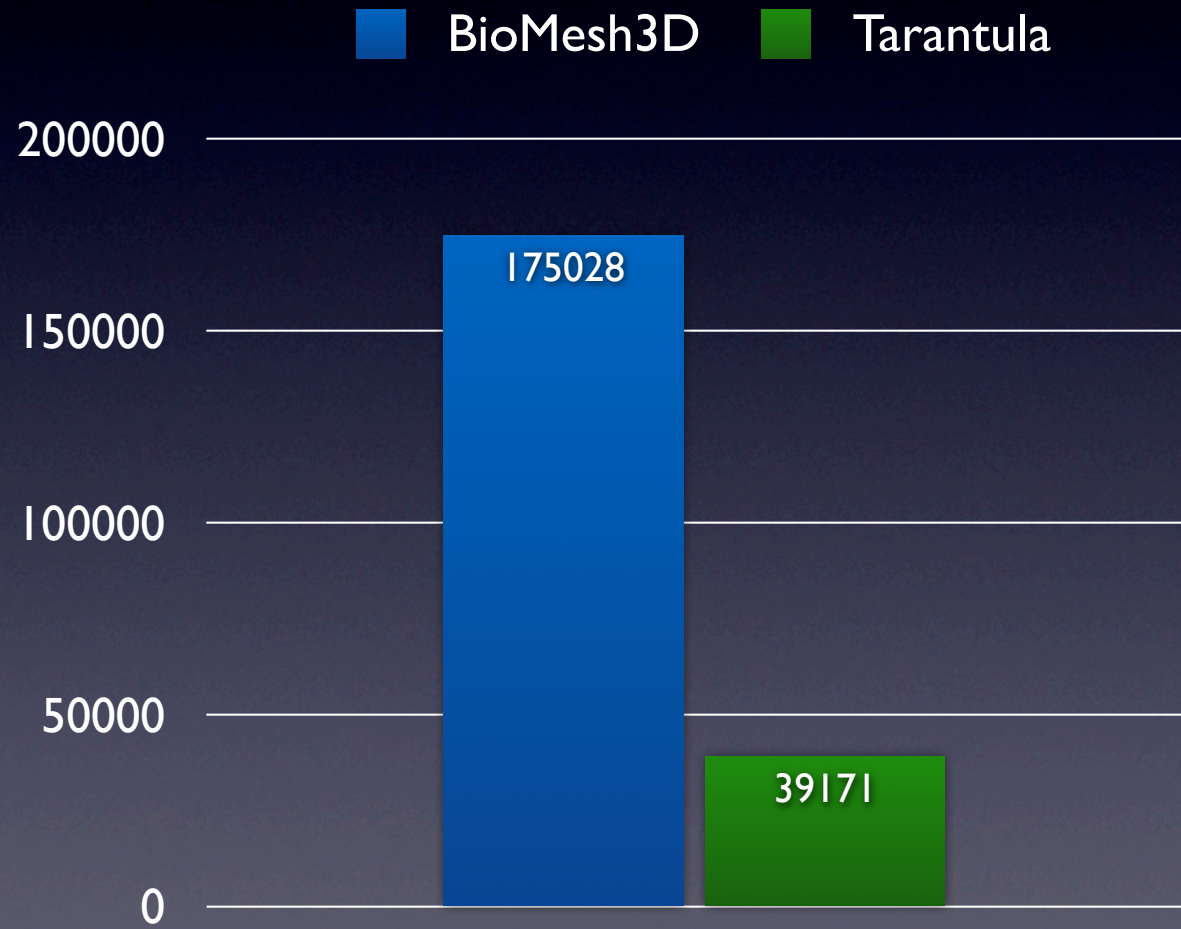
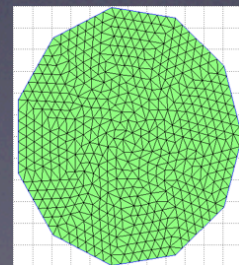
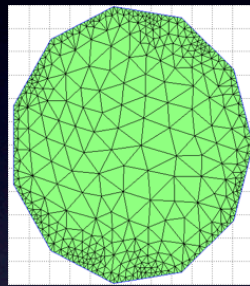


