Interface Tracking for Free-Surface Flow Simulations with Higher-Order Methods

Florian Zwicke, Sebastian Eusterholz and Stefanie Elgeti

Chair for Computational Analysis of Technical Systems
RWTH Aachen University
Schinkelstr. 2, 52062 Aachen, Germany
e-mail: zwicke@cats.rwth-aachen.de, web page: http://www.cats.rwth-aachen.de

ABSTRACT

The simulation with free surfaces is an important topic in the field of numerical flow simulations. Such surfaces occur, e.g., in simulations of viscoelastic die swell or the sloshing in tanks. Methods for the handling of such interfaces are generally categorized into two groups: interface tracking and interface capturing [1].

Interface capturing requires the simulation on a – possibly fixed – mesh that encompasses the interface along with the materials on both sides. In interface tracking methods, the mesh is adjusted to follow the location of the interface. In the context of free-surface flows, interface tracking has the advantage that it is sufficient to simulate the liquid alone, as long as the interface conditions are known well enough.

One of the principal challenges in free-surface flow simulations is the deformation of the mesh boundary in accordance with the no-penetration condition, such that no material is allowed to enter or leave across the free-surface boundary. This condition only defines the boundary movement in the normal direction, while arbitrary tangential movement remains possible.

Explicit update methods for the boundary are available for space-time finite-element simulations with linear basis functions [2]. Our aim is to provide interface tracking methods that can be used in conjunction with basis functions of arbitrary polynomial order, such as they are used in Isogeometric Analysis. We propose several new methods for the boundary movement that are based on variational formulations and investigate their suitability in terms of the fulfillment of the no-penetration condition as well as the retention of sufficient mesh quality. We show the results of the different methods for simple two-dimensional IGA simulations of a sloshing tank and die swell.

REFERENCES

[1] Elgeti, S. and Sauerland, H. Deforming Fluid Domains Within the Finite Element Method: Five Mesh-Based Tracking Methods in Comparison, *Archives of Computational Methods in Engineering* (2016) **23**:323–361.

[2] Tezduyar, T. E., Behr, M., and Liou, J. A new strategy for finite element computations involving moving boundaries and interfaces—the deforming-spatial-domain/space-time procedure: I. The concept and the preliminary numerical tests, *Computer Methods in Applied Mechanics and Engineering* (1992) **94(3)**:339–351.