- Cassiopée -

Pre- and Post-processing for CFD python CGNS workflow

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CFD Workflow : Meshing, Solving, Visualizing...

OSD : Onera Scientific Day – October 3rd, 2012

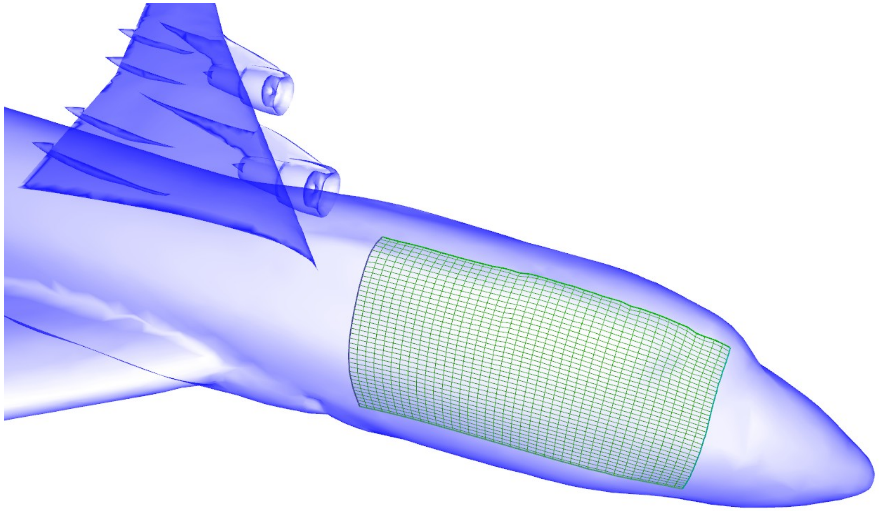
Python/CGNS

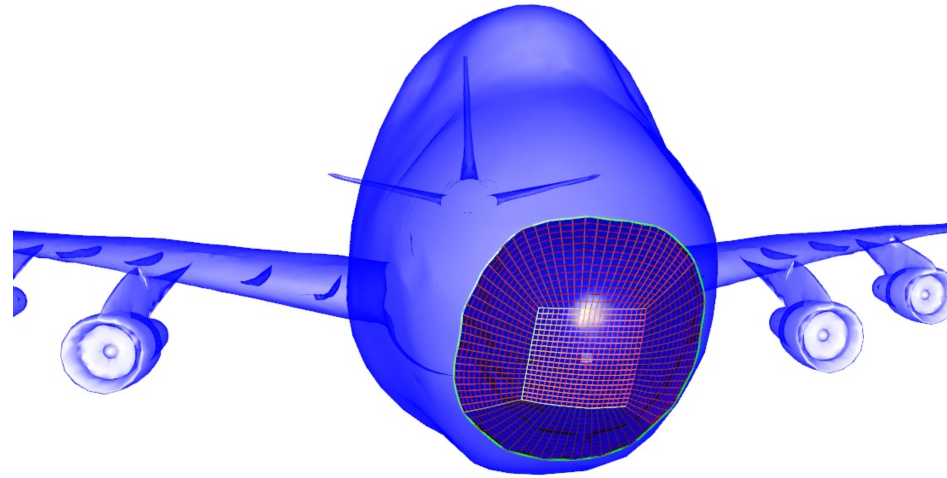
- Based on Python/CGNS
  - CGNS: standard/well established data model
  - Python: high level script language, easy to use
  - Python/CGNS standard (M. Poinot)

Python/CGNS

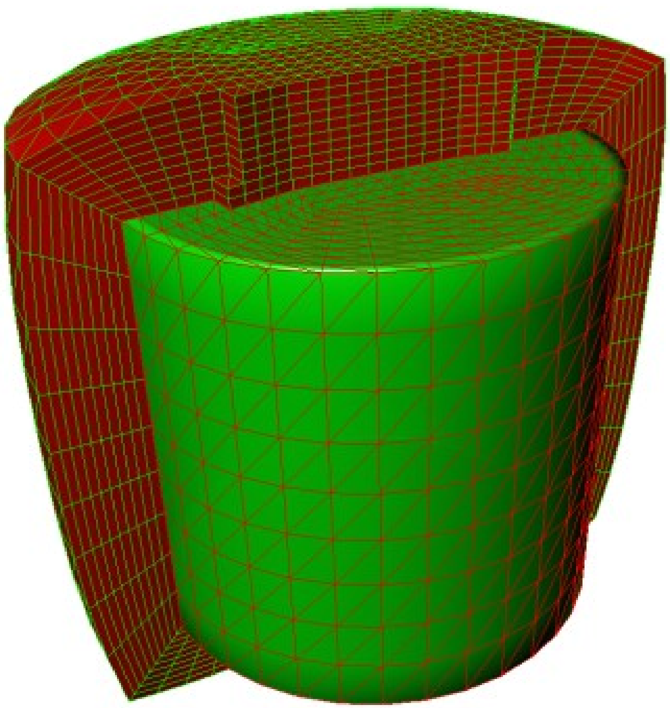
- Full CFD computation case is stored in a tree
  - Meshes, BCs, settings...
- Tree is stored as an imbricated set of python lists
- Cassiopée: a set of functions (python modules)
  - t' = f(t), t is the python CGNS tree
  - Generator : Mesh generation module
  - Transform : block transformation module
  - Connector : connectivity module
  - Post : solution post-processing module