Mesh
nodes in
[xMillion]

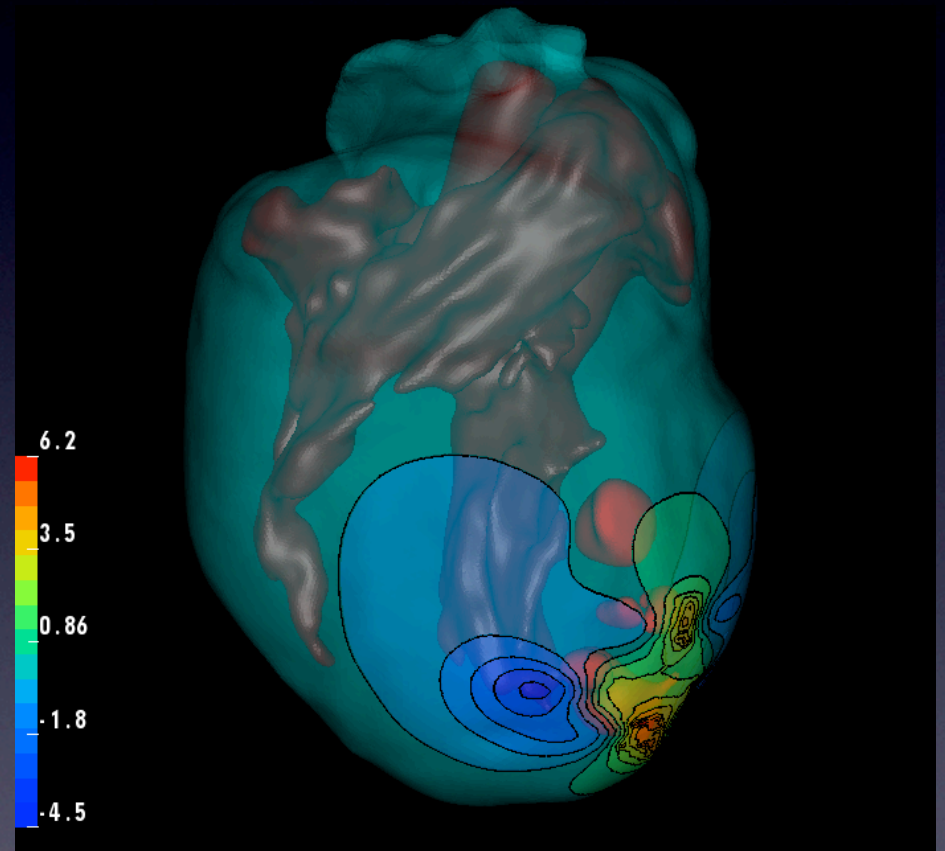
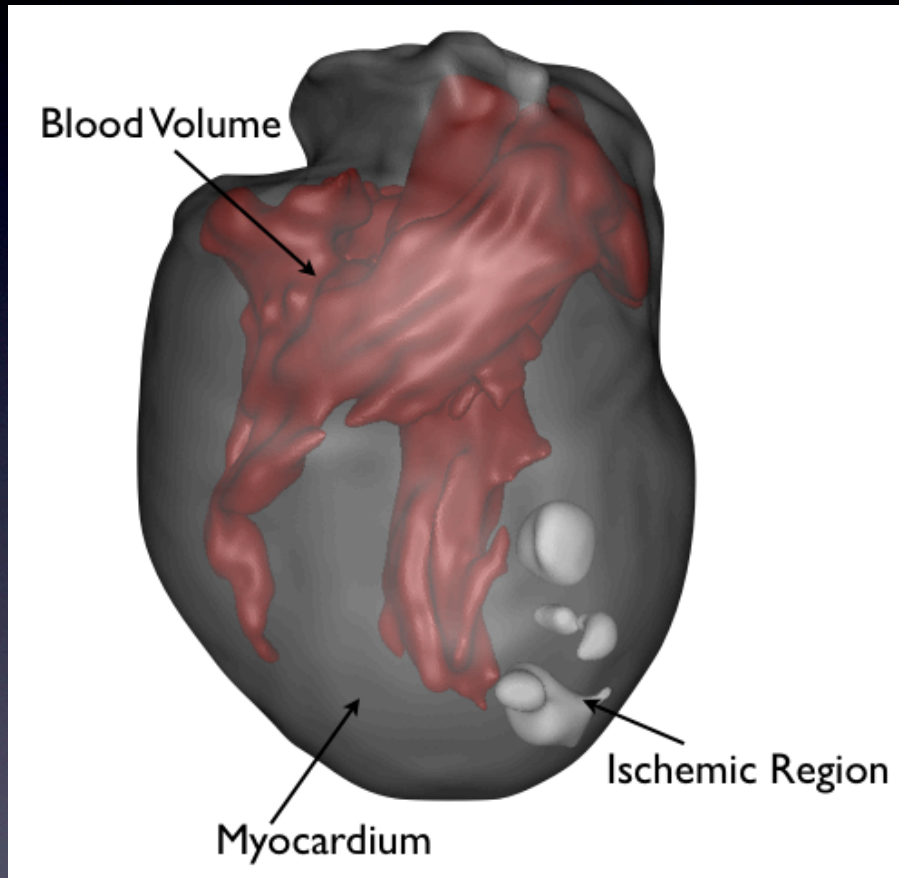


