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Computational 3D fluid-structure interaction for the aortic valve[1]

HAOXIANG LUO, YE CHEN, Vanderbilt University, WEI SUN, Georgia Institute of Technology — Three-dimensional fluid–structure interaction (FSI) involving large deformations of flexible bodies is common in biological systems. A typical example is the heart valves. Accurate and efficient numerical approaches for modeling such systems are still lacking. In this work, we report a successful case of combining an immersed-boundary flow solver with a nonlinear finite-element solid-dynamics solver, both in-house programs, specifically for three-dimensional simulations. Based on the Cartesian grid, the viscous incompressible flow solver can handle boundaries of large displacements with simple mesh generation. The solid-dynamics solver has separate subroutines for analyzing general three-dimensional bodies and thin-walled structures composed of frames, membranes, and plates. Both geometric nonlinearity associated with large displacements and material nonlinearity associated with large strains are incorporated in the solver. The FSI is achieved through a strong coupling and partitioned approach. We have performed several benchmarking cases to validate the FSI solver. Application to the native aortic valve will be demonstrated.

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