(Re)Meshing with Mmg

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Meshing & remeshing

Aim of meshing

Generation/creation of a mesh from a body model.
Lot of issues to be solved:

- Description of complex body models
- Holes
- Overlaps and auto-intersections
- User constraints

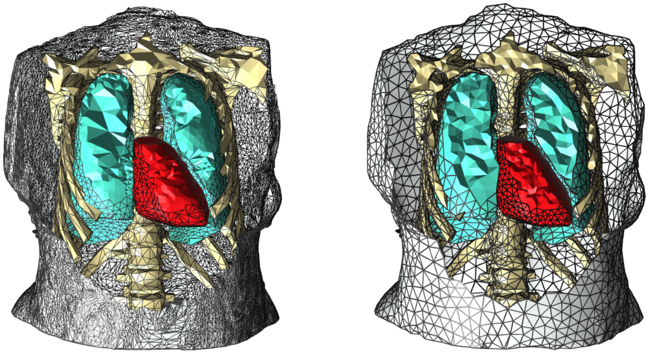
$\longrightarrow$ Need for human interventions

Aim of remeshing

Automatic modification of an existing mesh without going back through the step of generation from the body model.

Why remeshing ?

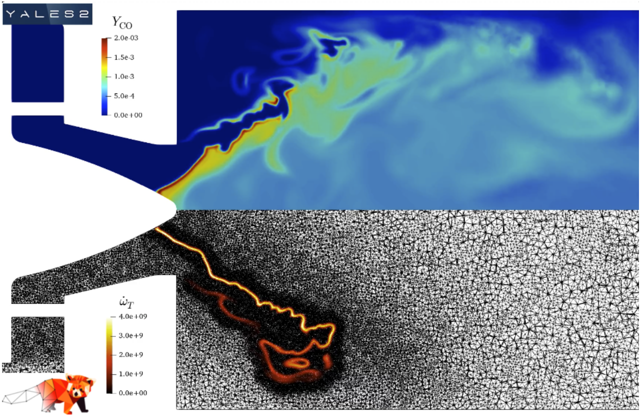
1. You have a first mesh not suitable for computations: it contains too many elements, too bad quality elements or it is a poor geometric approximation of the domain it is meant to represent



CT-scan segmentation (left) and computational mesh (right)
N. Zemzemi (Inria)

Why remeshing ?

2. To capture a solution at a minimal computational cost.

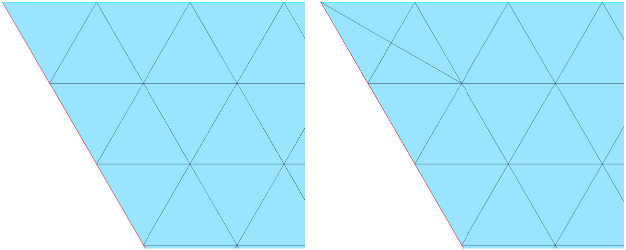


*PRECCINSTA burner [***benard:hal-02105031***].*
P. Bénard, G. Lartigue, V. Moureau (Coria); R. Mercier (SAFRAN Tech)

Main objectives and challenges of remeshing

Aim: provide a computational mesh

- no bad-qualities elements;
- sufficiently accurate boundary approximation;
- respect of an input size map;
- minimal number of elements.



Non computational mesh (left) and computational mesh (right).

Main objectives and challenges of remeshing

Computational/implementation issues

- robustness and topology preservation;
- efficiency: dynamic process ⇒ management of memory and storage...
- Idempotence

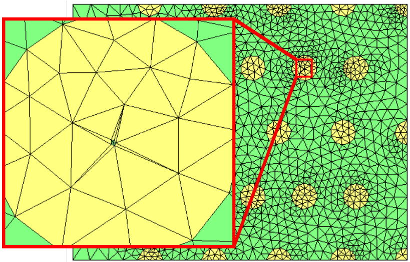


Illustration of topology preservation.

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Mmg platform in few words

Three software (under L-GPL license)

- Mmg2d: 2d mesh;
- Mmgs: 3d surface mesh;
- Mmg3d: 3d volume mesh.