Comparison - Adaptivity

Size variability
of elements:
std dev. of
volume [μM^3]



BioMesh3D Examples



BioMesh3D - Properties



Pros:

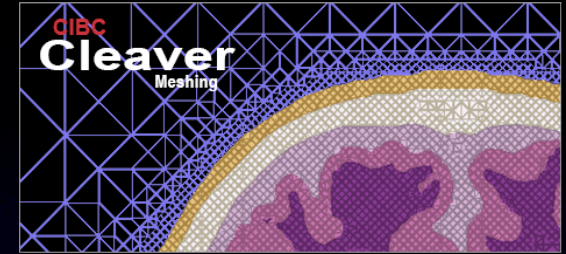
- + Conforming
- + Highly Adaptive
- + Preserve smooth/
small features



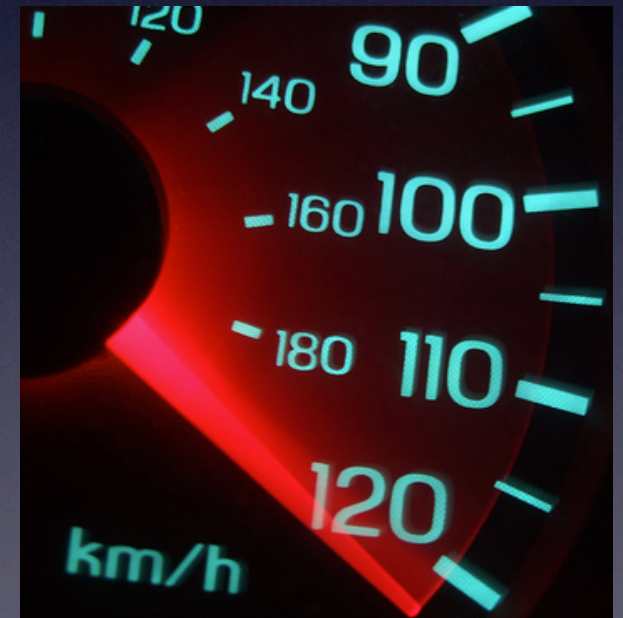
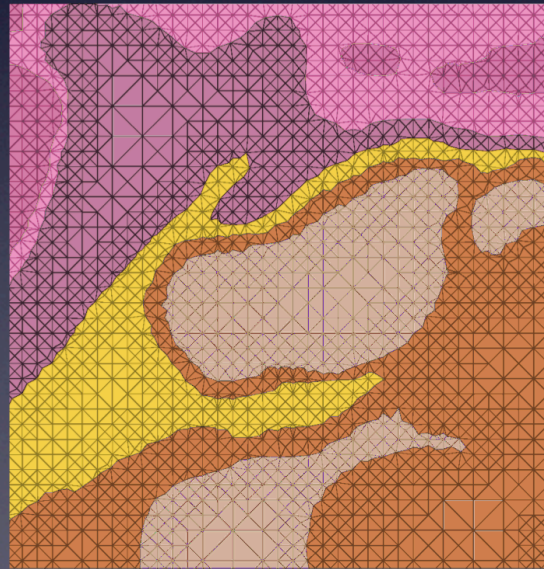
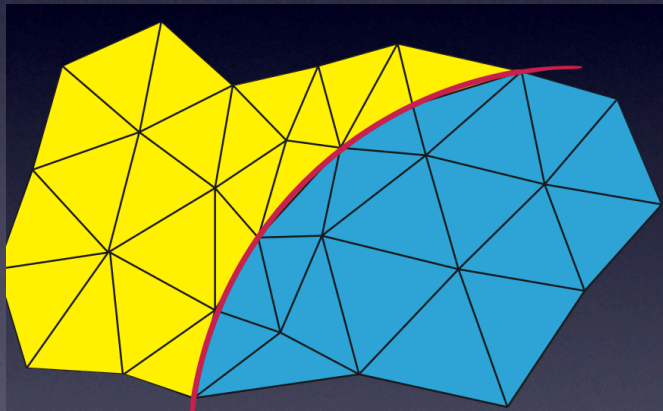
Cons:

- Lack of Robustness
- Mediocre usability
- Long run time
- Poor control of node density
- Inconsistent element quality

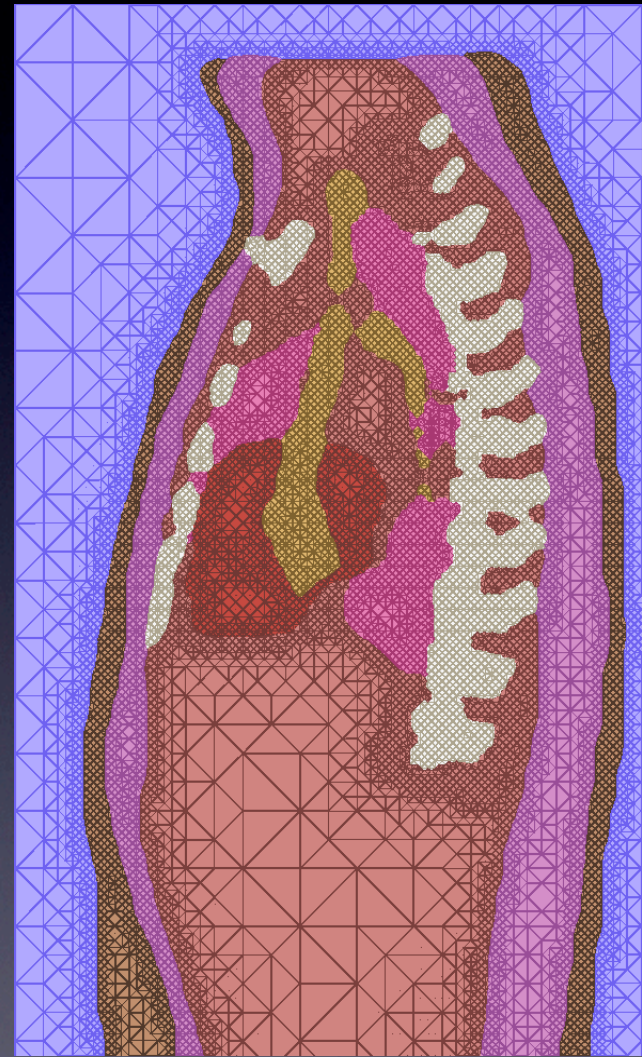
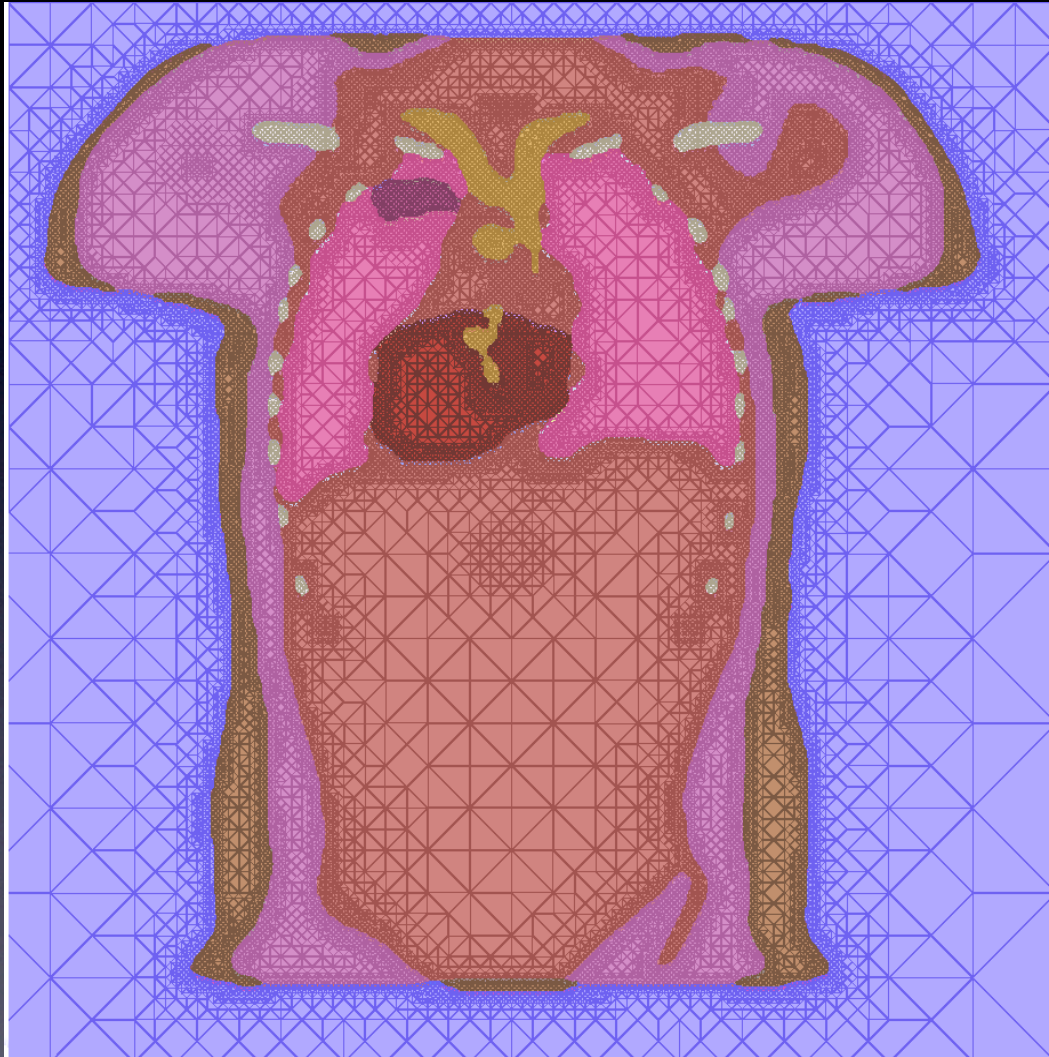
New Meshing Approach: “Clever”



