Università degli Studi di Pavia
Dipartimento di Ingegneria Civile e Architettura

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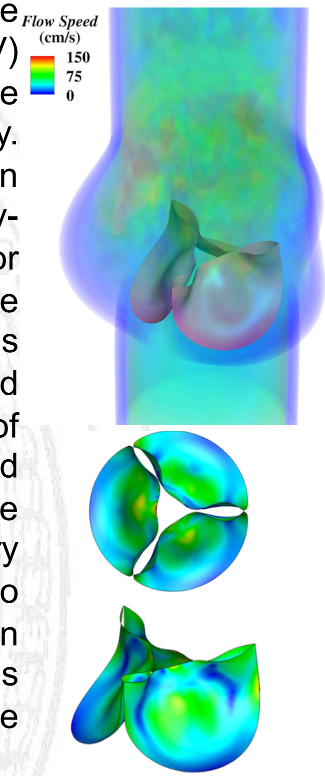
Isogeometric Fluid–Structure Interaction Analysis of Bioprosthetic Heart Valves

The aim of this work is to develop a robust and accurate computational fluid-structure interaction (FSI) framework to simulate a tri-leaflet bioprosthetic heart valve (BHV) function over the complete cardiac cycle. Due to the complex motion of the heart valve leaflets, the fluid domain undergoes large deformations, including changes of topology. We propose a variational immersed-boundary method that directly analyzes an isogeometric surface representation of the structure by immersing it into a non-boundary-fitted discretization of the surrounding fluid domain. The variational formulation for immersed-boundary FSI is derived using an augmented Lagrangian approach. The framework also includes a penalty-based dynamic contact algorithm for shell structures represented by isogeometric surfaces. To evaluate the accuracy of the proposed methods, we test them on benchmark problems and compare the results with those of established boundary-fitted techniques. We then simulate the coupling of the BHV and the surrounding blood flow under physiological conditions, demonstrating the effectiveness of the proposed techniques in practical computations. An arbitrary Lagrangian–Eulerian/variational immersed-boundary hybrid methodology is also developed under the augmented Lagrangian framework for FSI. A single computation combines a boundary-fitted, deforming-mesh treatment of some fluid–structure interfaces with a non-boundary-fitted treatment of others. This approach enables us to also simulate the FSI of a BHV implanted in an elastic artery through the entire cardiac cycle.



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Thursday, July 10, Aula MS1, 12.00 (sharp)
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