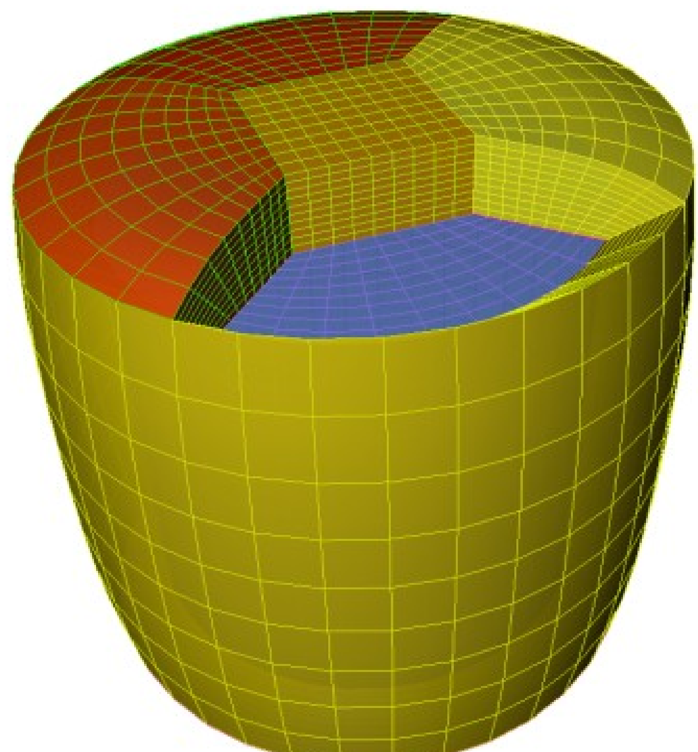
Generator





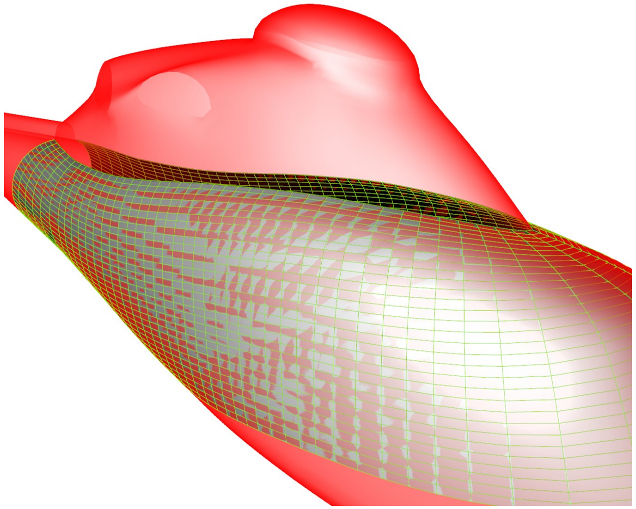
TFIs



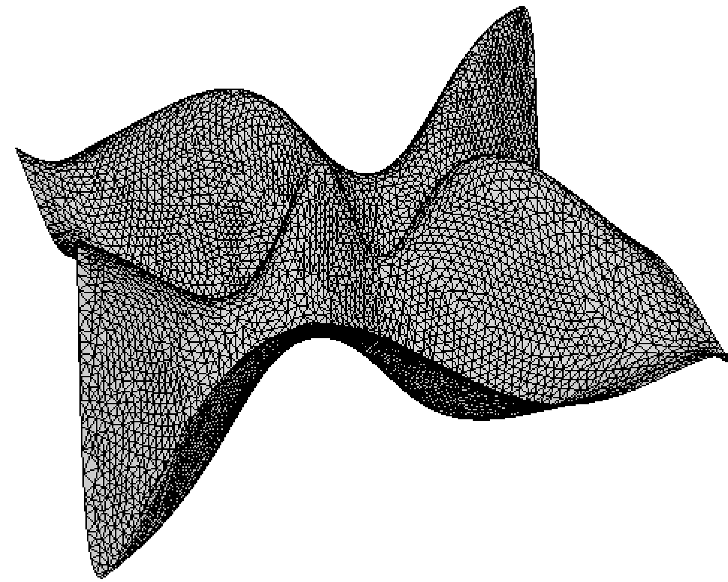


Normal extrusion

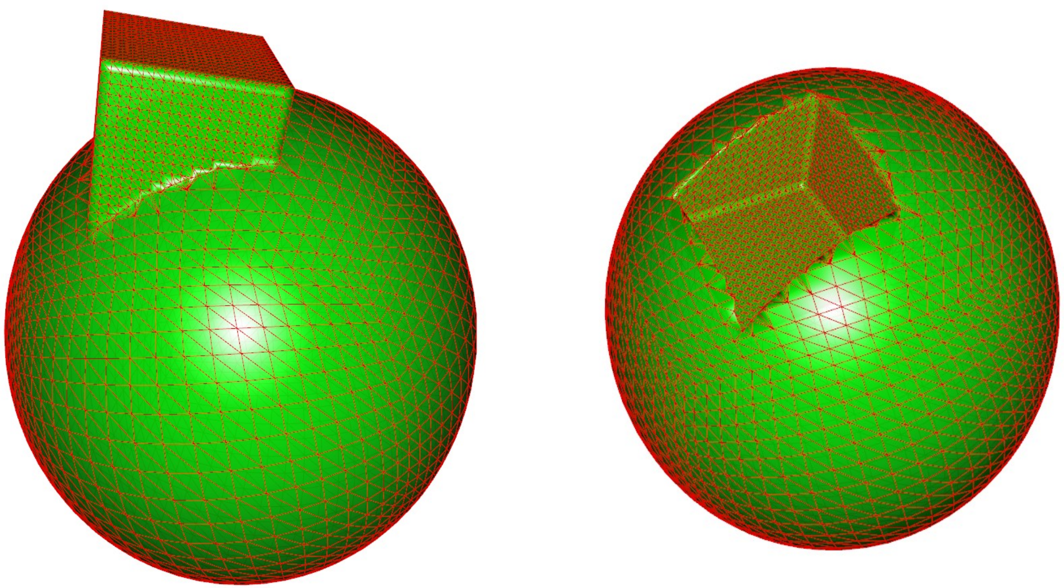
Generator



Surface orthogonal walk

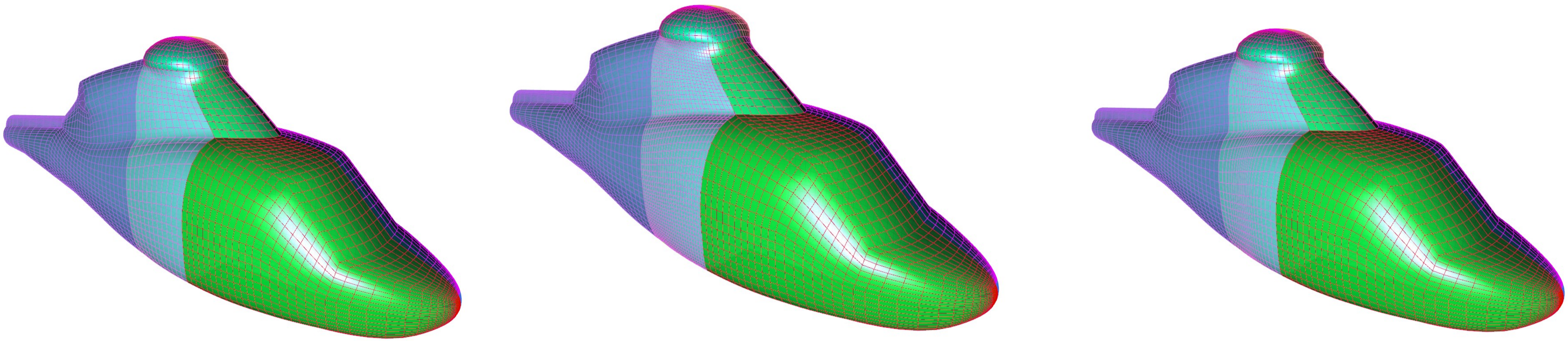


Surface delaunay

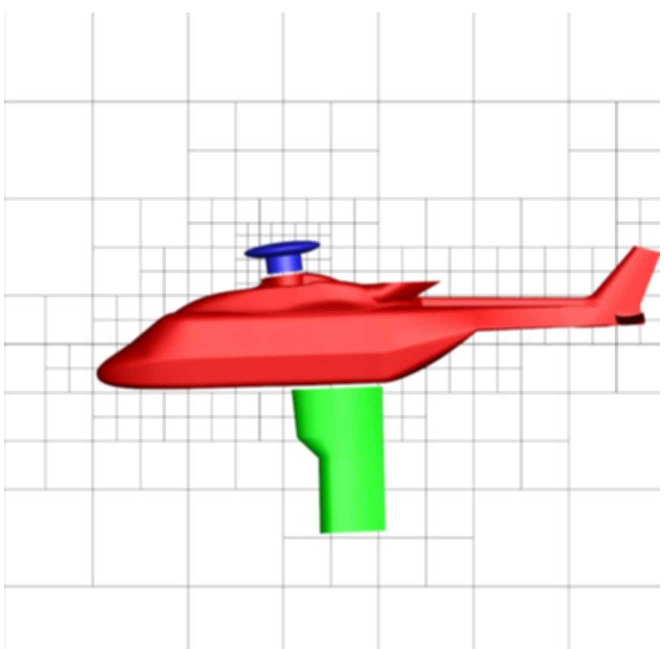


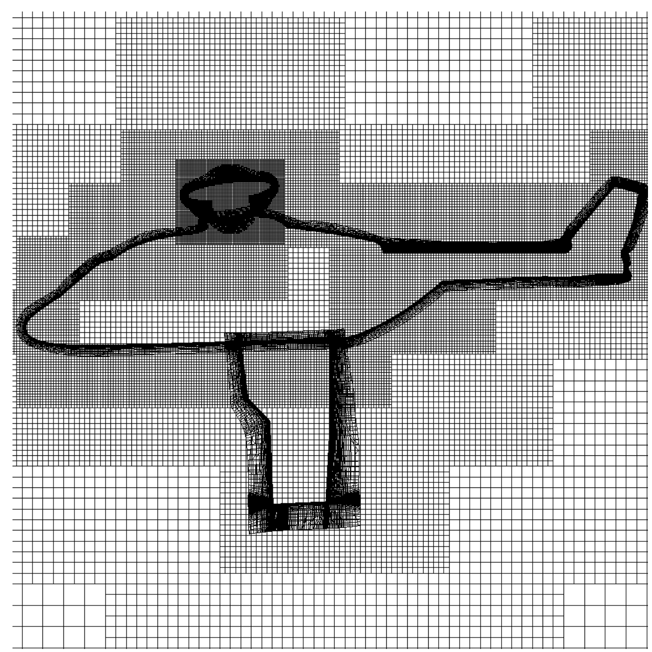
Surface boolean operators

Generator



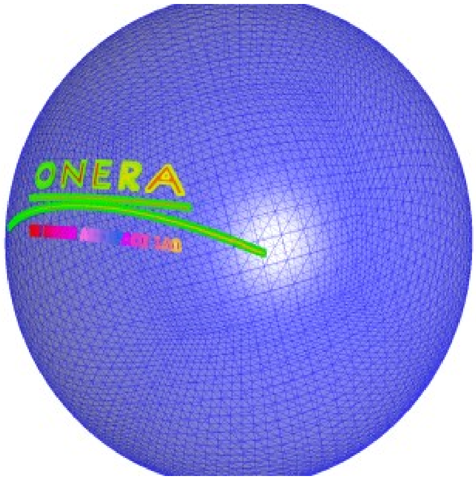
Mesh refinement



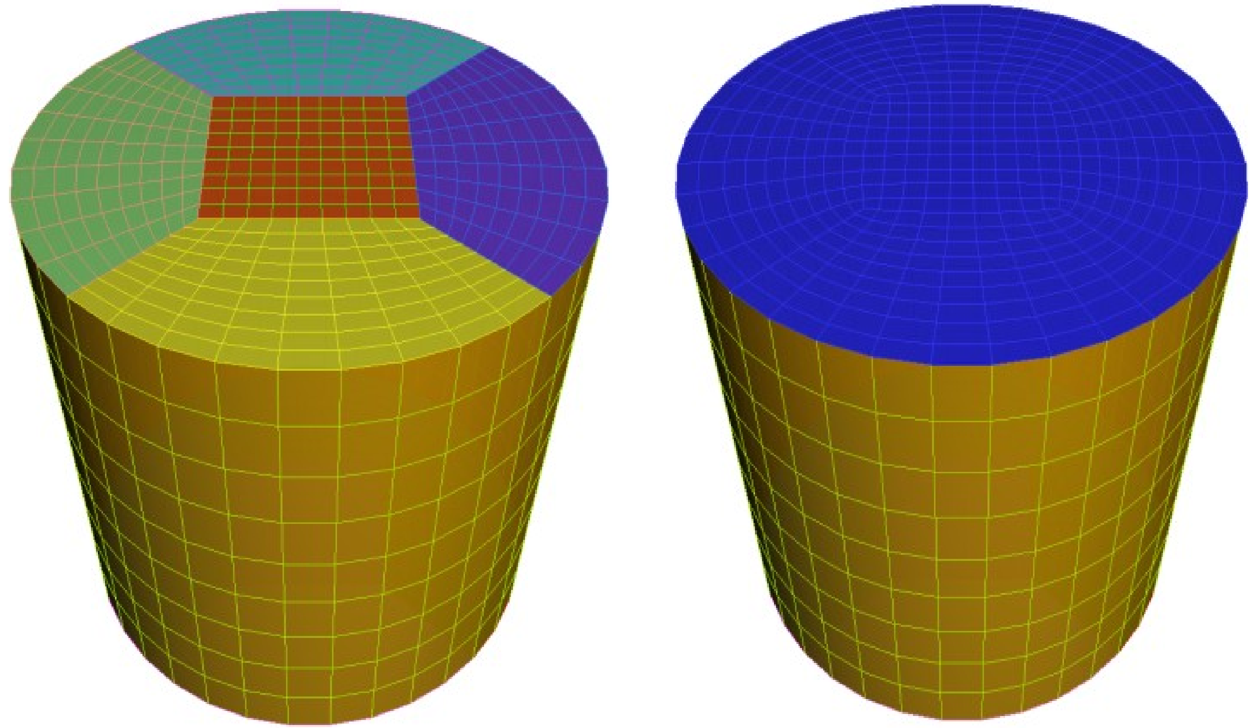


Octrees