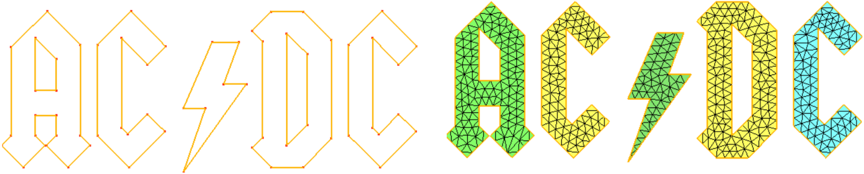
Both start with an initial mesh, which is:

- valid, insofar as it does not contain overlapping elements;
- conforming, in the Finite Element sense;
- possibly ill-shaped, *i.e.* some elements have very bad qualities.

Mmg platform in few words

Features

1. 2D Mesh generation;
2. Mesh enhancement (oriented remeshing);
3. Iso/anisotropic mesh adaptation (*w.r.* to a user-defined size map);
4. Level-Set discretization/implicit domain meshing;
5. Lagrangian movement.



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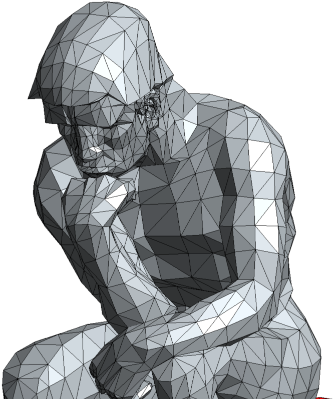

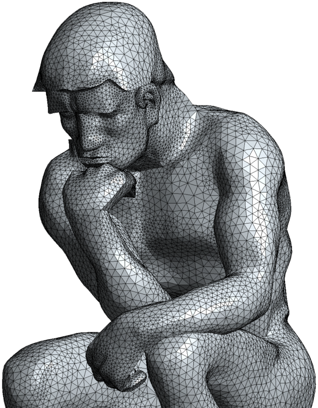

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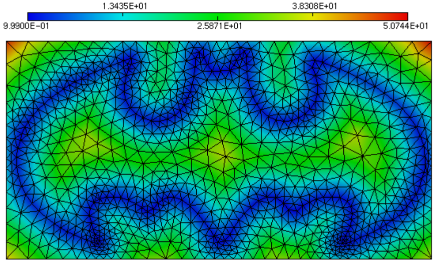

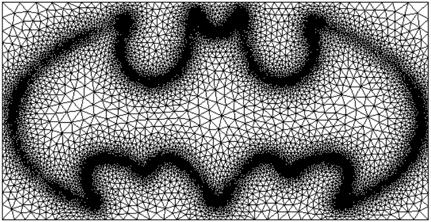

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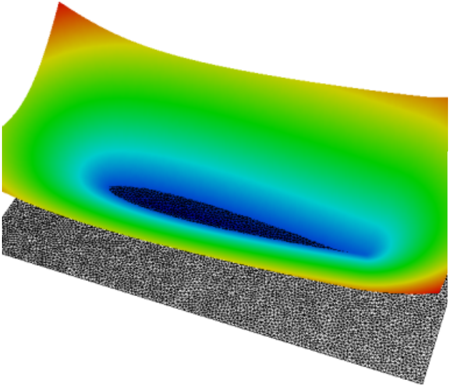

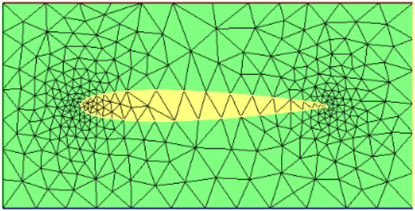

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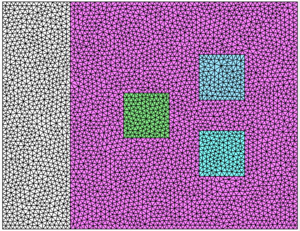

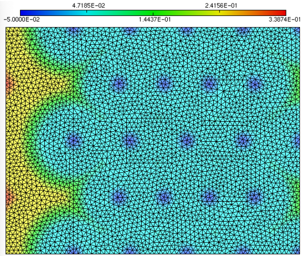

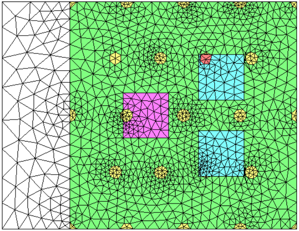

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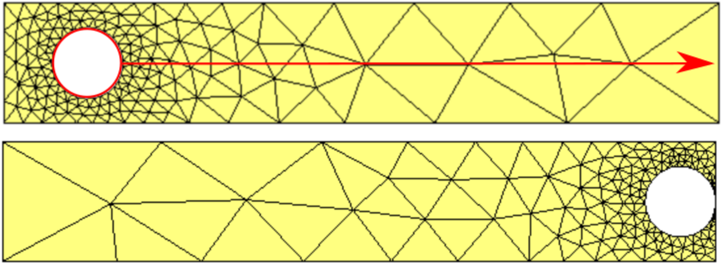

