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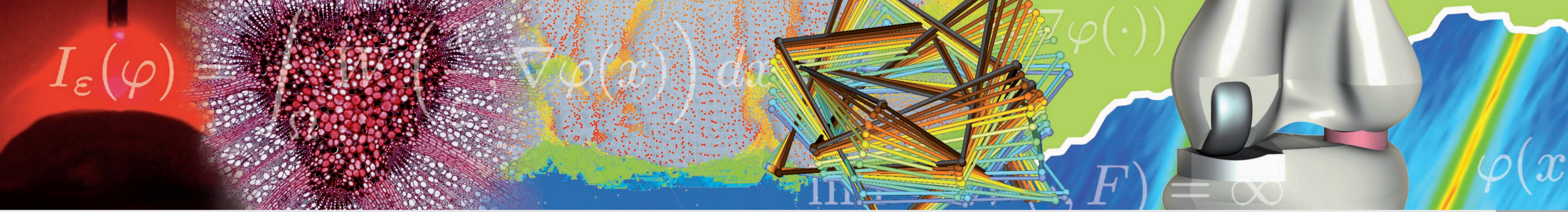
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NUMERICAL DETERMINATION OF AN ANATOMICAL STRUCTURE'S UNLOADED STATE FROM IN VIVO MEDICAL IMAGING

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Context

- Implantable Medical Device (IMD) deployment's computation in patient specific anatomical structures.
- Competitive computation time.

Objectives

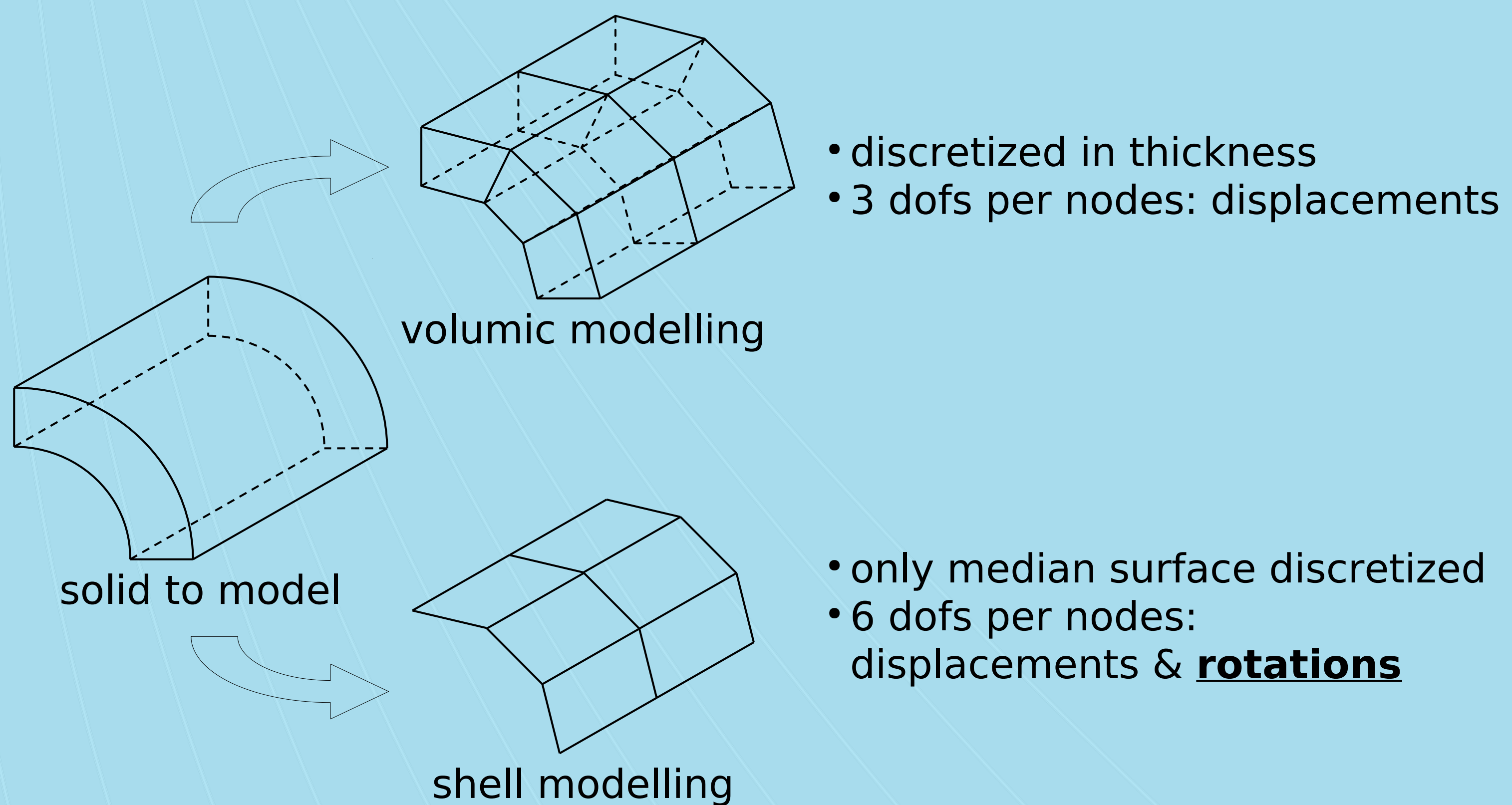
Inspect impact of the choice of stress-free configuration of anatomical structures in the result of IMD-anatomical structure interaction's computation.