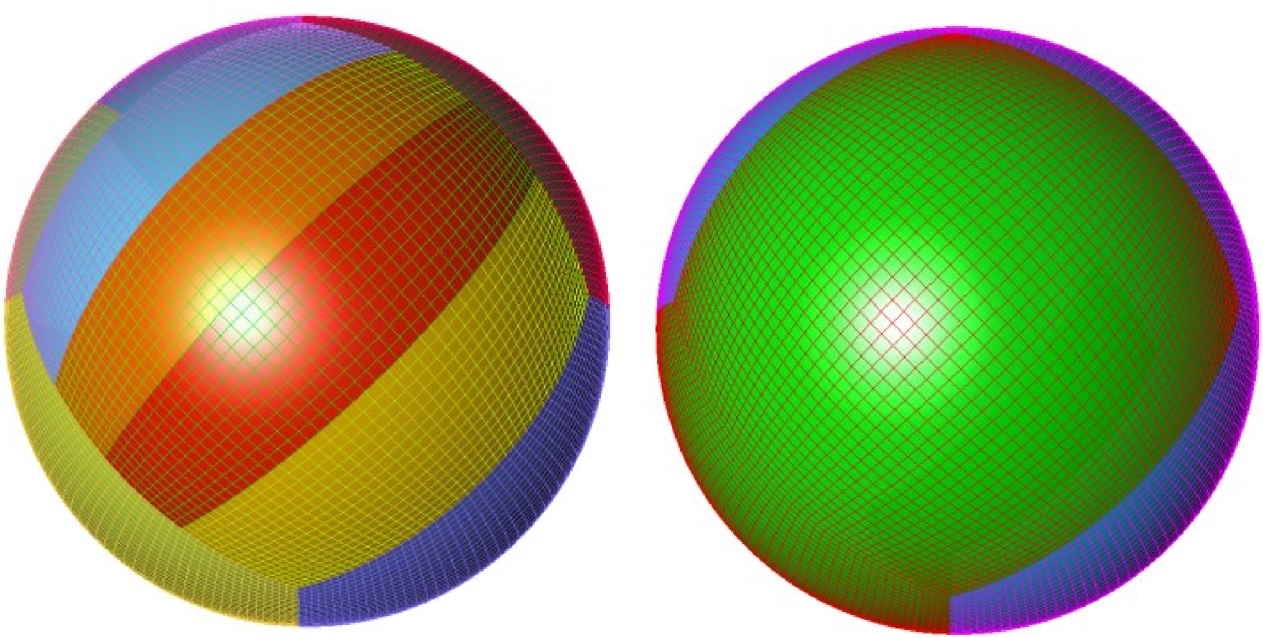
Transform



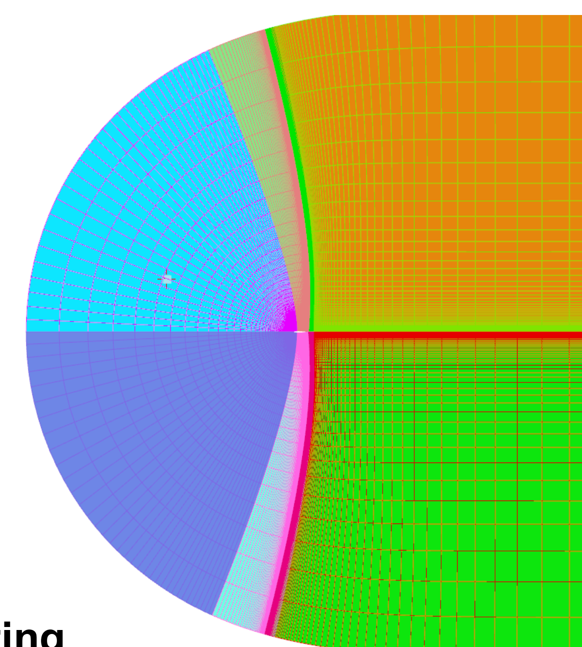
Projections



Mesh smoothing

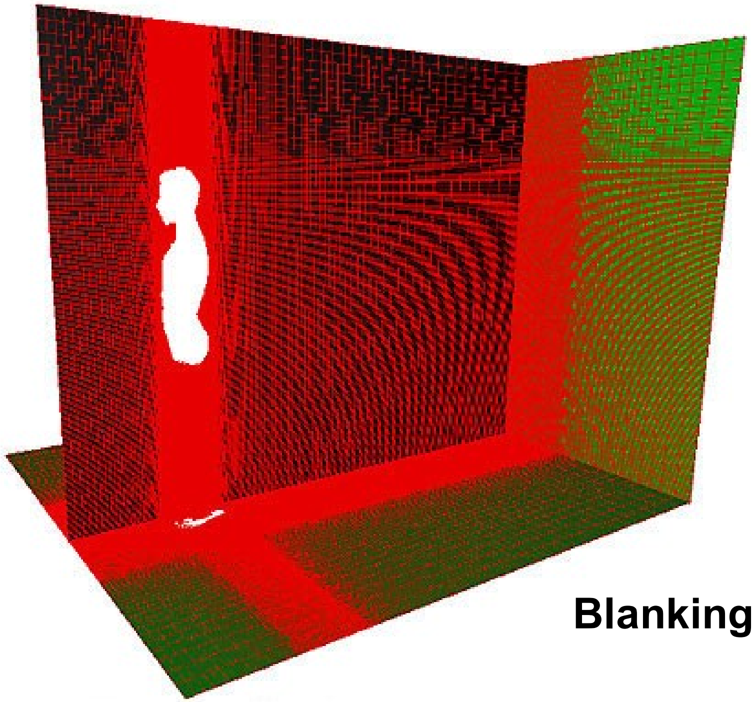


Mesh merging

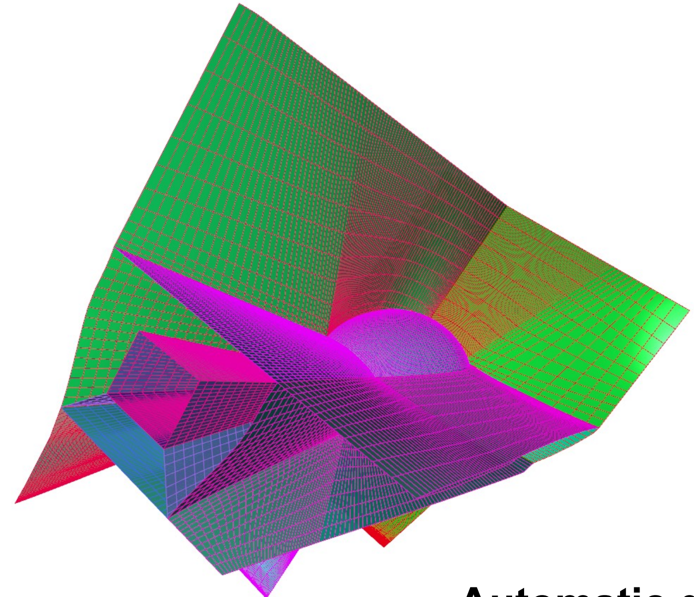


Mesh splitting

Connector

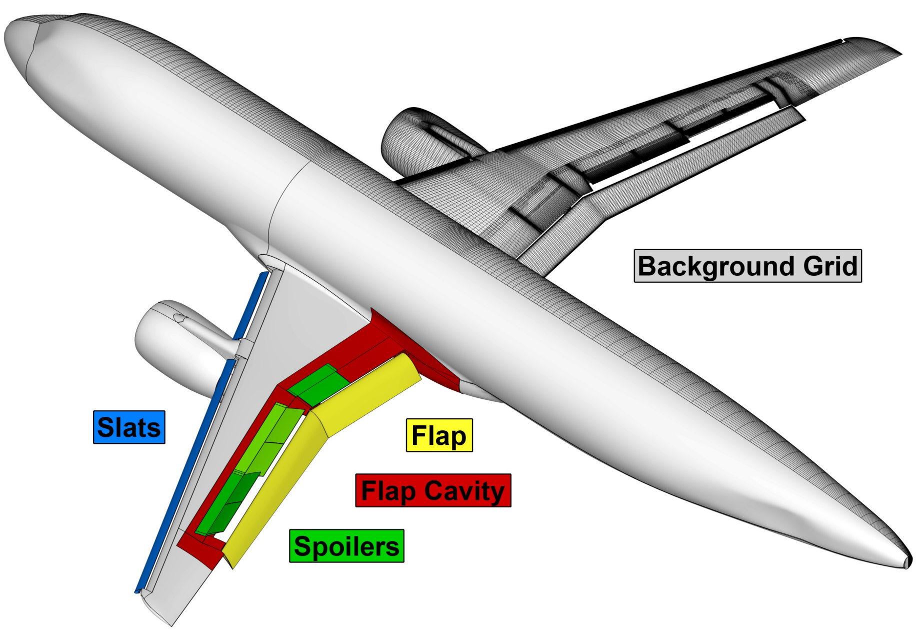


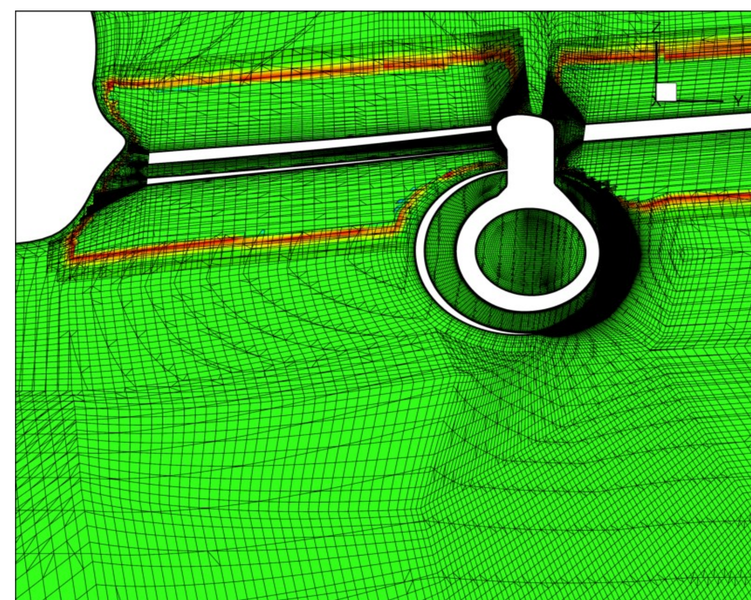
Blanking



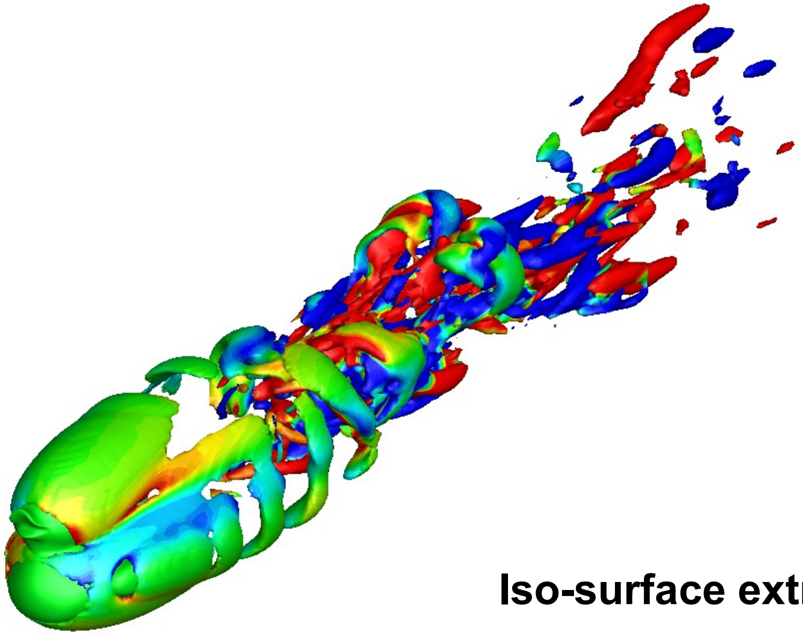
Automatic detection of matching boundaries

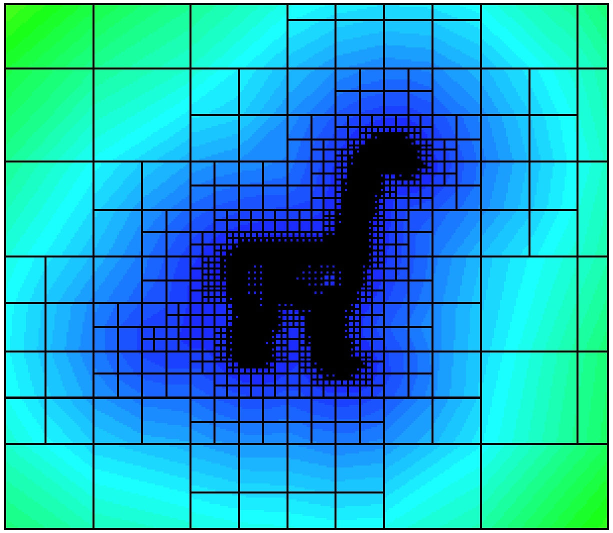
Chimera connectivity : overlap optimization, interpolation coefficient computation