$$\min(\text{SICR}) \geq \text{const}$$

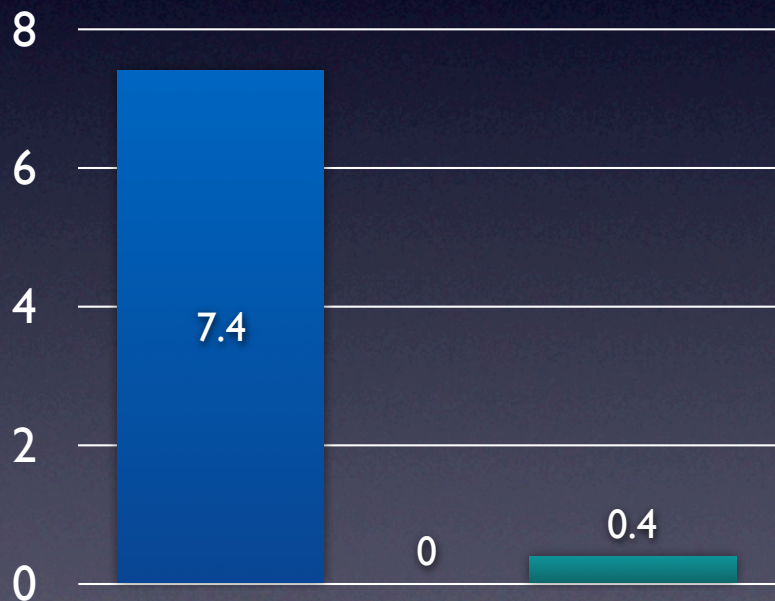


Cleaver Example

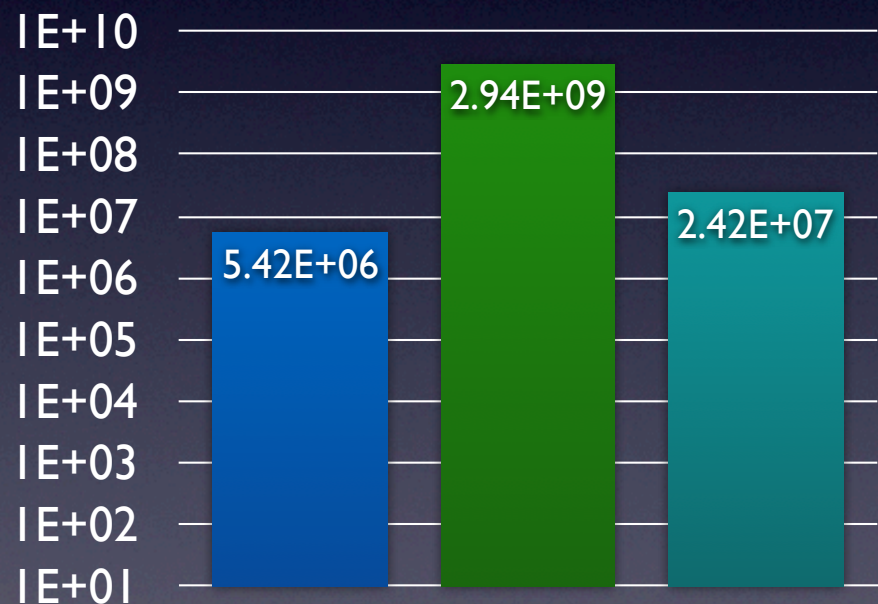


Comparison - Torso

Cleaver BioMesh3D CGAL