Shell modelling

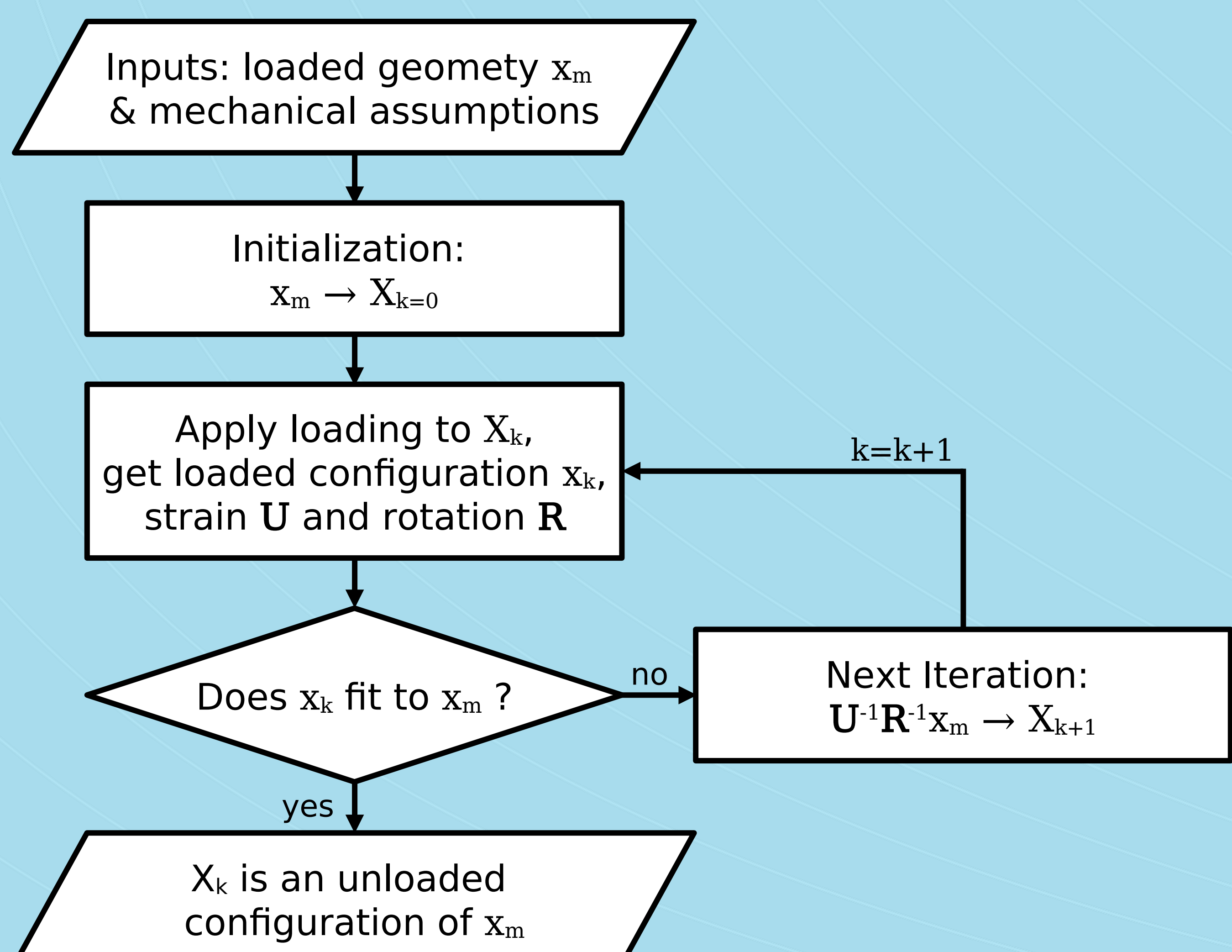
Stress-free configuration determination algorithm already exist in the literature^{1,2}, but are adapted to volumic mesh modelization of structure.

Medical imaging, with segmentaton, provides geometrical inputs of anatomical structures as their median surfaces. To avoid a step of volumic reconstruction and thickness discretization that would results in more degree of freedom and longer computation time, one could model those structures with shells.