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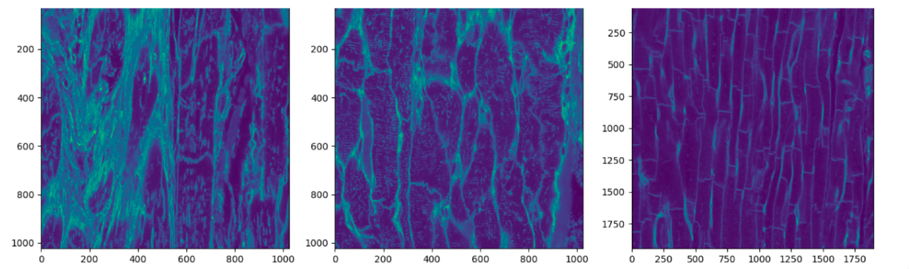
Goals

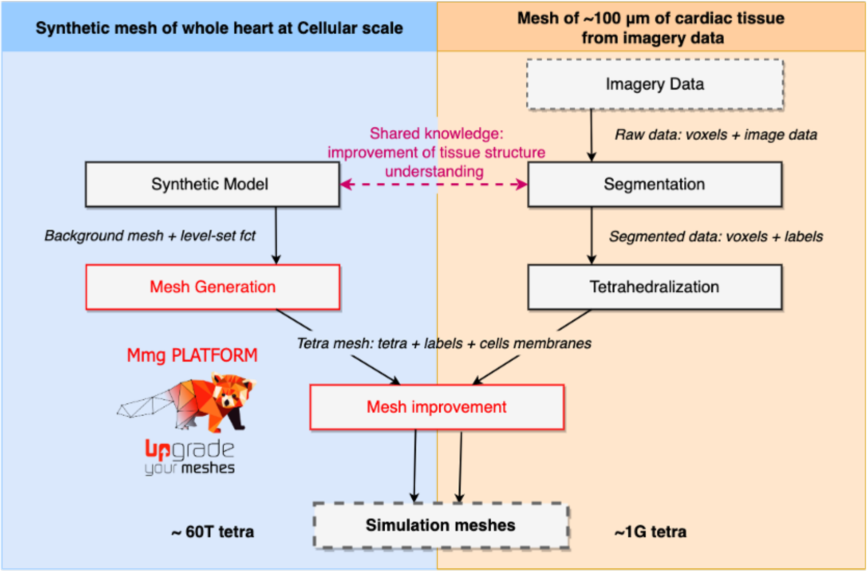
Setting up a workflow to generate meshes for macroscopic cell by cell model:

- provide very large cell-by-cell meshes so partners can test their new models;
- pave the road to generate minimal computational meshes from images data.



Examples of input data: $\sim 100\mu m$ of cardiac tissue from confocal imagery (Courtesy J. Greiner)

Remeshing in the context of MICROCARD

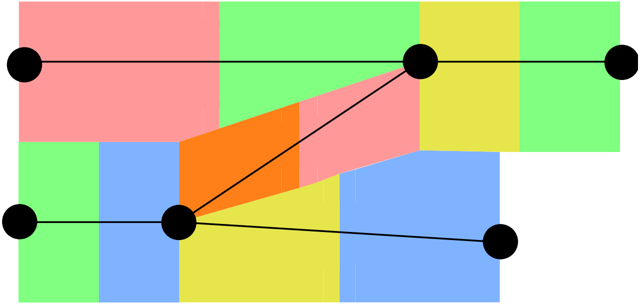


Complementary workflows to mesh cardiac tissue at Cellular scale.

