6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

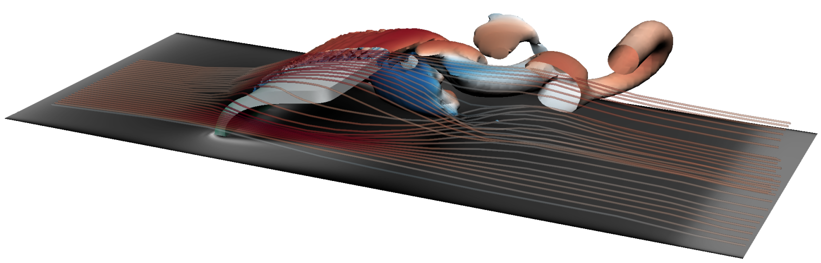
PARALLEL NUMERICAL LIBRARY FOR FLUID-STRUCTURE INTERACTION IN BIOMECHANICS

Barna Becsek[1,*], Maria Nestola[2], Rolf Krause[2] and Dominik Obrist[1]

[1]ARTORG Center for Biomedical Engineering Research, University of Bern, CH-3008 Bern
[2] Institute of Computational Science, Università della Svizzera Italiana, CH-9600 Lugano
[*] presenting author: barna.becsek@artorg.unibe.ch

Key words: *Fluid-Structure Interaction (FSI), Immersed Boundary Method, Fluid Dynamics, Solid Mechanics, DNS, Complex Materials, Anisotropic Material, High-Performance Computing*

A new numerical framework for fluid-structure interaction (FSI) using high-performance computing (HPC) libraries is presented. This modular FSI framework based on the Immersed Boundary Method [1] incorporates a high-order finite-difference Navier–Stokes solver for incompressible flow [2], a time-implicit finite-element solver for the elastodynamic equations of solid motion using various constitutive laws [3] and a novel approach to data transfer between grids of arbitrary type [4]. All modules are optimized for a massively-parallel supercomputing platform with GPGPUs (Cray XC50 at CSCS, Switzerland). The framework was developed to study the effects of FSI in aortic heart valves. Fluid and solid are coupled in a weak fashion by transferring velocities from fluid to structure and reaction forces back. A fixed-point iteration at each time step ensures stability of temporal evolution, solving the coupled spatial problems to a desired accuracy. The framework was validated with benchmarks from literature and problems with analytic solutions. Three-dimensional simulations were performed at various Reynolds numbers.



Vortical structures and streamlines around an elastic Holzapfel–Ogden wall at $\mathrm{Re} = 2250$.

REFERENCES

[1] C. S. Peskin, "The immersed boundary method," *Acta Numerica*, vol. 11, pp. 479–517, 2003.

[2] R. Henniger, D. Obrist, and L. Kleiser, "High-order accurate solution of the incompressible Navier-Stokes equations on massively parallel computers," *J. Comp. Phys.*, vol. 229, no. 10, pp. 3543–3572, 2010.

[3] C. Gross and R. Krause, "Proposal for numerical benchmarking of fluid-structure interaction between an elastic object and laminar incompressible flow," *SIAM J. Num. Anal.*, vol. 47, no. 4, pp. 3044–3069, 2009.

[4] R. Krause and P. Zulian, "A Parallel Approach to the Variational Transfer of Discrete Fields between Arbitrarily Distributed Unstructured Finite Element Meshes," *SIAM J. Sci Comp.*, vol. 38, no. 3, pp. C307–C333, 2016.