Our contribution is to adapt such algorithm to shell modelling.



Algorithm adaptation



Flowchart of the proposed algorithm

Application to in vivo neural aneurysms

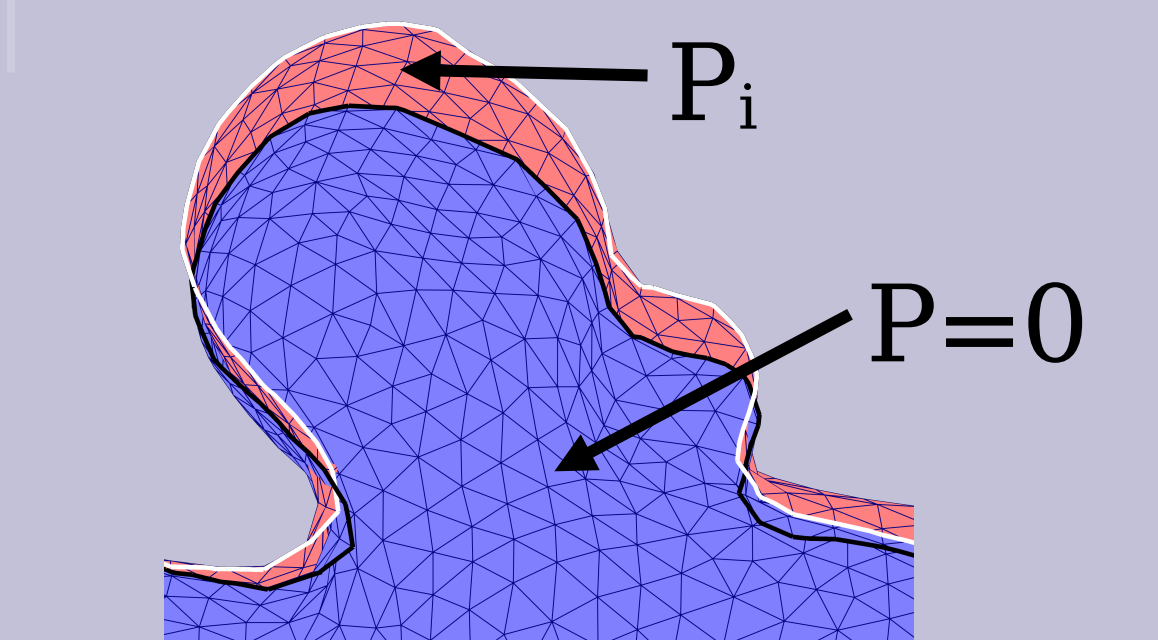
