Isogeometric Discretization of Branched Artery Models for FSI Computations

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Introduction

Objective

Generate mesh for branched artery models for fluid–structure interaction (FSI) computations.

Why FSI?

- Blood flow and arterial-wall motion need to be determined for diagnosis.
- The two are coupled and need to be solved simultaneously.

Why isogeometric discretization?

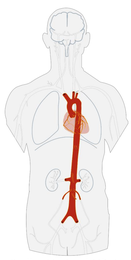
- Higher accuracy in surface model and in solid and fluid mechanics solutions.

Merit

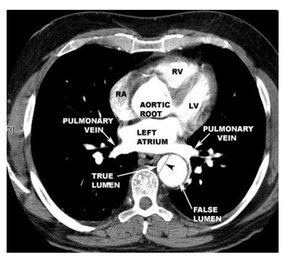
- Elucidate pathology of vascular disease in the view of dynamic factors.

Methods and Results

Extract arterial inner surface



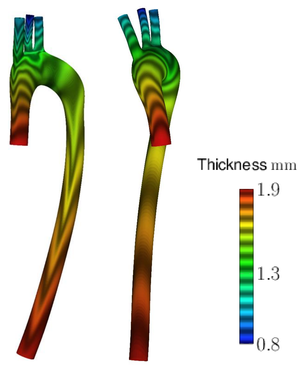
https://en.wikipedia.org/wiki/Aorta



http://www.meddean.luc.edu/lumen/meded/radio/curriculum/surgery/dissecting_aorta.htm

Patient-specific aortic inner surface model is extracted from medical images.

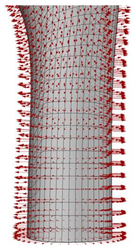
Thickness calculation

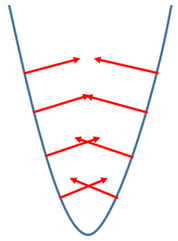


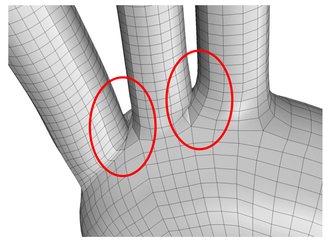
- At the inlet and outlet, based on the average diameter, calculate the wall thickness.

- Using the Poisson's equation, calculate the thickness elsewhere.

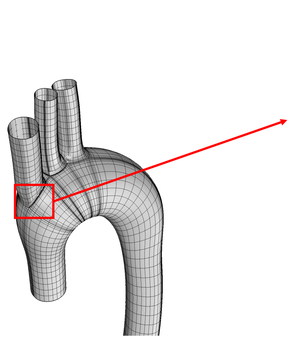
Build outer surface based on thickness and normal vector

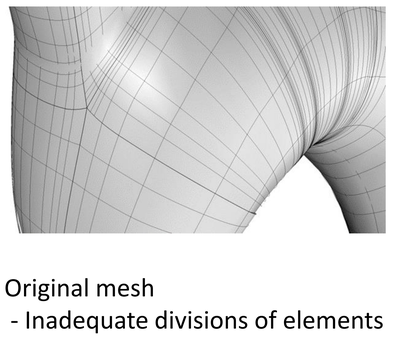






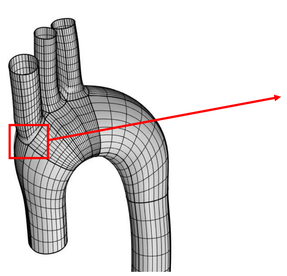
× Crossing normal vectors in high-curvature regions

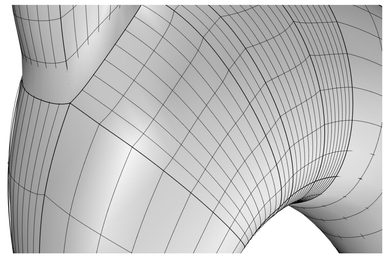


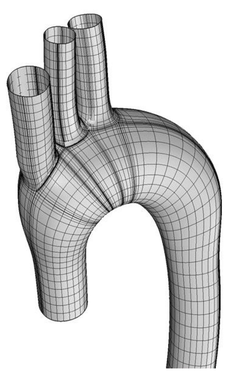


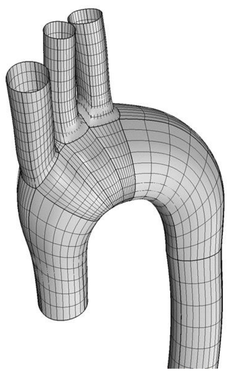
Original mesh
- Inadequate divisions of elements
- Not uniform knots

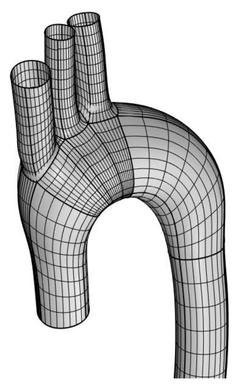
Results





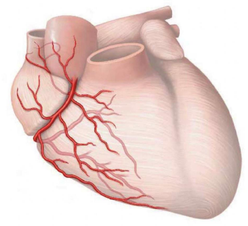






Application

Coronary artery



http://www.ykudo.com/diagram/diagram-of-right-coronary-artery

Conclusion

Built an algorithm for generating mesh for branched artery models.

Future work:

- Perform FSI computations and analyze characteristics of patient-specific aorta shapes.
- Apply it to multi-layer wall model.

References

[1] Y. Bazilevs, K. Takizawa, and T.E. Tezduyar, "Computational Fluid–Structure Interaction: Methods and Applications", Wiley (2013)

[2]A. Cottrell, T. Hughes, Y. Bazilevs, ''Isogeometric Analysis: Toward Integration of CAD and FEA'', Wiley(2009)

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