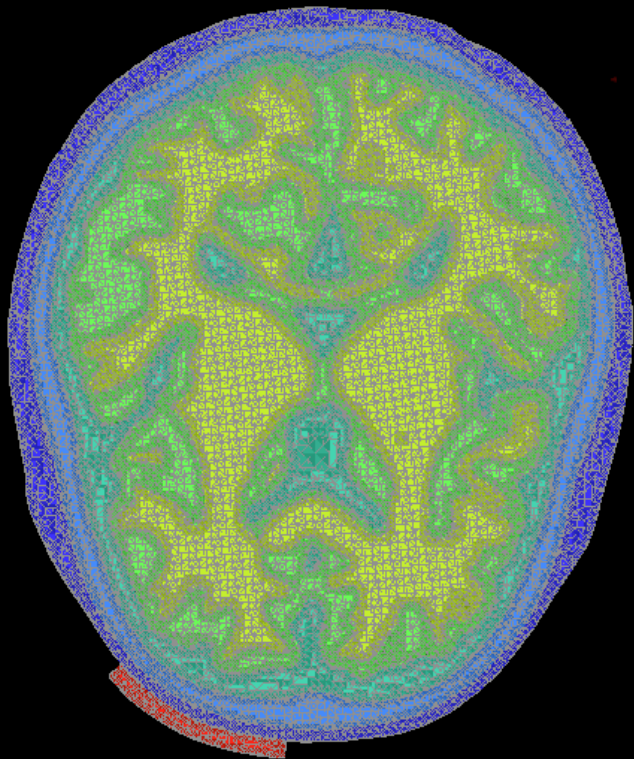


min(Dihedral Angle)



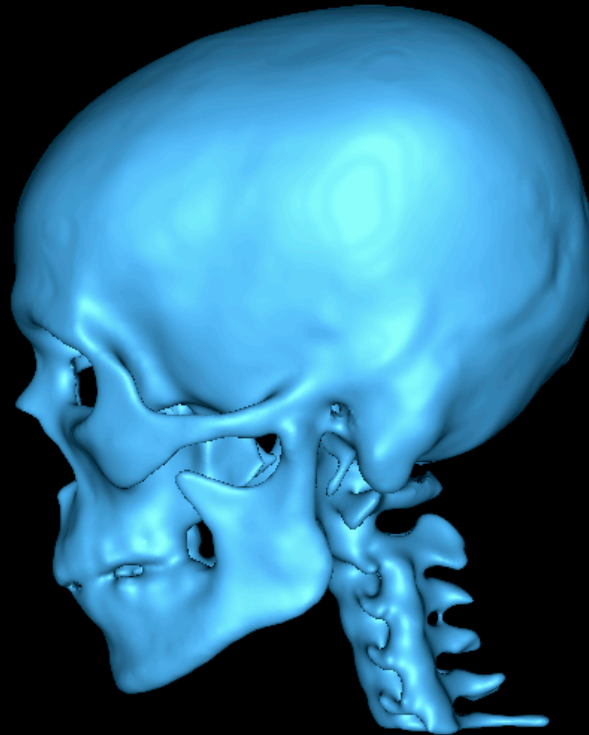
Condition number

Example: Head Model

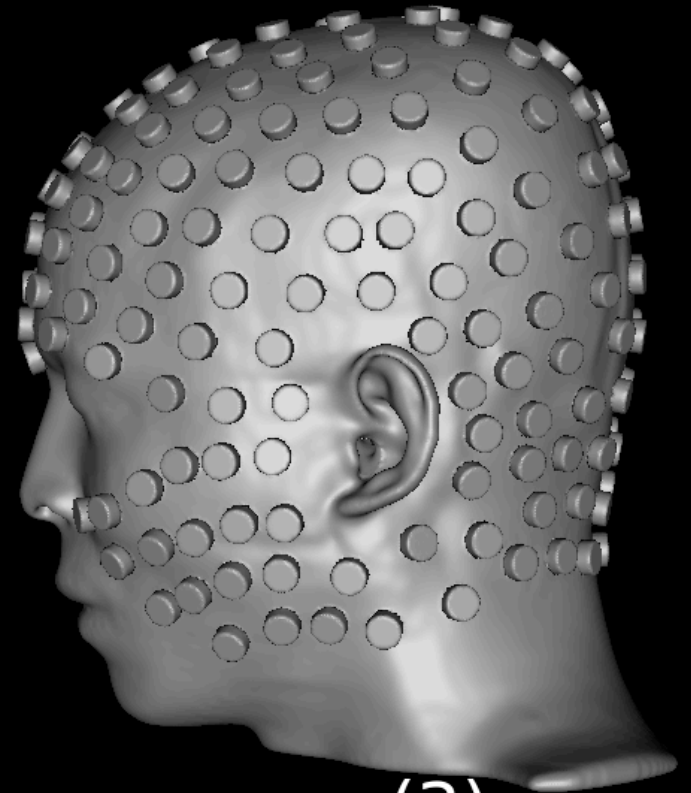


(1)