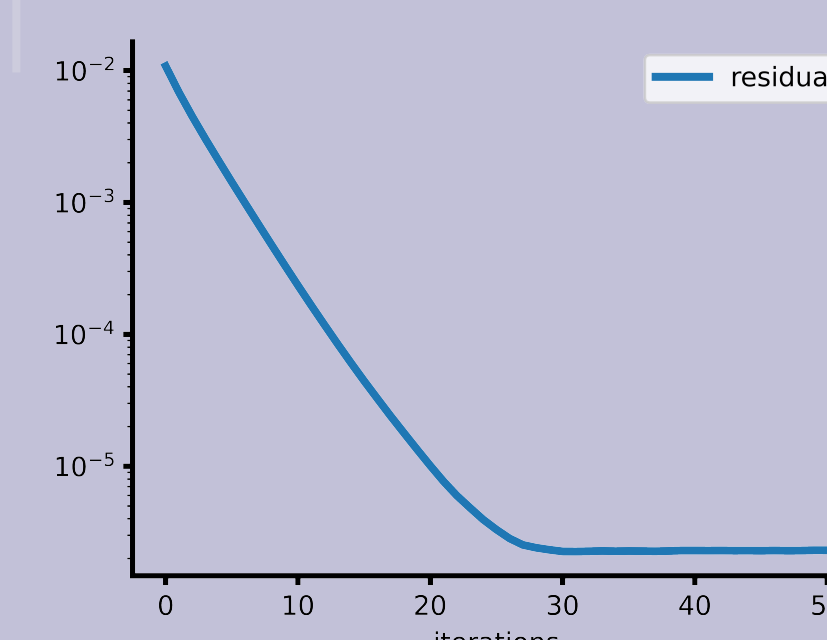
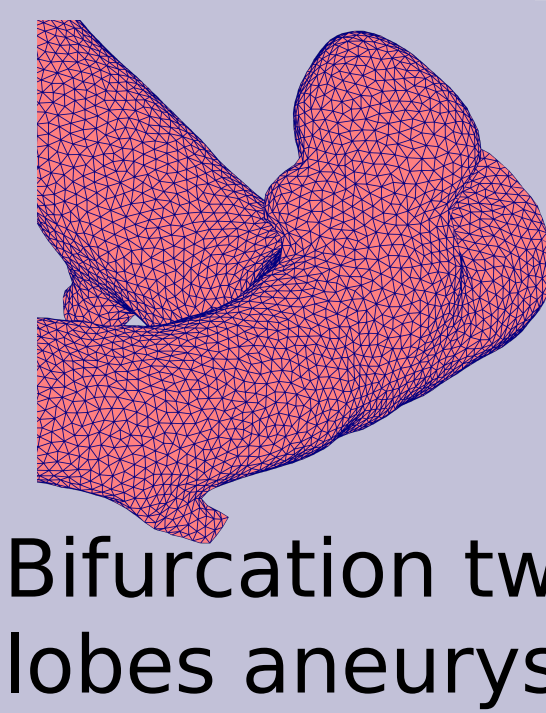
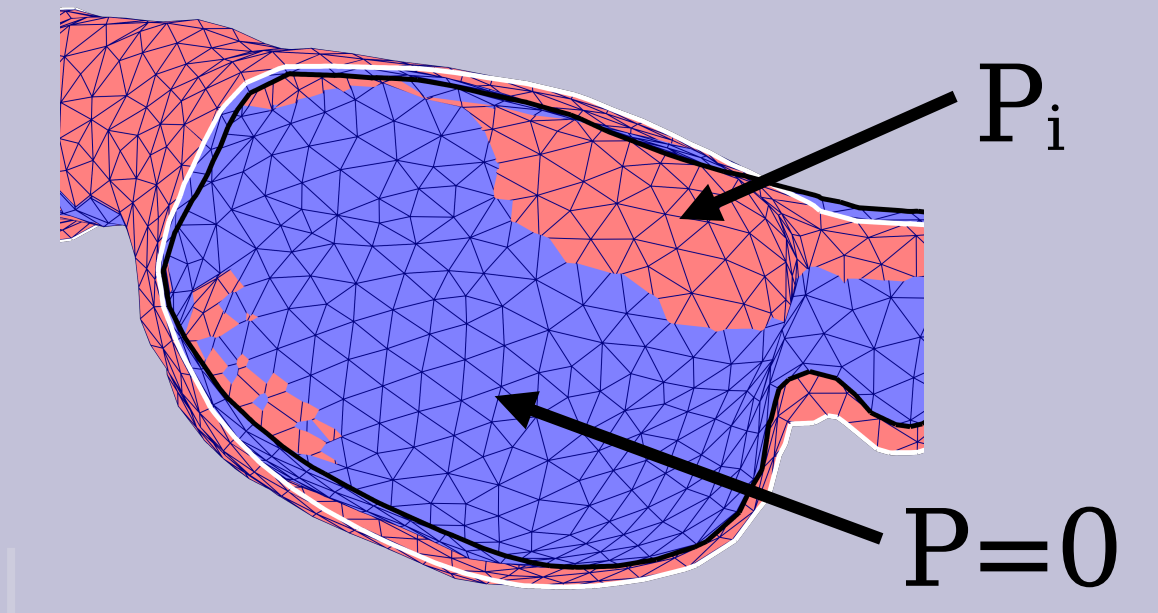
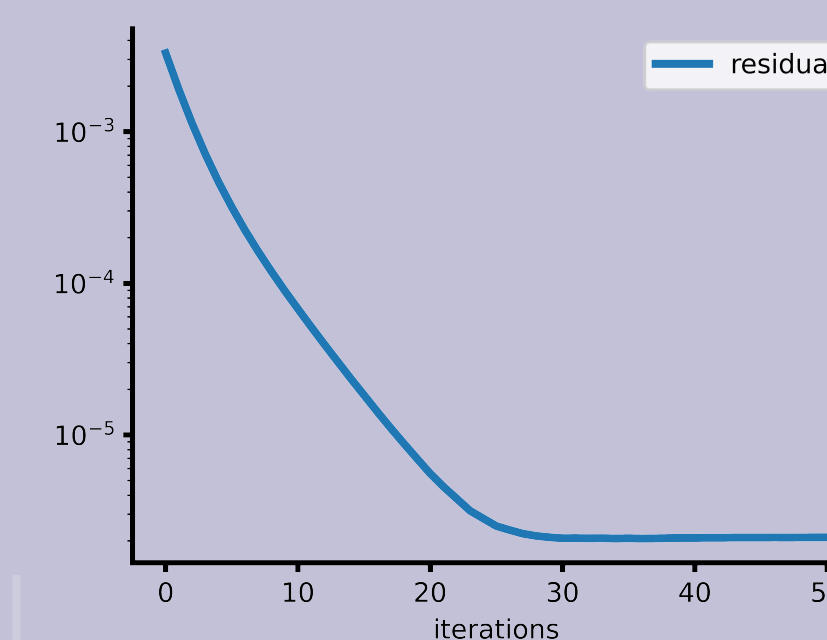
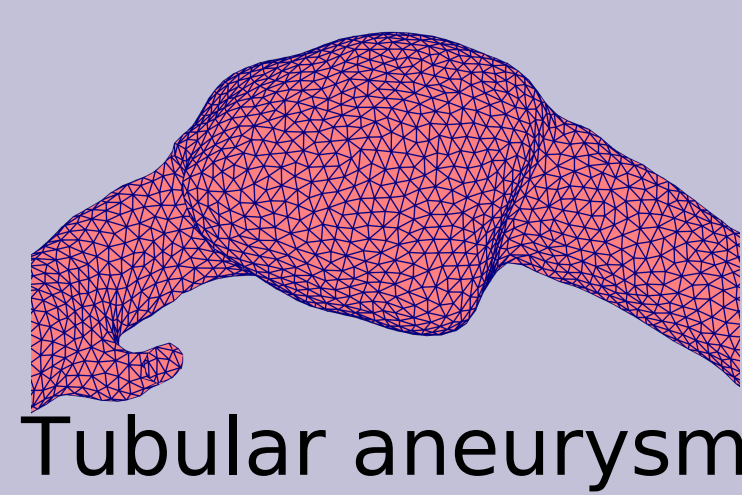
Hypothesis:

- Soft hyperelastic material from in vivo aneurysm wall³
- Homogeneous blood pressure⁴ P_i
- No displacement on contours of the artery

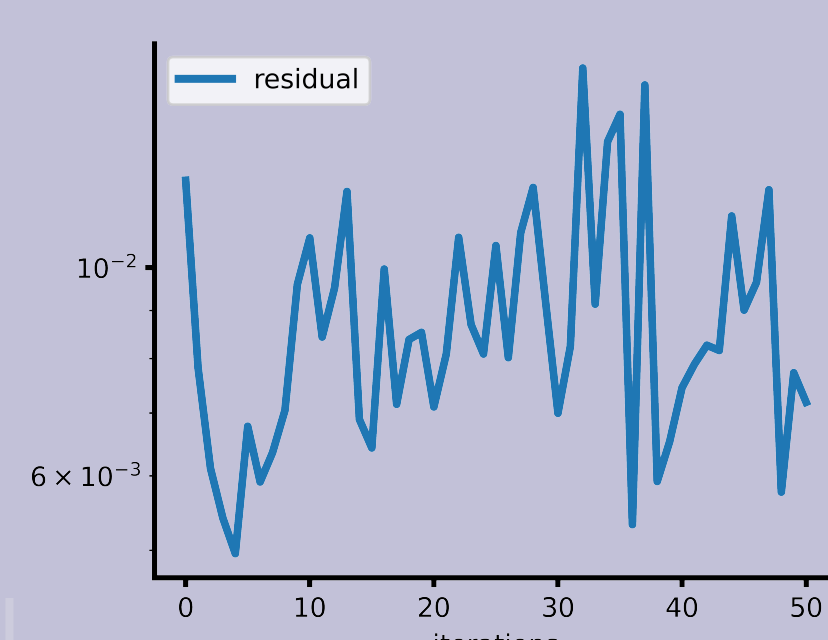
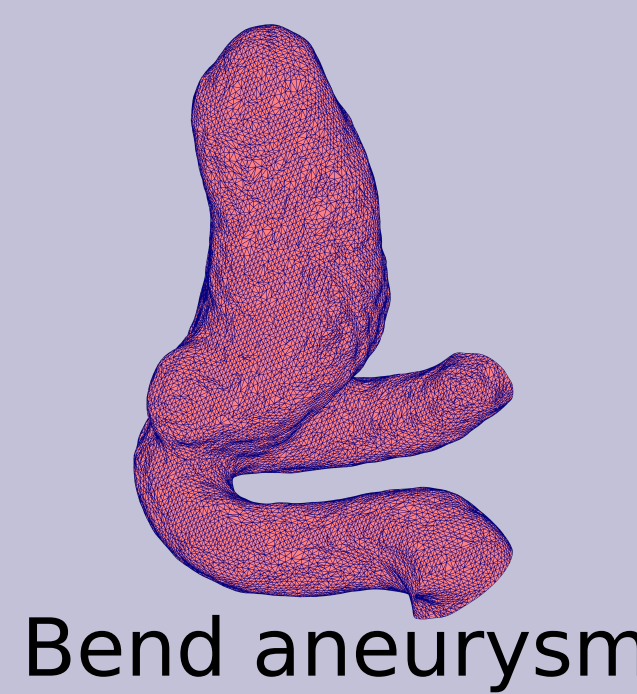
Pressurized geometries from medical imaging