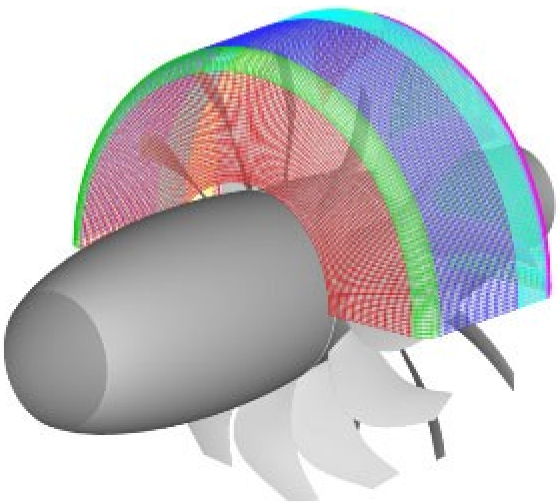
Post

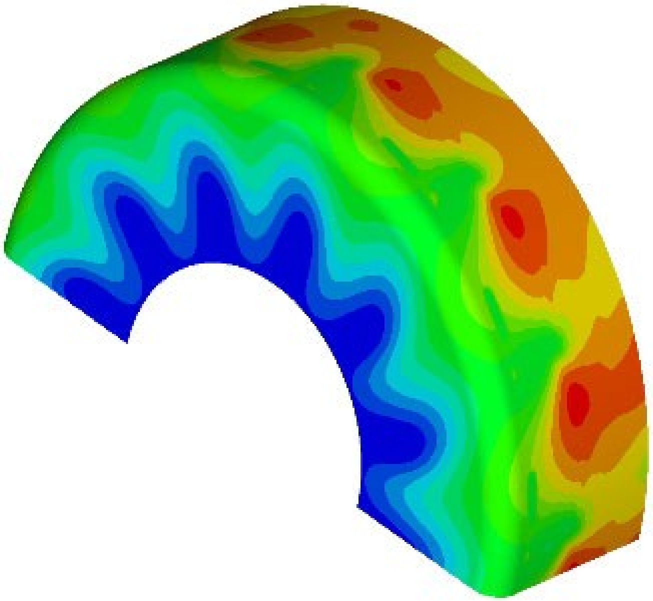




Iso-surface extraction

Signed distance field

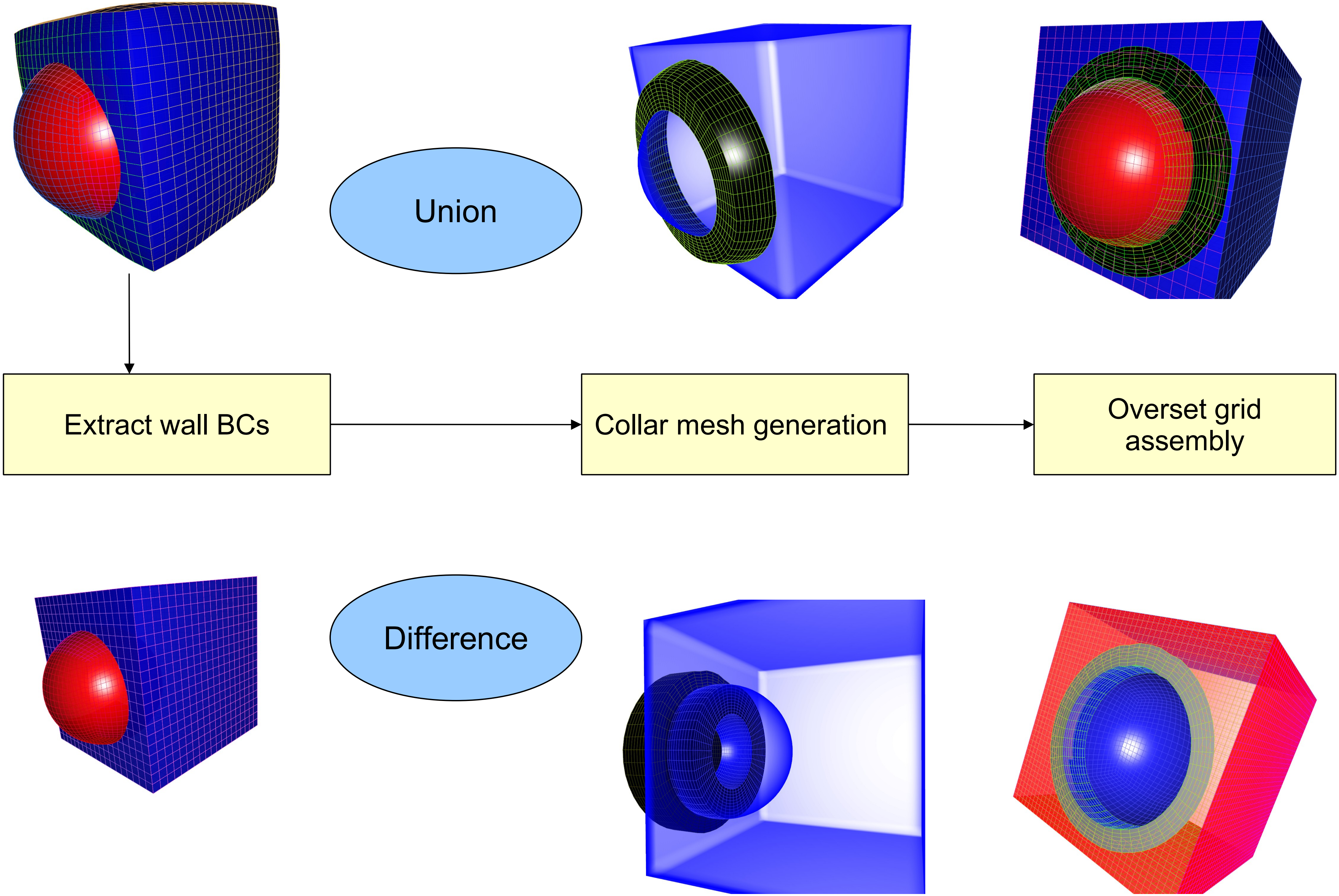




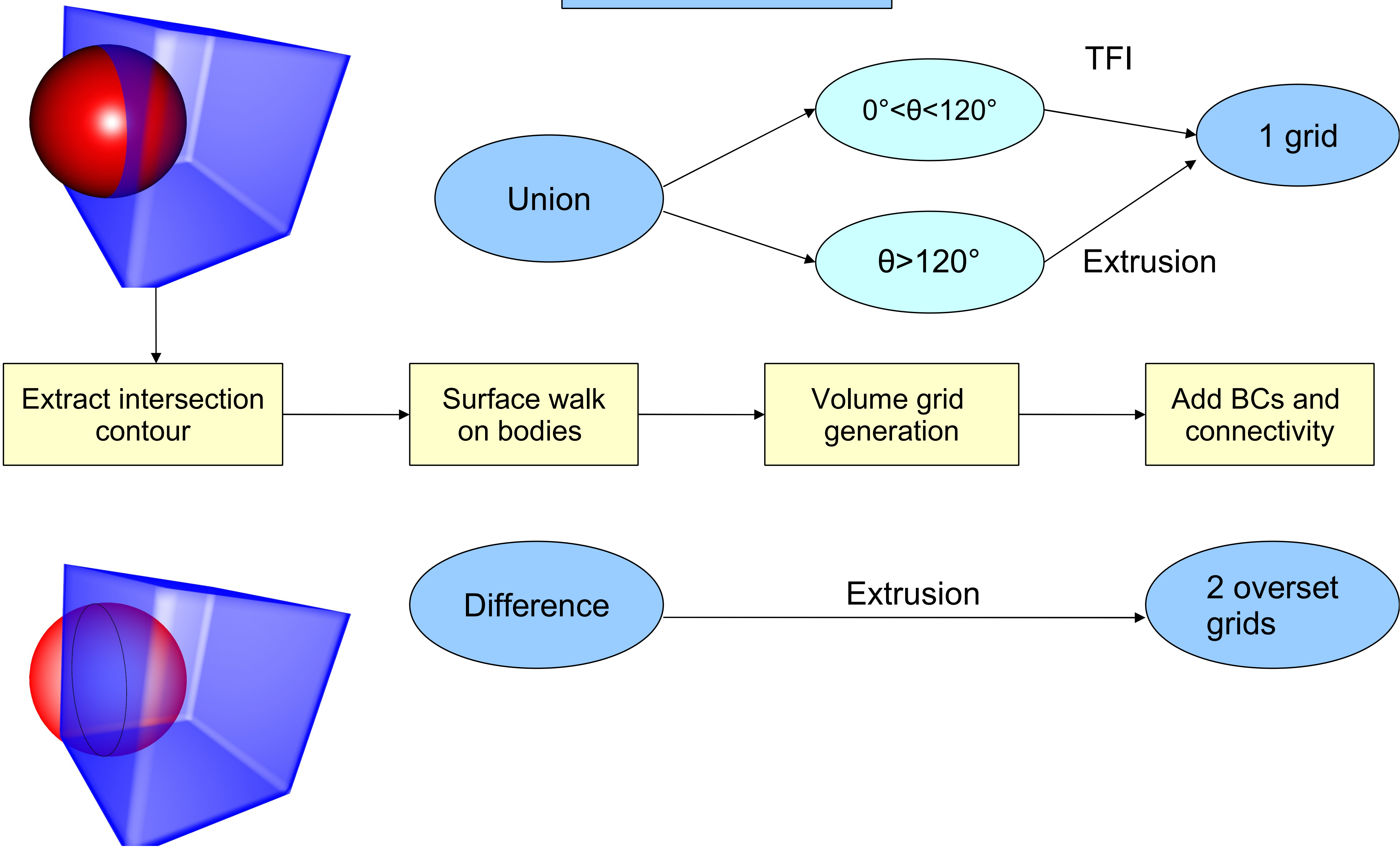
Surface extraction

Application to automatic grid assembly (collar grids + chimera)

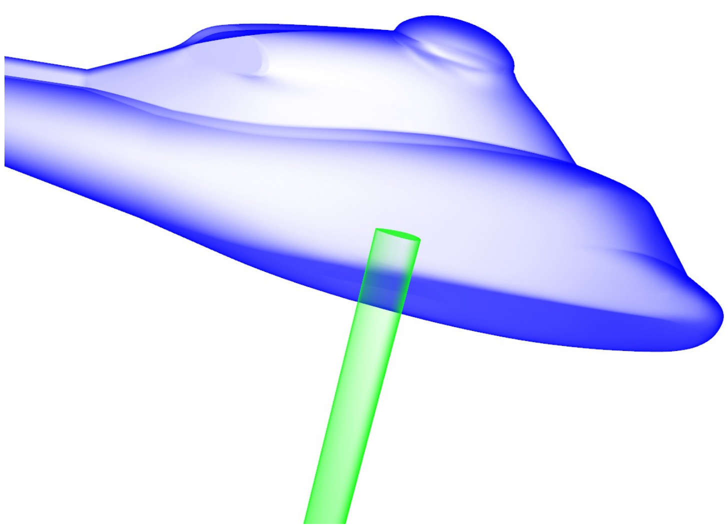
Workflow

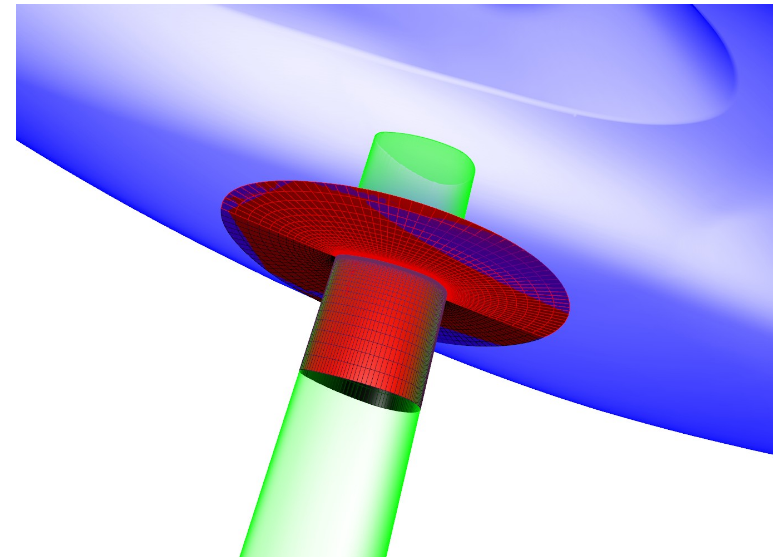

Union
Extract wall BCs
Collar mesh generation
Overset grid assembly
Difference

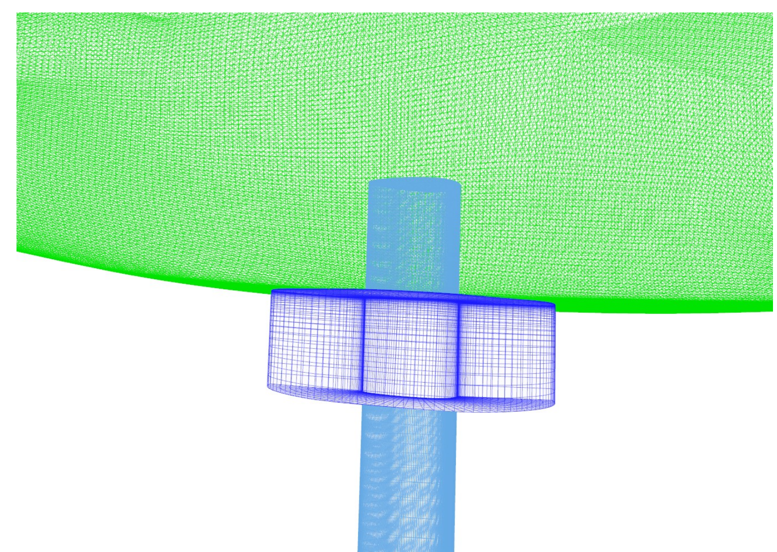
Collar mesh generation



Example : DGV fuselage with a strut







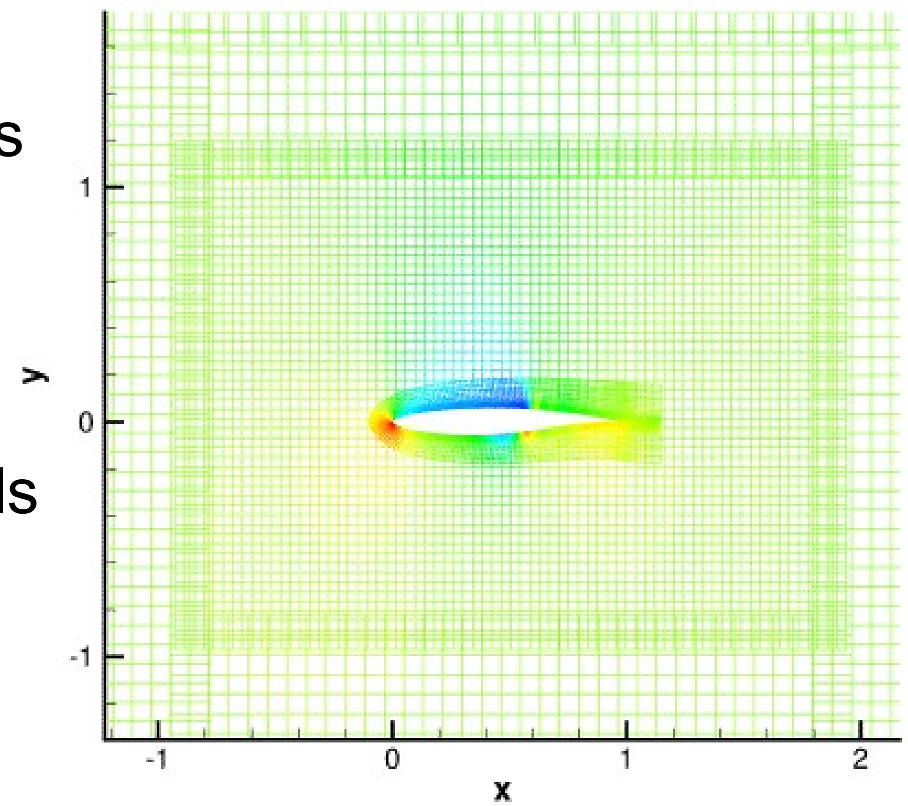
Application to Cartesian mesh generation and adaptation

Framework

- The computational domain is partitioned into:
  - near-body regions around bodies (fuselage, wing, ...)
  - off-body regions

- Each geometrical component is meshed independently by a set of grids extending a short distance in the domain

