Tuning Numerical Coupling Parameters for Heart Valve Simulations with OpenFOAM and CalculiX

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ABSTRACT

Fluid-structure interaction simulations (FSI) are complex and practically relevant simulations to perform in computational mechanics. In order to perform such simulations, preCICE was developed as a general purpose, black-box, multiphysics coupling library. One of the most challenging cases for FSI simulations is that of heart valves. Current artificial heart valves fall short of a correctly functioning native valve, and new simulation technologies are being used to improve the designs of heart valves. Even with recent advances in FSI simulation capabilities, this still remains a large challenge as heart valves are characterised by a low fluid-to-solid density ratio and large displacements of the heart valve leaflets.

Instead of developing a monolithic solver from scratch, preCICE was used with over-the-counter solvers. To perform a coupled simulation with preCICE, there is a multitude of input settings that must be specified for the coupling numerics. Due to the complex nature of multiphysics simulations, the choice of the input settings is not obvious and often involves trial and error. The input settings include the choice of coupling schemes, mesh mapping, post-processing acceleration and filtering, to name a few.

This talk will discuss how preCICE has been used to perform heart valve simulations using OpenFOAM and Calculix as the fluid and solid domain solvers. The talk will discuss the selection of various input settings, best practices for the choice of input settings, and the resulting impact on the simulation performance and results. The test case covers many difficulties faced in real-world multiphysics simulations, including highly deforming meshes, remeshing and restarting.