Convergence graphs $\|x_m - x_k\|_2$

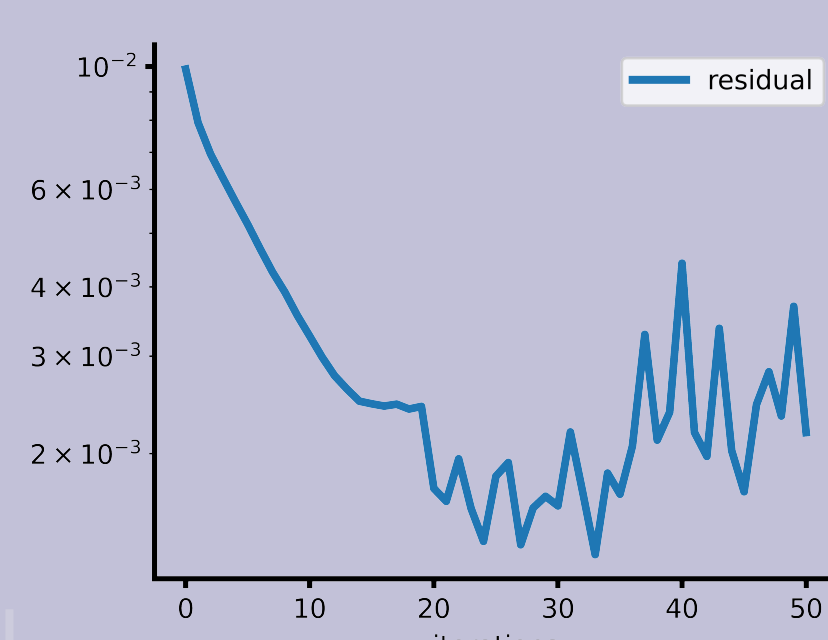
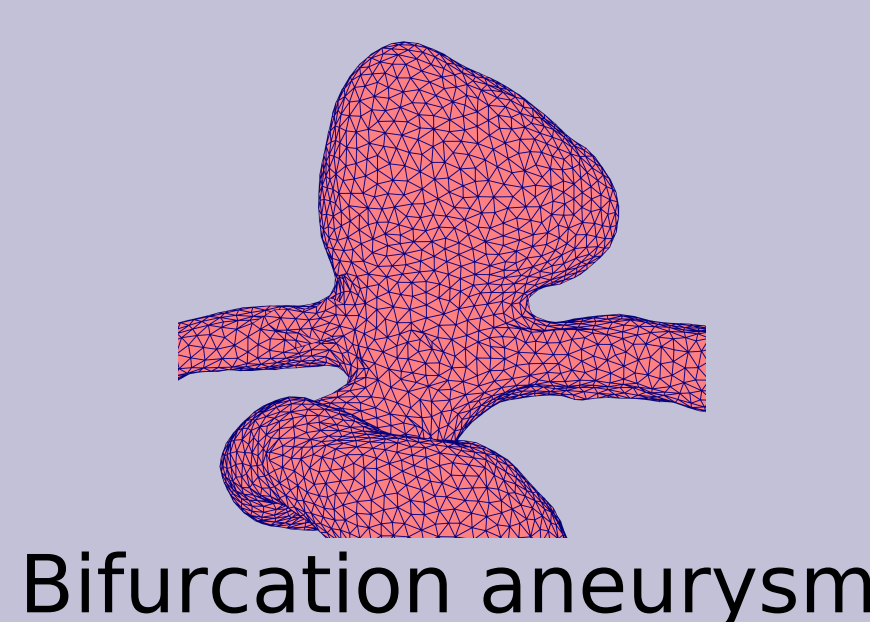
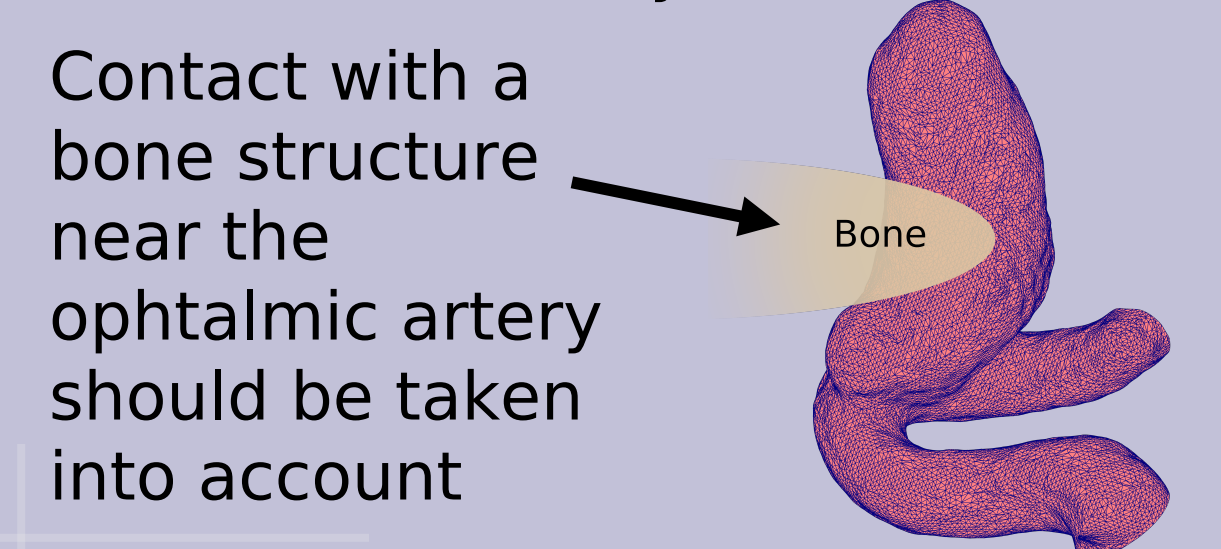
Depressurized geometry obtained with the algorithm (pressurized in red, depressurized in blue)