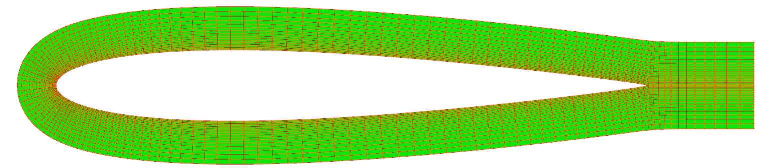
- Off-body regions are described by a set of adaptive Cartesian grids, overlapping near-body grids

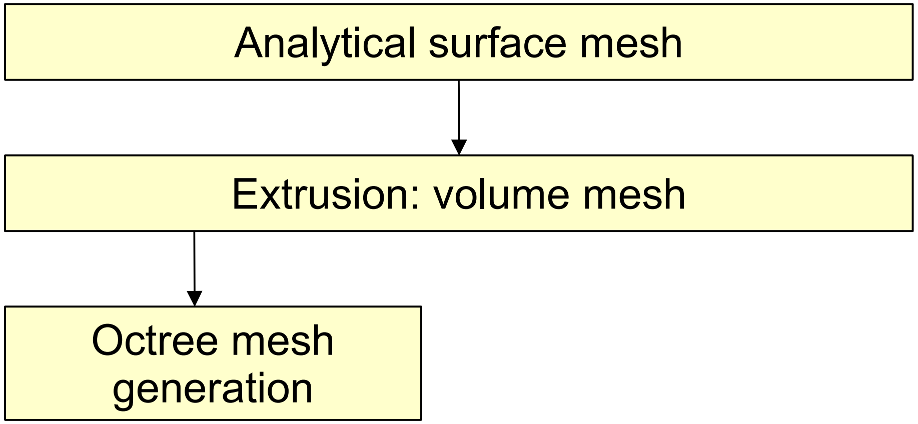


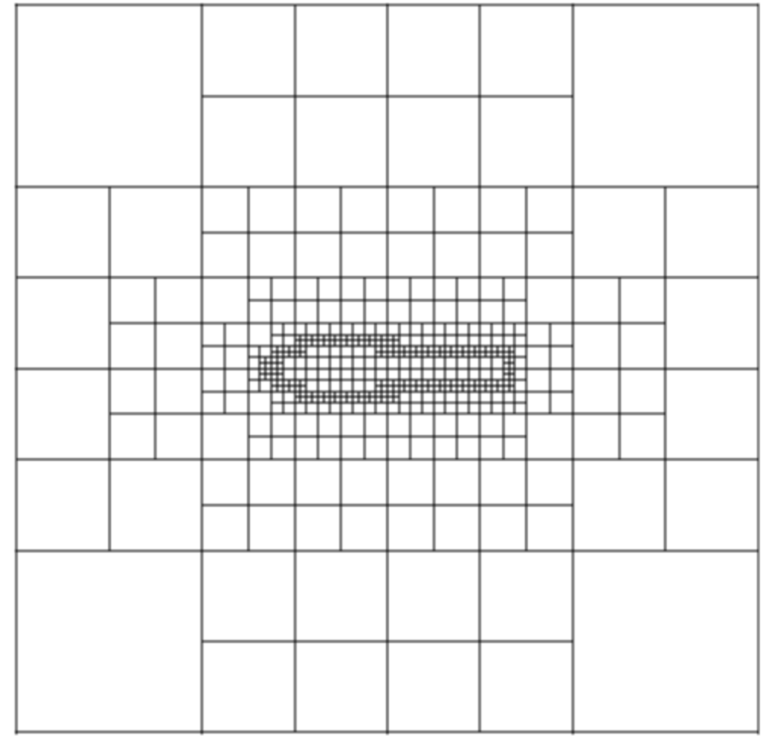
Analytical surface mesh

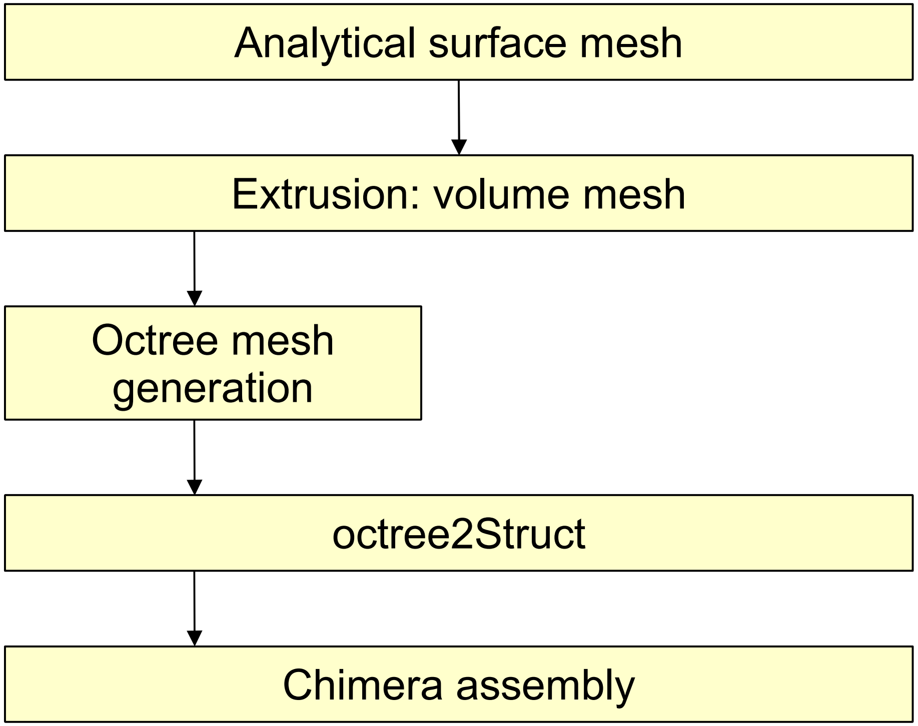
↓

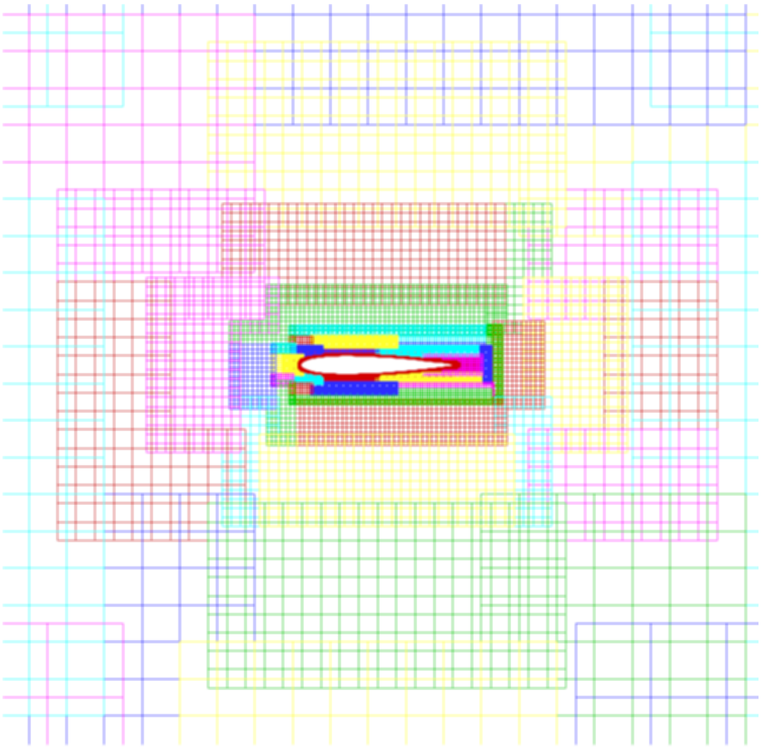
Extrusion: volume mesh

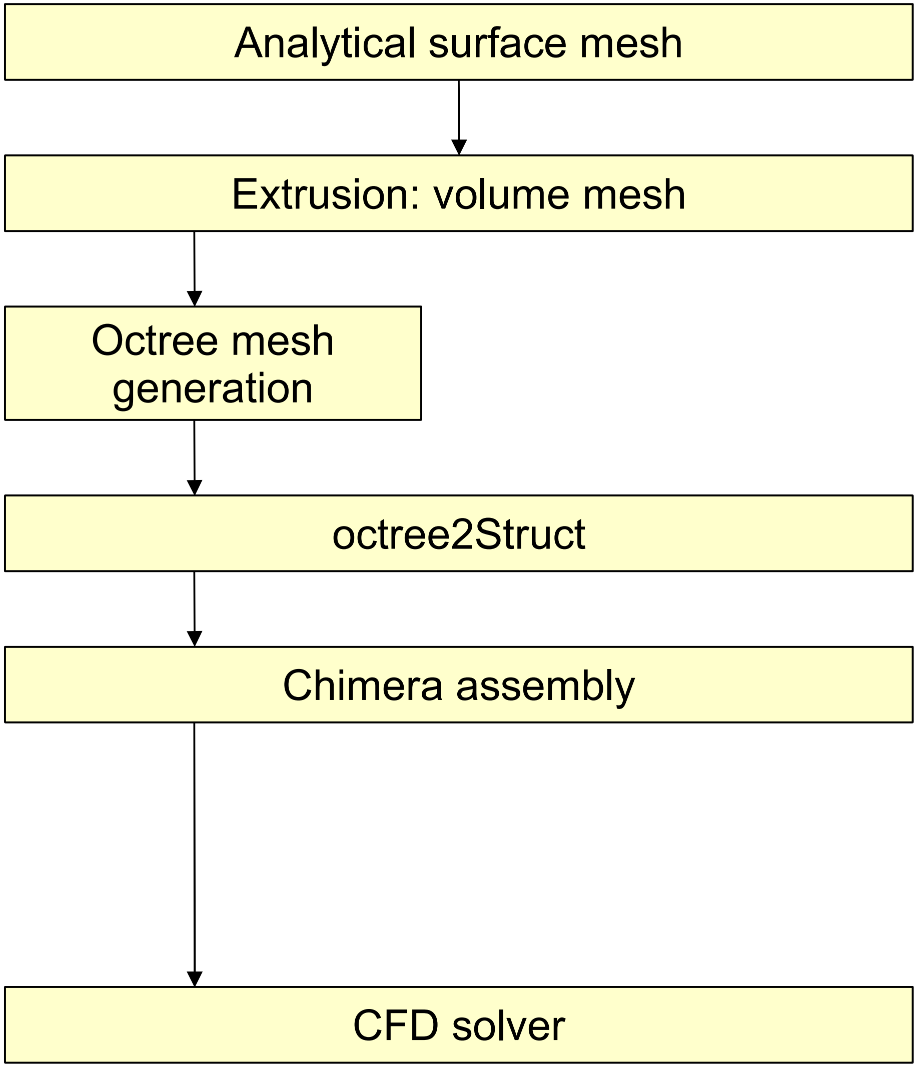


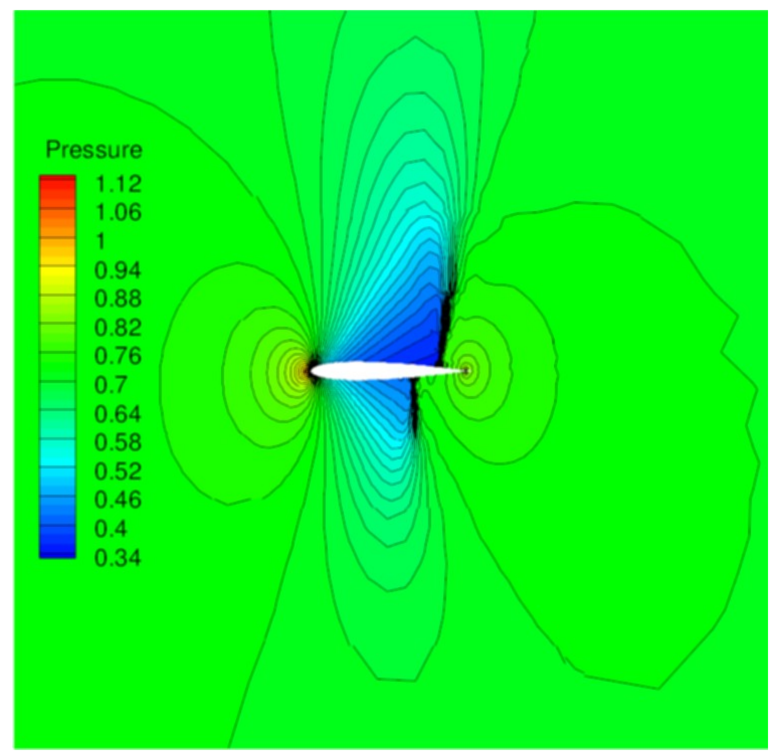

Analytical surface mesh
Extrusion: volume mesh
Octree mesh generation

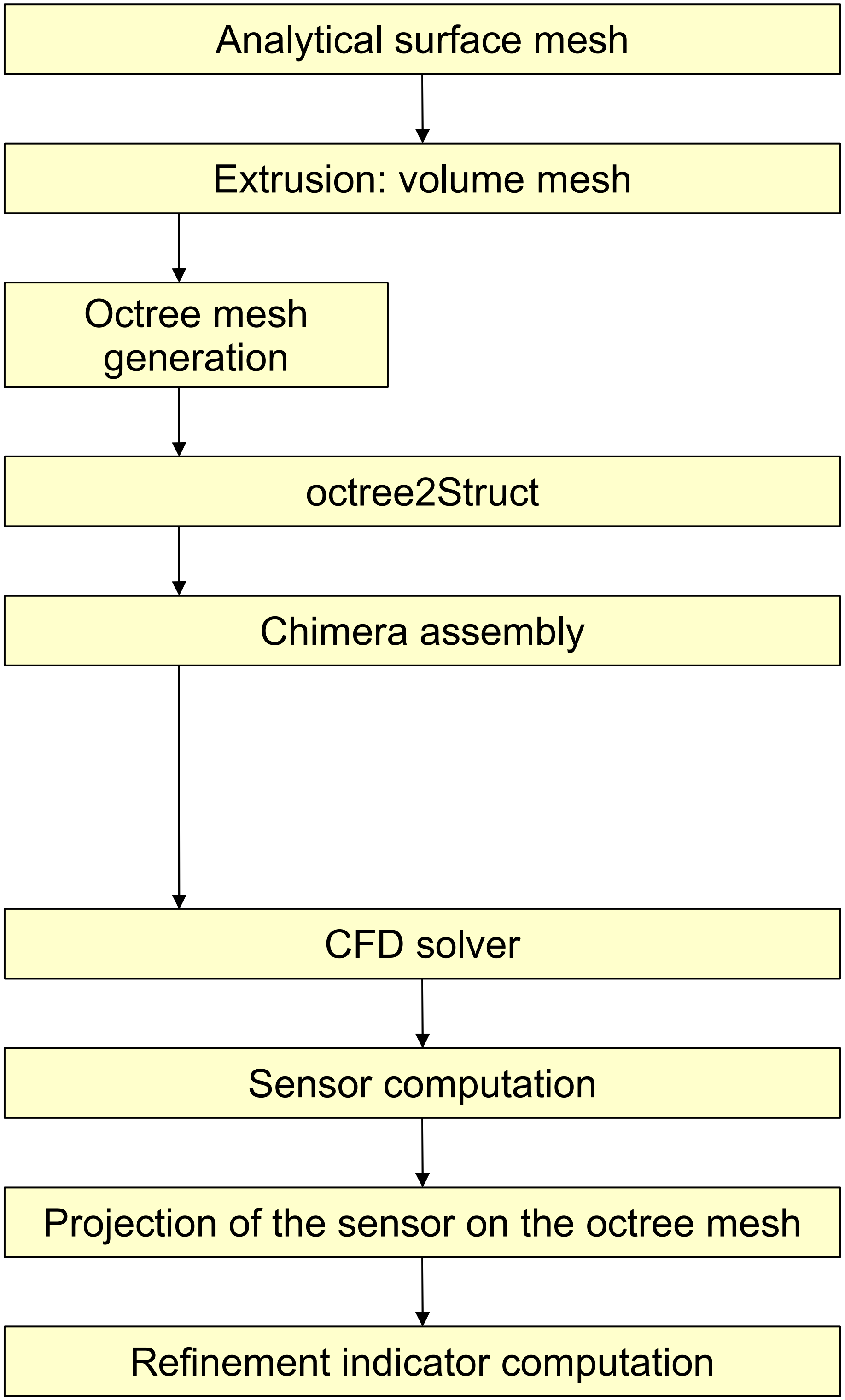



Analytical surface mesh
Extrusion: volume mesh
