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A scalable parallel nonlinear solver for numerical simulation of fluid-structure interactions with applications in hemodynamics

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Numerical simulation of fluid-structure interactions (FSI) with a patient-specific geometry provides a valuable tool in computer-aided surgeries. Especially, with the rapid development of supercomputers, a high resolution of the numerical simulation of cardiovascular dynamics becomes achievable, and calculated metrics such as the blood velocity, the blood pressure and the wall displacement can be used directly or indirectly as valuable means, instead of empirical and often risky clinical experiments, to examine the suitability and the efficiency of various reconstructive procedures. However, the parallel numerical solution of the FSI system with a patient-specific geometry is still challenging because (1) computation domains are irregular and deformable so that the construction of efficient solvers such as multigrid methods or multilevel methods is difficult; (2) fluid-structure interactions need to couple different types of equations together and different parts of the FSI system behave differently so that the resulting nonlinear algebraic system is hard to solve. In this talk, we discuss a highly scalable, fully implicit multilevel fluid-structure interaction solver based on isogeometric unstructured 3D coarse spaces. The proposed nonlinear solver is shown to be scalable with more than 10,000 processor cores.