Remeshing in the context of MICROCARD

Synthetic model of the heart: algorithm outline

1. Random 3D network of **centers** and **links**
2. Background domains discretization
3. Cell membrane definition as an implicit surface
4. Discretization of the membrane with background domains mapping



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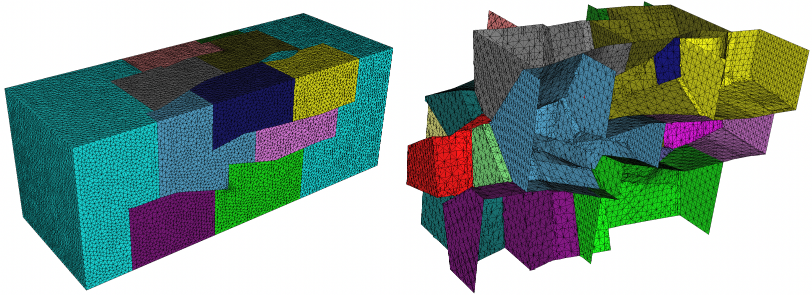

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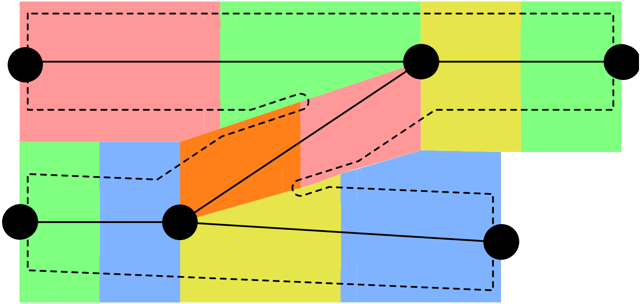

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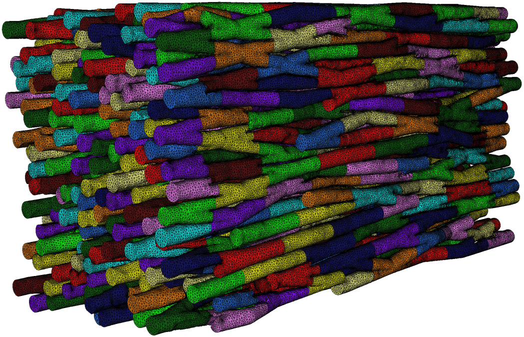
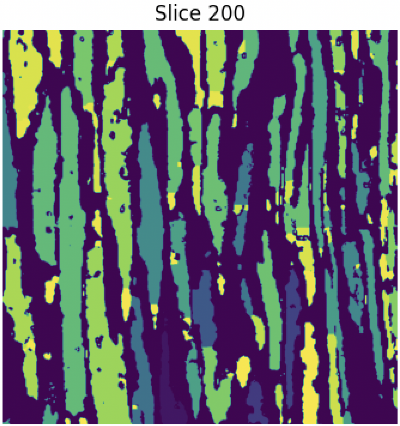


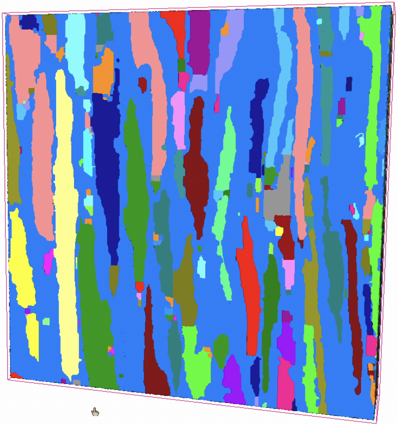
Portion of a mesh of $1mm^3$ of tissue. (M. Potse)

Remeshing in the context of MICROCARD

Mesh generation from segmented images

Mesh decimation with topology preservation: from 1.3G to 19M tetra.





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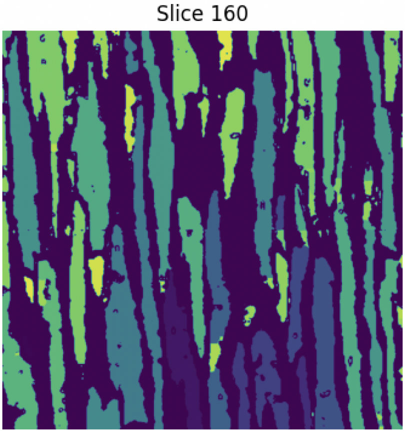

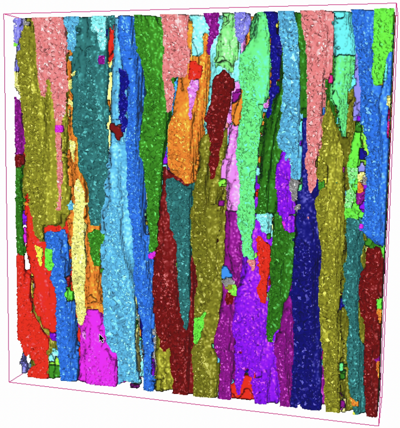

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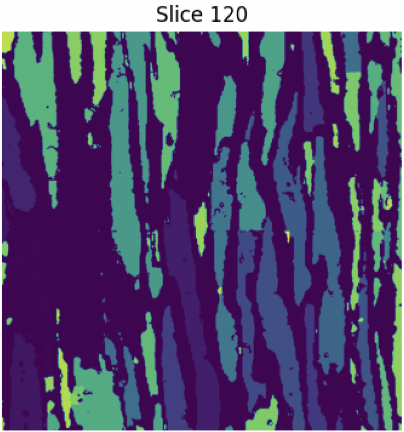