Octree mesh generation
octree2Struct
Chimera assembly




Analytical surface mesh
Extrusion: volume mesh
Octree mesh generation
octree2Struct
Chimera assembly
CFD solver


Pressure
1.12
1.06
1
0.94
0.88
0.82
0.76
0.7
0.64
0.58
0.52
0.46
0.4
0.34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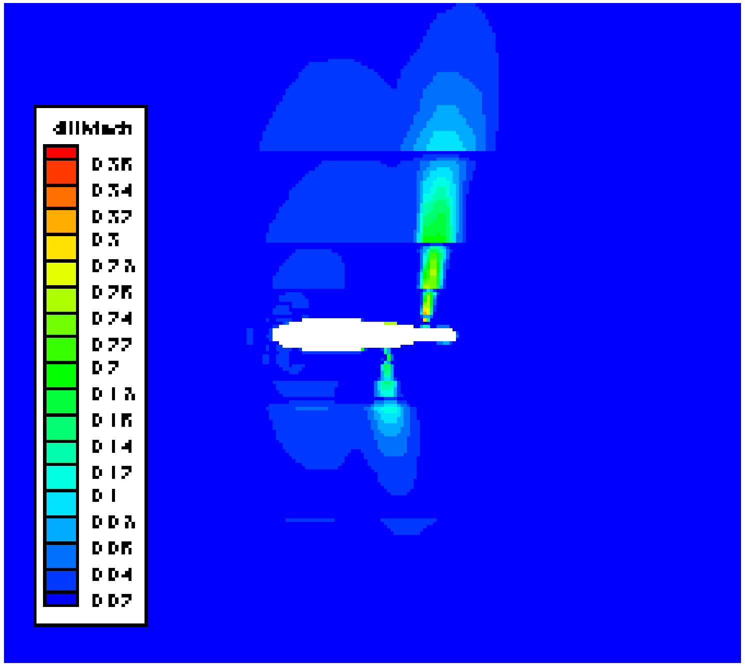
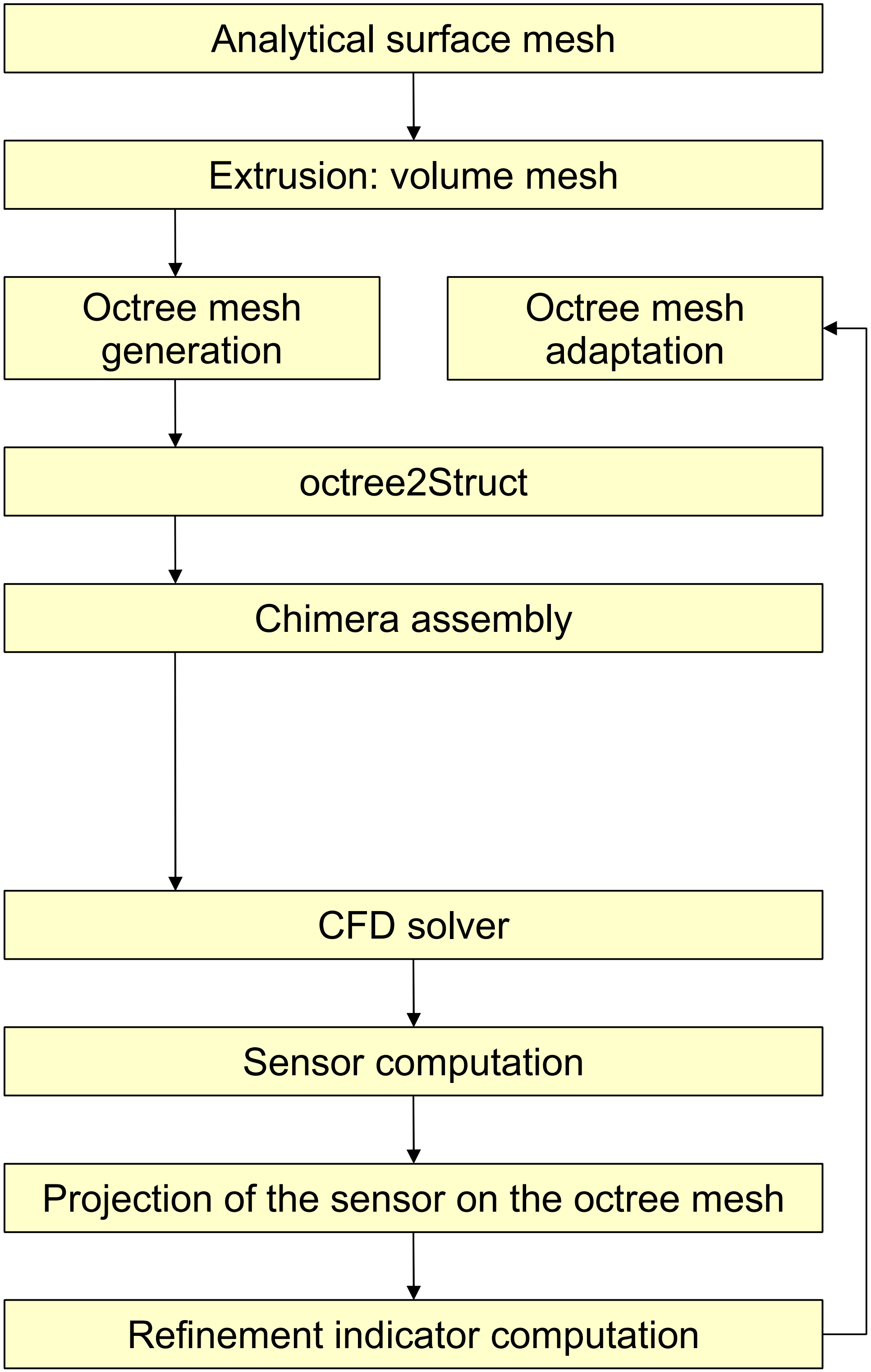
Chimera assembly
CFD solver
Sensor computation
Projection of the sensor on the octree mesh
Refinement indicator computation

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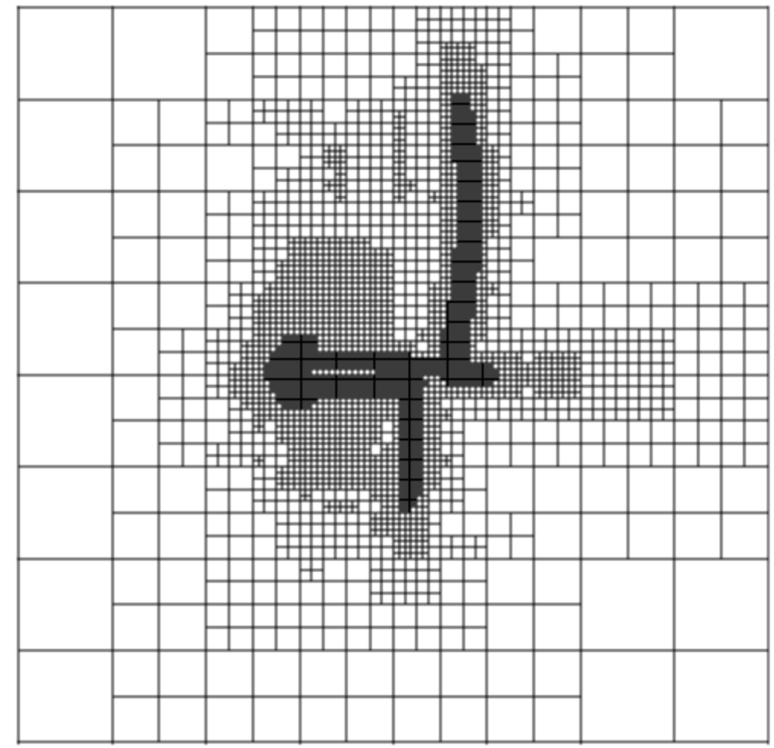

