Recent Advances in the Fully Eulerian Approach for Fluid-structure Interaction Problems

S. Frei[1] and T. Richter[2]

Abstract: Fluid-structure interaction problems play an important role in a variety of applications in biology, medicine or the engineering sciences. In many cases, the Arbitrary Lagrangian Eulerian (ALE) method provides an elegant and robust technique to deal with moving interfaces and subdomains. The ALE method shows problems for large deformations or movements of the structure, however, as the underlying grid may degenerate.

In a Fully Eulerian ansatz, in contrast, domains and interface move over a fixed background mesh [1]. This ansatz is thus capable of dealing with arbitrary movements up to contact of e.g. a structure with a wall. The difficulty in the Eulerian ansatz lies in the correct treatment of cells that are split by the interface. Applying standard discretization methods leads to a reduced order of convergence and stability issues.

In this talk, we present modified discretization schemes in both space and time in order to avoid these issues. The proposed finite element discretization in space corresponds to a fitted finite element method that uses a fixed patch mesh [2]. Instead of moving mesh nodes, we resolve the interface locally by an adapted parametric approach. For time discretization, we use a modified time-stepping scheme that is based on the fixed-mesh ALE method [3]. We show second-order convergence for both discretization in space and time and give a bound on the condition of the system matrix. Finally, we illustrate the capability of our approach by means of benchmark problems and prototypical applications.

[1] T. Dunne, *An Eulerian approach to fluid-structure interaction and goal-oriented mesh refinement*, Int. J. Numer. Meth. Fl. 51 (2006), 1017-1039

[2] S. Frei, T. Richter, *A locally modified parametric finite element method for interface problems*, to appear in: SIAM J. Numer. Anal. (2014)

[3] R. Codina, G. Houzeaux, H. Coppola-Owen, J. Baiges, *The fixed-mesh ALE approach for the numerical approximation of flows in moving domains*, J. Comp. Phys. 228 (5), 1591-1611

[1,2] Institute of Applied Mathematics, Heidelberg University
Im Neuenheimer Feld 293, 69120 Heidelberg, Germany
stefan.frei@iwr.uni-heidelberg.de, thomas.richter@iwr.uni-heidelberg.de