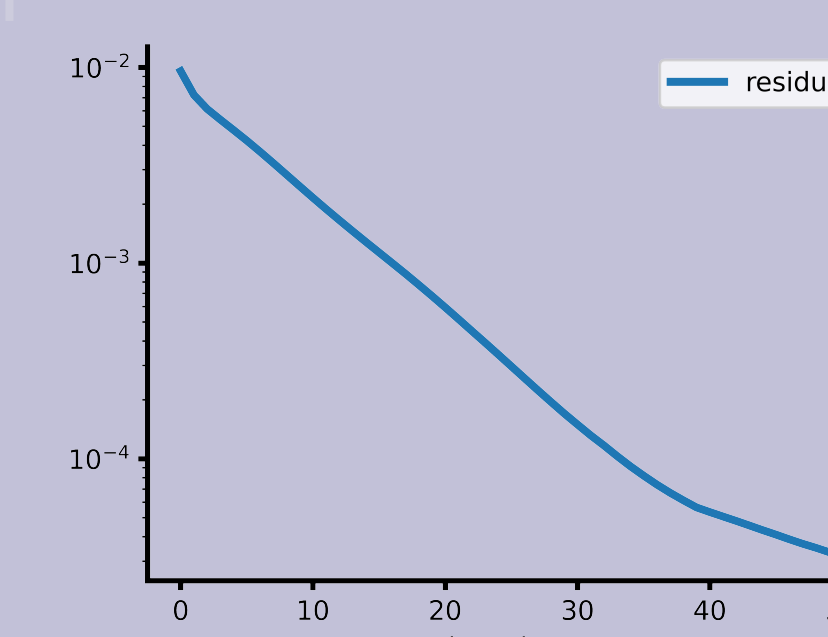
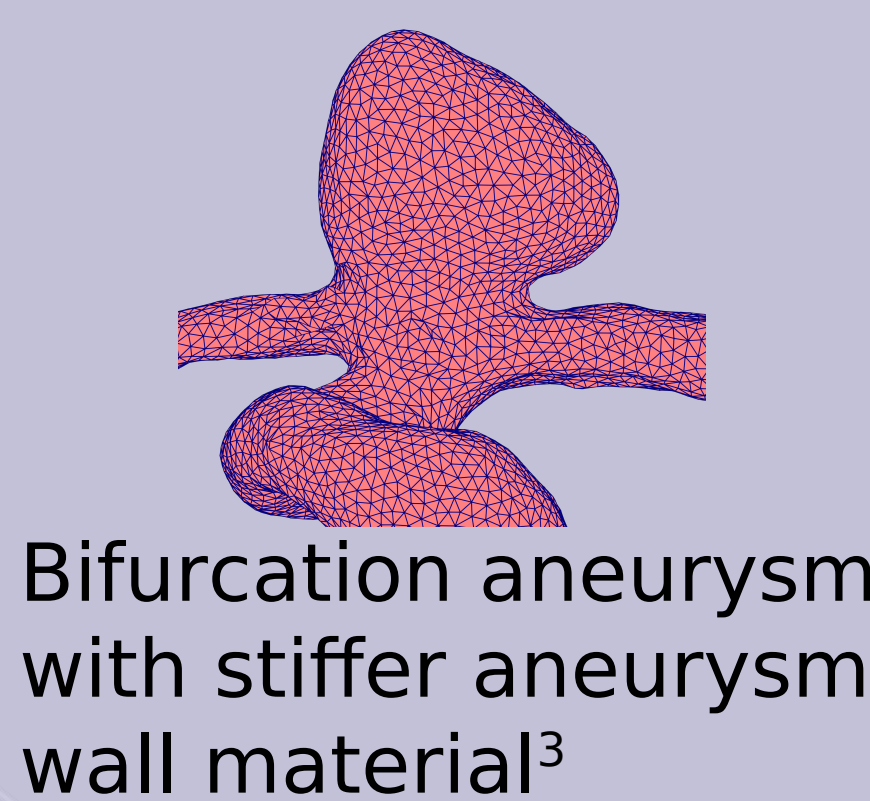
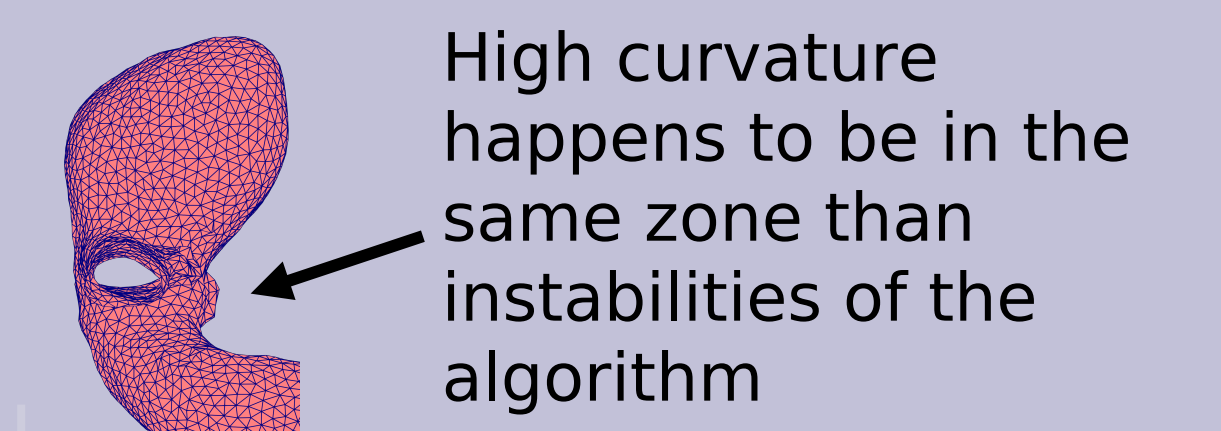
Confession of limitations