8 Materials



(2)



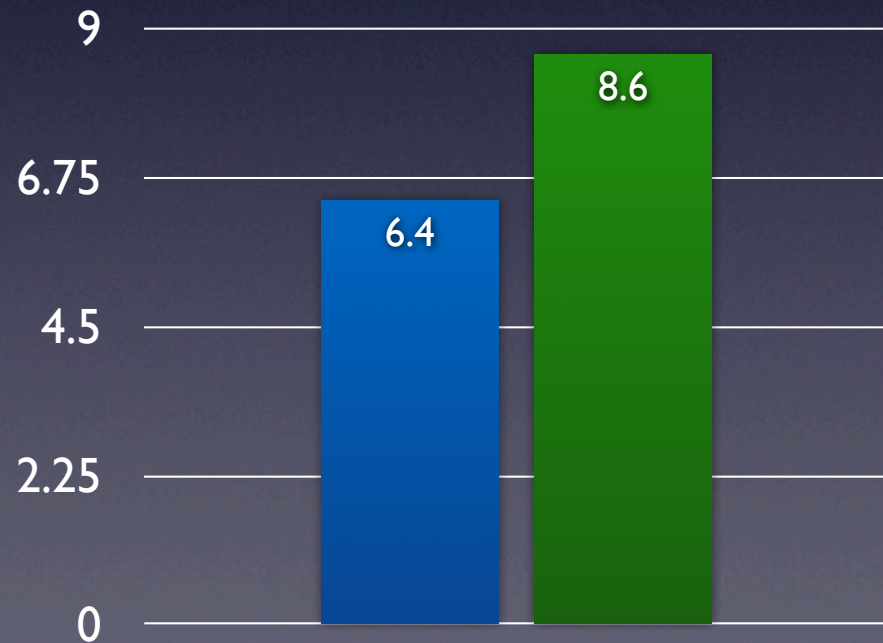
(3)

Integrated
electrodes

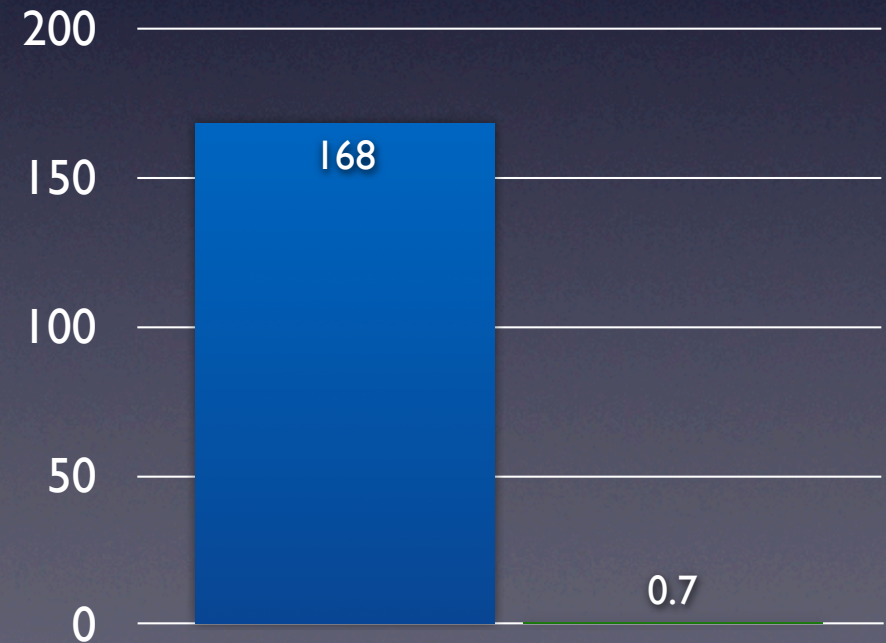
Comparison - Head Model

■ BioMesh3D ■ Cleaver

Mesh
nodes in
[xMillion]



Time in
[hours]



Cleaver in Action

Multi-Ball Drop
Mesh Cutaway