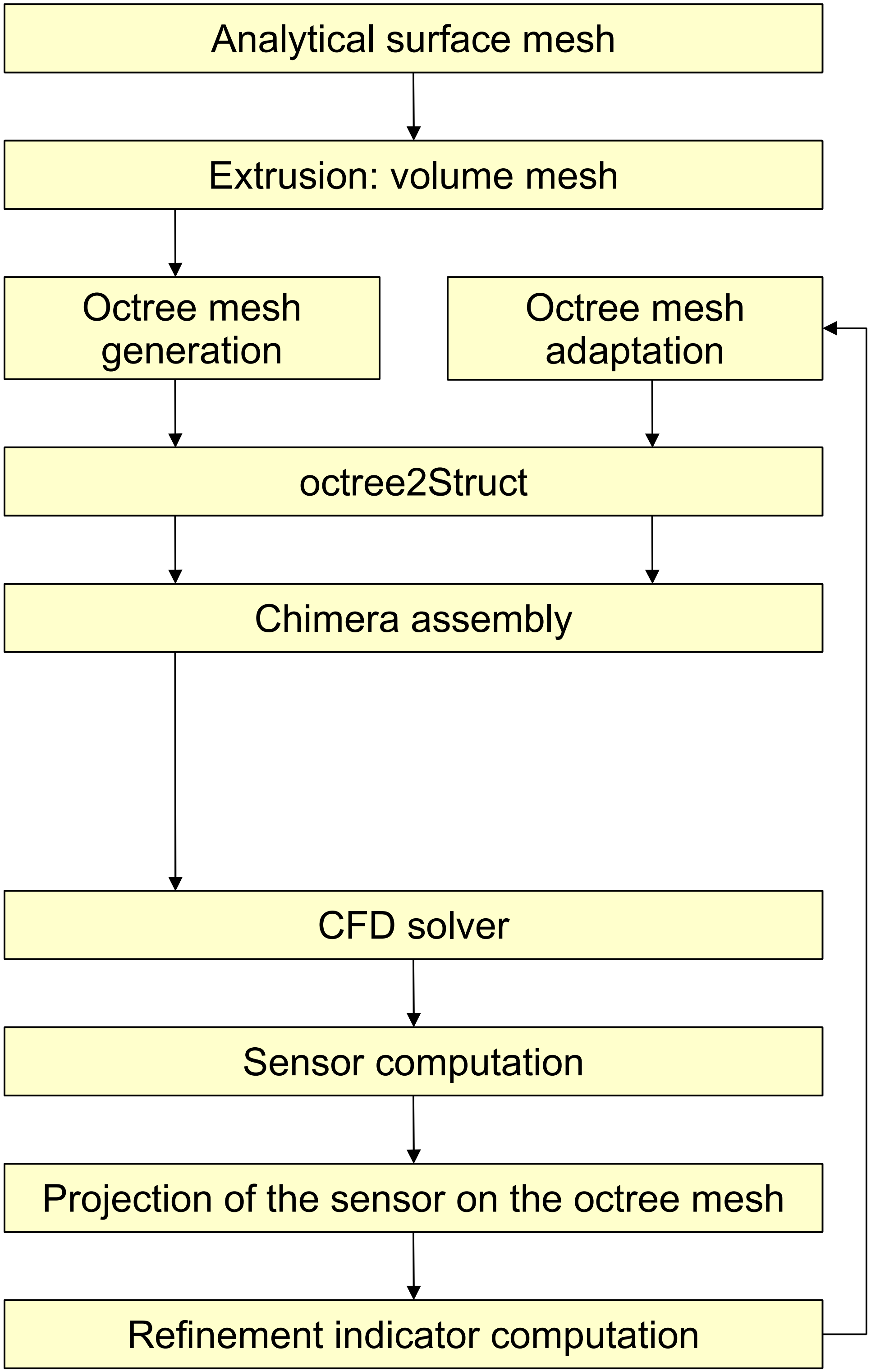
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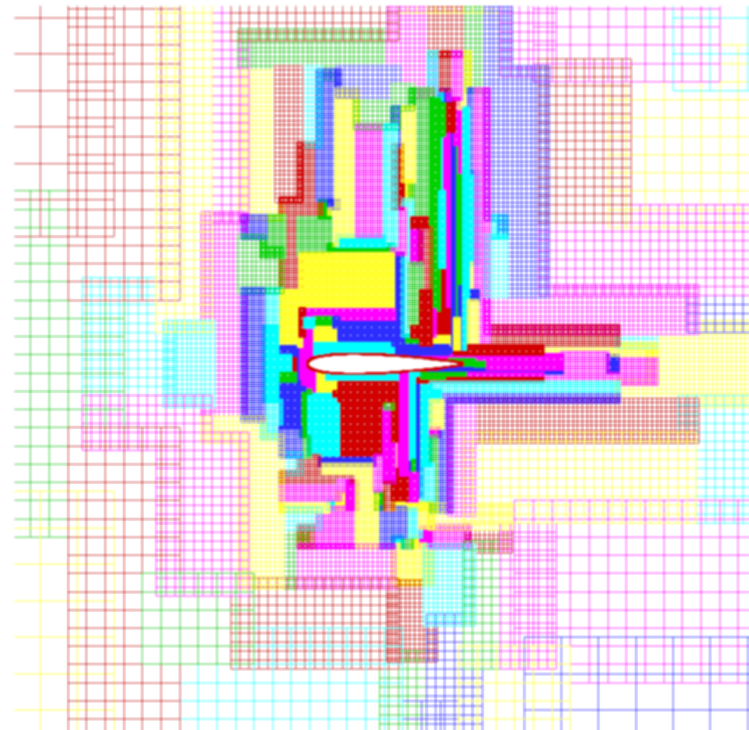

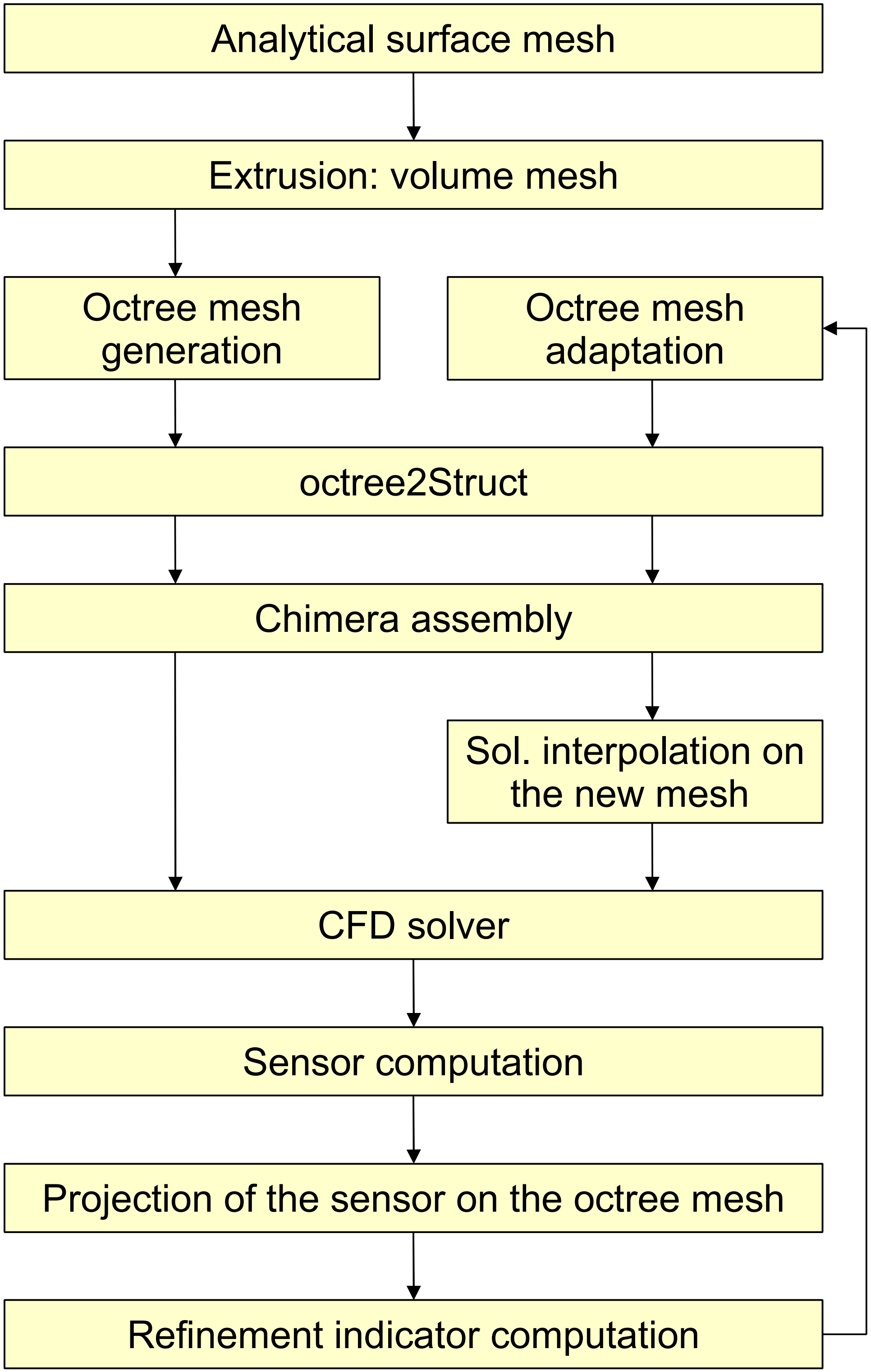
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Sol. interpolation on the new mesh
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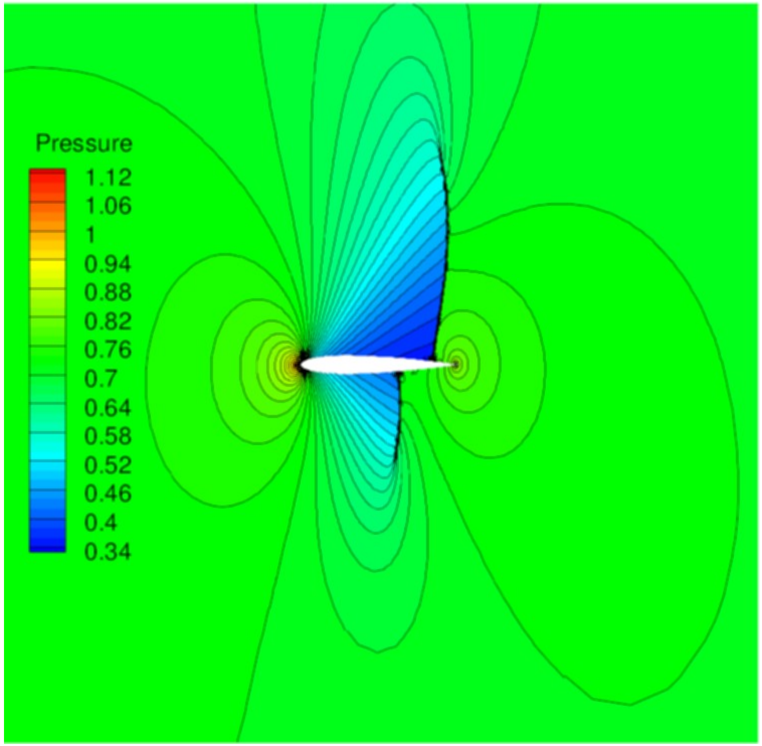
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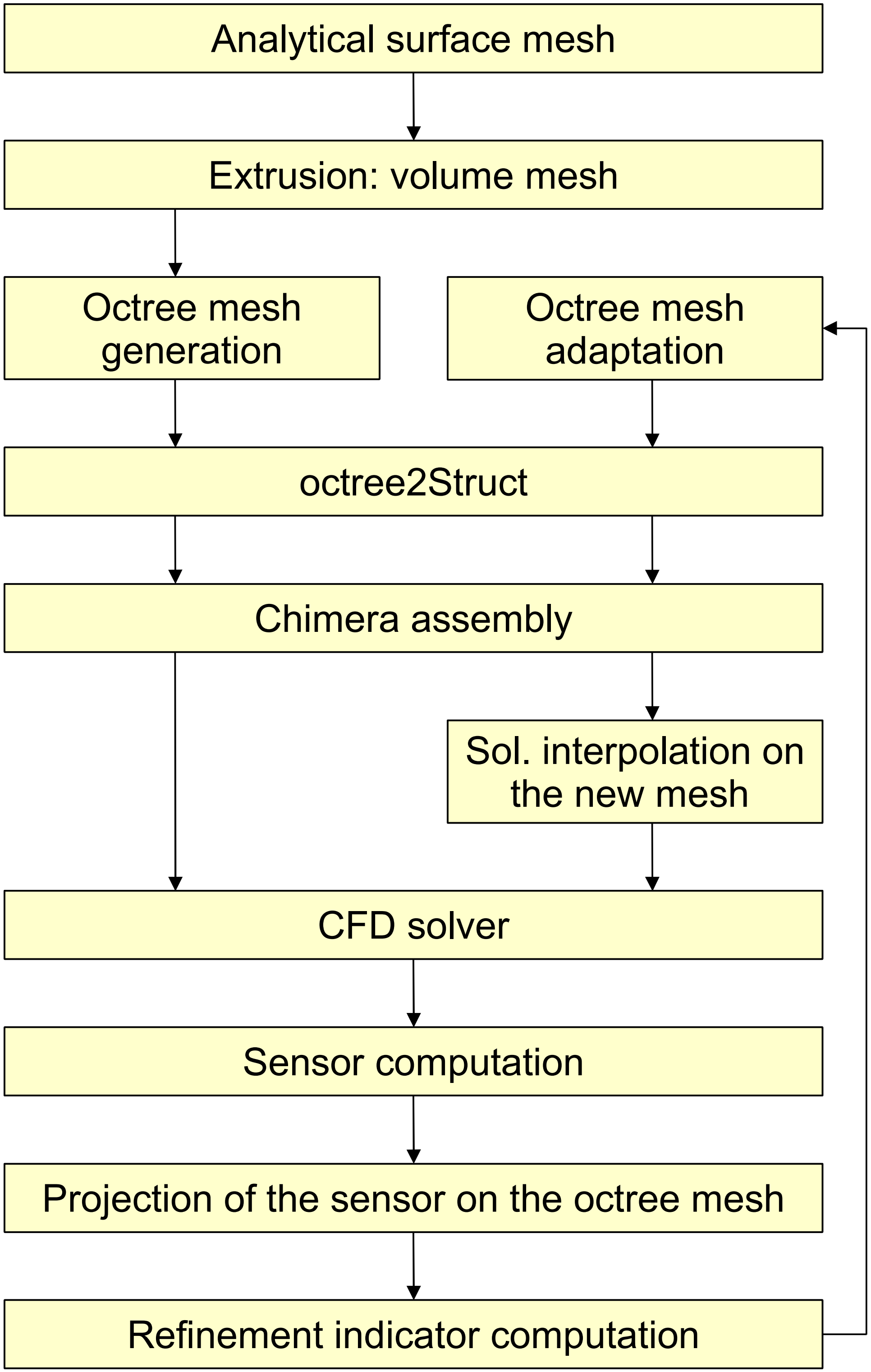
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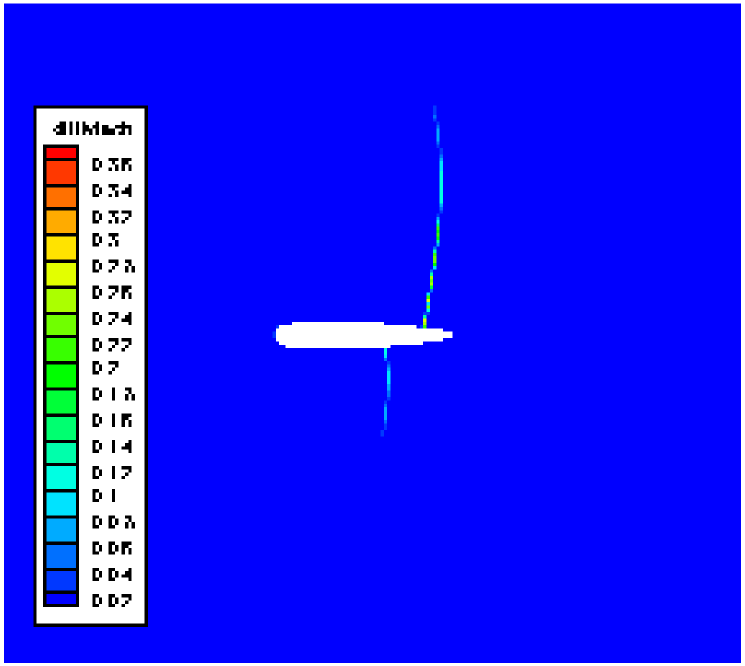
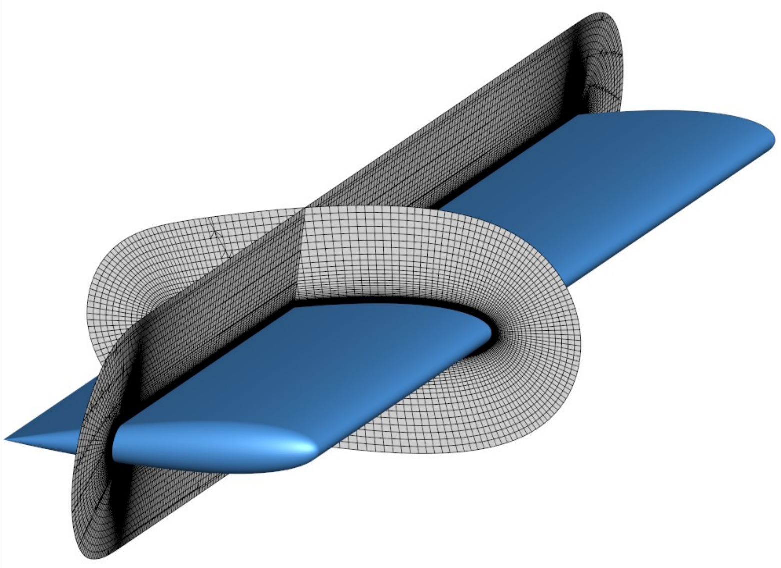