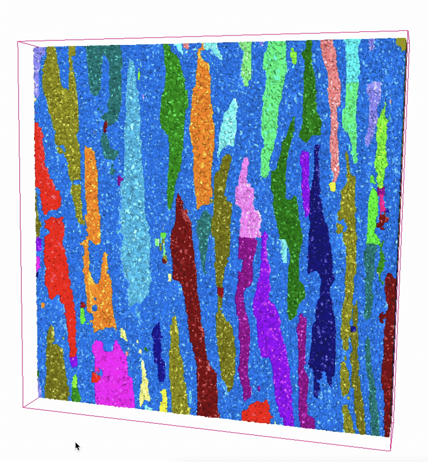

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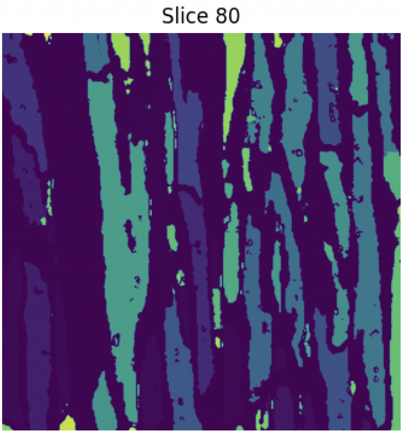

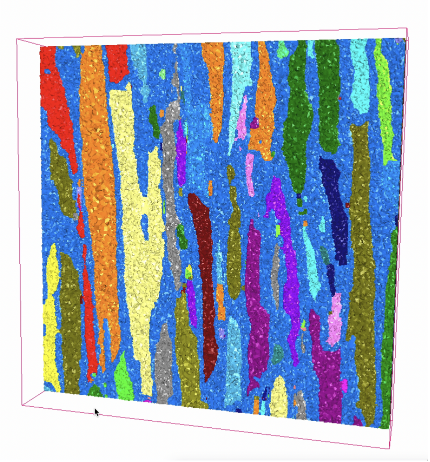

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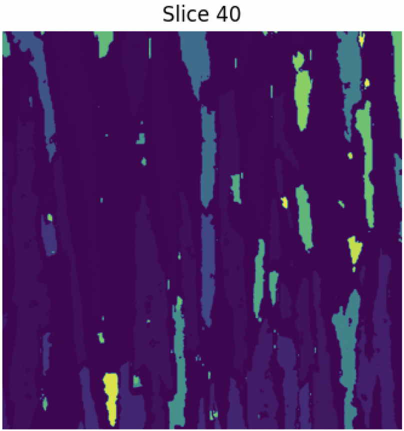

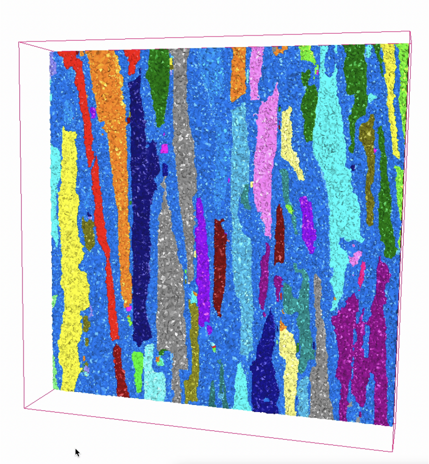

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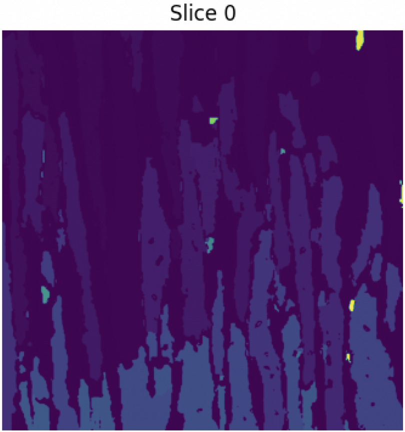

