MECHANICS

Development of high-fidelity numerical models for 3D printing of patient-specific anatomy

Publié le 3 juin 2024 - ECCOMAS Congress 2024 - The 9th European Congress on Computational Methods in Applied Sciences and Engineering

Auteurs : Loïc Guezou, Andrea Barbarulo, Bing Tie

In this work, we intend to conduct a parametric optimization of realistic 3D-printed models of abdominal aortic aneurysms (AAA) for surgical training and rehearsals. To do so, we propose to use the Proper Generalized Decomposition (PGD) technique. PGD is an a priori model reduction technique relying on the separation of variables in the solution to compute quickly and efficiently the solutions to some complex problems. These separated variables may be space and time, the different space coordinates or material properties. In this framework, the first parameters to be considered are the loading characteristics, since during an endovascular repair, the surgeon uses guidewires and catheters inside the organ, which exert forces whose position and amplitude vary. PGD has been used in biomechanical applications, such as the real-time simulation of the haptic feedback of a liver [3]. As seen there, the most appropriate material constitutive model considered for biological tissues (and as such, for biomimetic tissues) is hyperelasticity [2]. This nonlinear material behavior implies a linearization of formulations, which will be done directly in the PGD algorithm using an innovative algorithm described in [1]. This algorithm has not been used on this type of problems before. In this work, a numerical implementation of the proposed PGD algorithm, coupled with the appropriate hyperelastic model has been done on a simple problem. We also discuss the possible next steps, such as the design of our optimization method or the use of shell theory to lighten the computation further. REFERENCES [1] B. Favoretto et al., Reduced Order Modeling via PGD for Highly Transient Thermal Evolutions in Additive Manufacturing. Computer Methods in Applied Mechanics and Engineering 349, pp. 405-430, 2019. [2] G. A. Holzapfel, Nonlinear Solid Mechanics: A Continuum Approach for Engineering. Wiley, 2000. [3] S. Niroomandi et al., Real-Time Simulation of Biological Soft Tissues: A PGD Approach. International Journal for Numerical Methods in Biomedical Engineering, 29 (5), pp. 586-600, 2013.