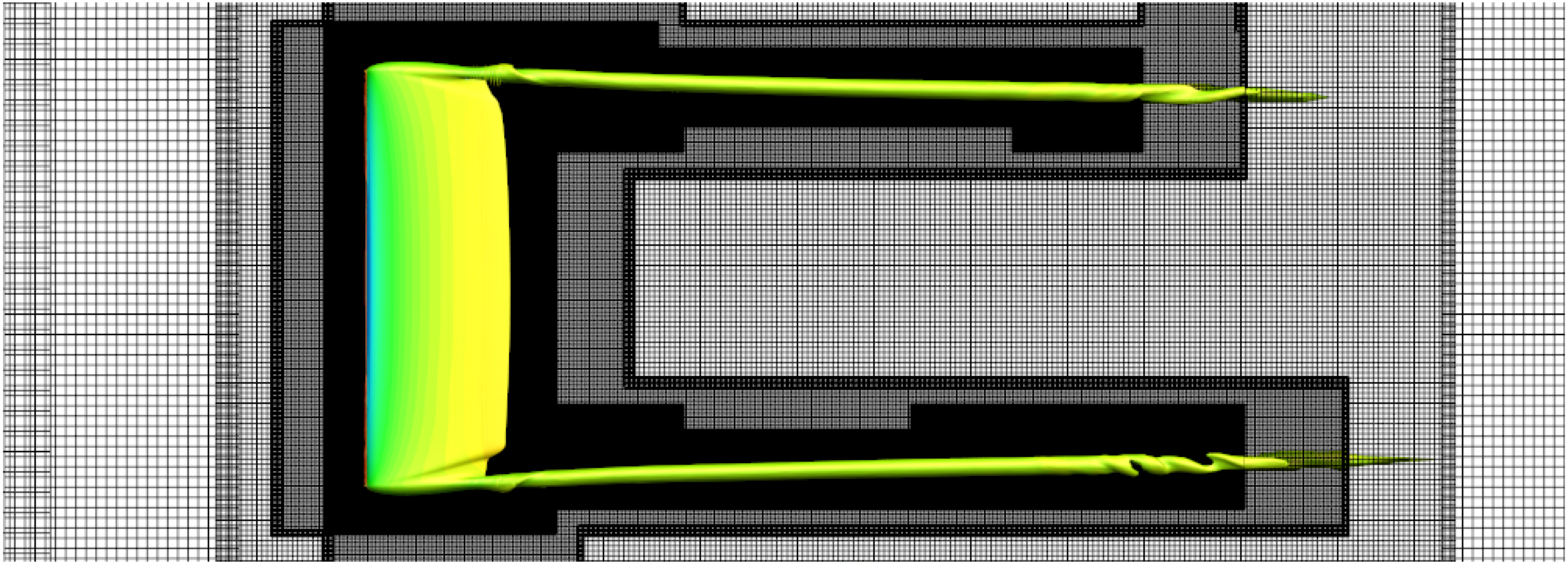
Example: RANS simulation of the flow on a NACA0015 rounded tip wing

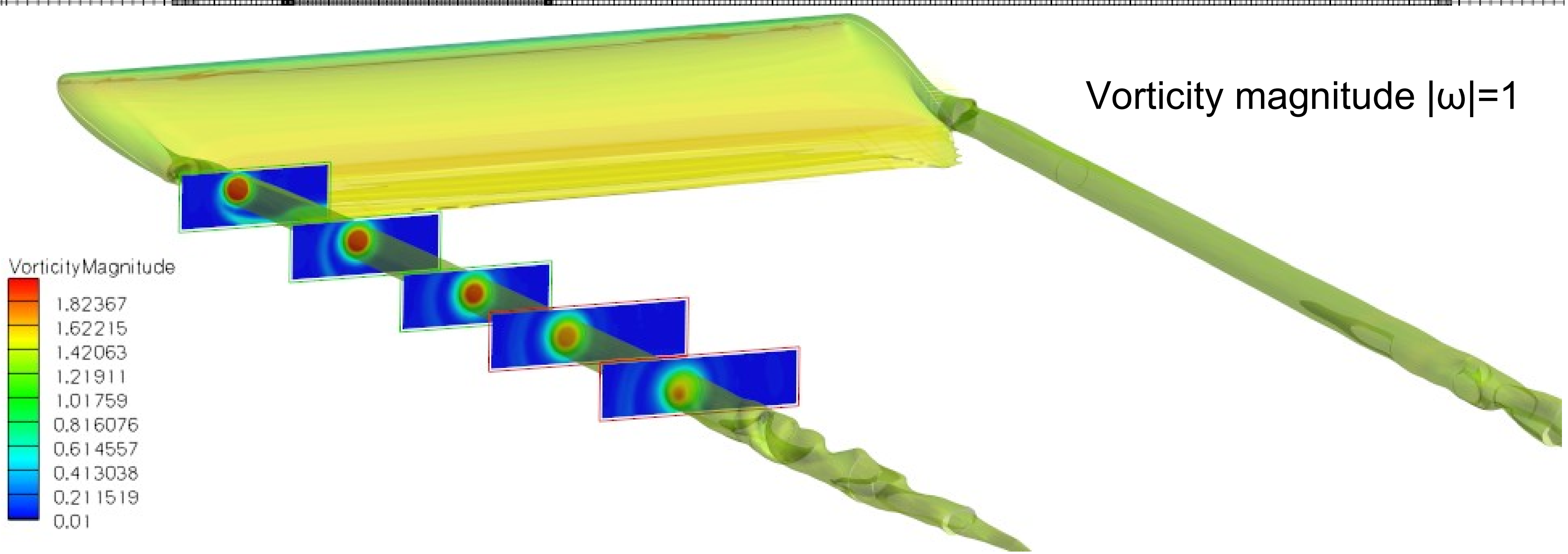
- Simulation:
  - Exp. by McAlister & Takahashi
  - M=0.1235 , AoA=12°, Re = 2 million
  - Rectangular wing, rounded tip and root, blunt trailing edge
- Near-body mesh:
  - Near-body mesh obtained by extrusion from the analytical surface mesh: 297x101x90 points
  - Overlap BCs applied at external borders
  - Spacing at external borders ~ 2%c



Workflow

- Initial octree mesh refined in the vicinity of external surfaces of the near-body mesh
- Derivation to Cartesian grids, with dx_{min}=2%c (8MPts over 72 blocks)
- Chimera assembly with overlap optimization
- RANS simulation using AUSM+ scheme, Wilcox k-ω turbulence model
- Cartesian off-body mesh adaptation performed according to the previous workflow:
  - Sensor field: streamwise component of the vorticity
  - Adaptation performed every 500 iteration (9 times)





Réf : S. Péron, C. Benoit, «*Automatic off-body overset adaptive Cartesian mesh method based on an octree approach*», Journal of Computational Physics, 2012,http://dx.doi.org/10.1016/j.jcp.2012.07.029 (on line)

Conclusion

- Cassiopée contains a set of pre- and post-processing functions
- All the functions operate on the same data (CGNS/Python tree)
- This enables to quickly design solutions for mesh generation/adaptation/assembly and post-processing.