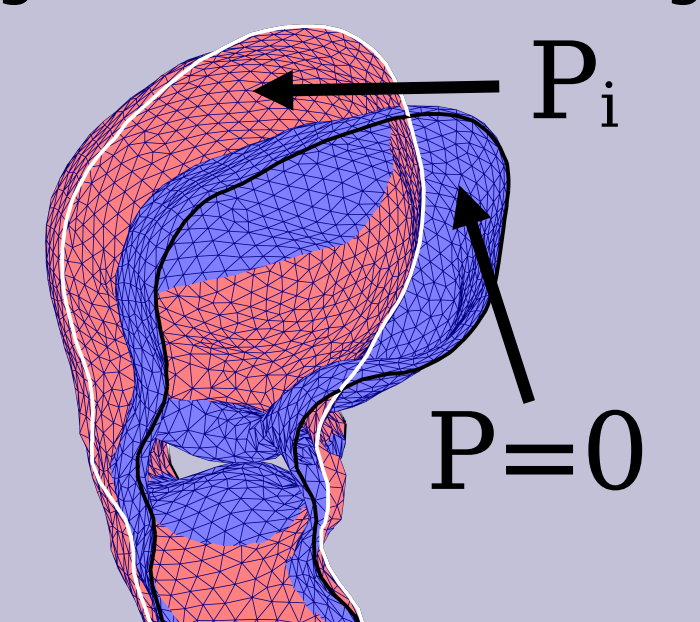
No convergence could due to flawed boundary conditions.



No convergence, could due to too soft material mixed with curvature, causing too big rotations.



With a stiffer material, the algorithm now converge



Conclusion

This algorithm allows to find stress-free configuration to implement computations with based of hyperelastic model and patient specific geometry. The convergence of such algorithm depends of the compatibility between the measured geometry, the boundary conditions and the assumed material of the structure.

Perspectives

- Implement more complex boundary conditions, heterogeneous loading or contact with other structures, to adress more cases.
- Assign a different material to the arterial wall than the aneurysm.
- Use Aitken type relaxation to improve convergence.

References

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- ³Costalat *et al.* Soft hyperelastic material from Biomechanical wall properties of human intracranial aneurysms resected following surgical clipping. 2011
- ⁴Steiner *et al.* Imposed homogeneous pressure, with values obtained from Monitoring the injured brain: ICP and CBF. 2006