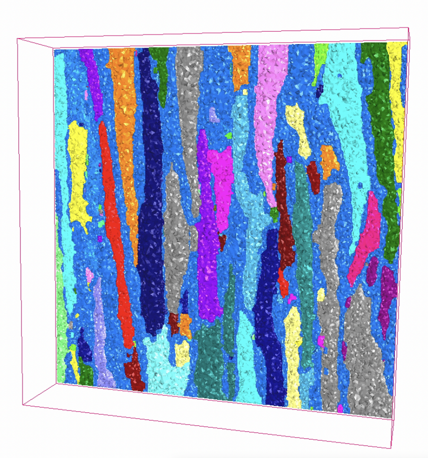

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Conclusion

Latest software developments (release 5.7)

- 64 bit integers support to handle larger meshes
- Surface point positions regularization (-xreg)
- Isovalue discretization along boundaries only (-lssurf)
- Non-bijective multimaterial maps (at the user's risk)

	mmg2d	mmgs	mmg3d
32 bit integers	450 M tria	465 M tria	476 M tetra
64 bit integers	>1.1 G tria	>1. G tria	>1.5 G tetra
mem overhead for 450 M elts	∼19 Gb	∼19 Gb	∼16 Gb

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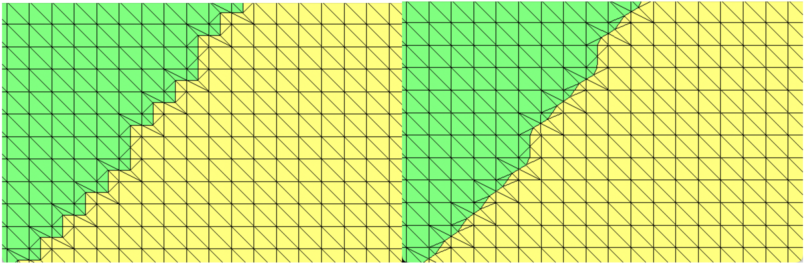

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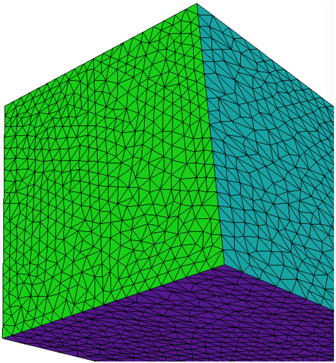

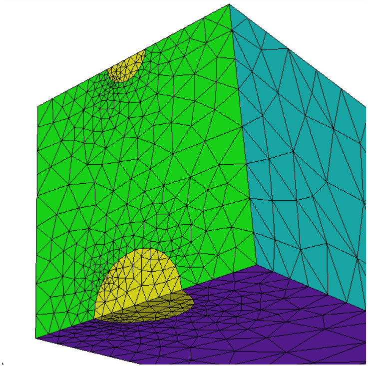

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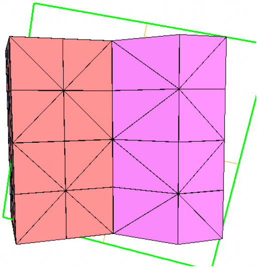

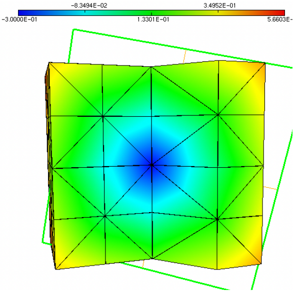

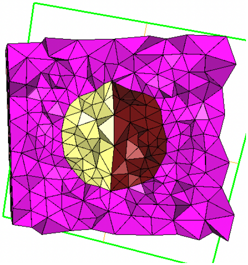

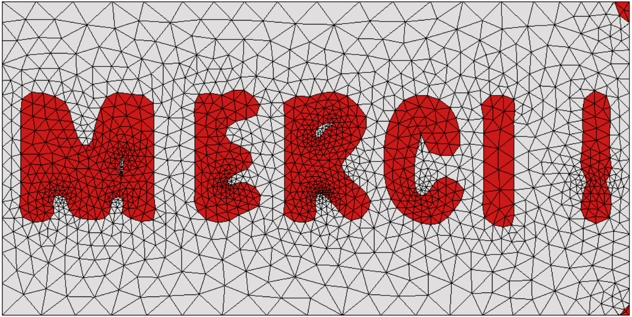

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