Comparison of Coupled Euler-Lagrange and Smoothed Particle Hydrodynamics in Fluid-Structure Interaction

Christian Zehetner, Markus Schörgenhumer, Franz Hammelmüller, and Alexander Humer

Linz Center of Mechatronics GmbH
Altenberger Straße 69
4040 Linz, Austria
e-mail: christian.zehetner@lcm.at, web page: http://www.lcm.at

ABSTRACT

In fluid-structure interaction problems, fluid flow and flexible deformations of structures are coupled; examples are obstacles in fluid flow or the dynamics of fluid-filled structures. In this paper, two methods are compared for modelling such problems.

First, the Coupled Euler Lagrange approach (CEL) is considered [1], where solid bodies and structures are modelled by Lagrangian finite elements in which the material is fixed with the element. On the other hand, the fluid is modelled by Eulerian finite elements which are fixed in space, and the material moves through the elements. The coupling is established by contact interactions, implemented as a penalty contact method.

In contrast, Smoothed Particle Hydrodynamics (SPH) [2] is a mesh-free Lagrangian method where the fluid is divided into discrete elements represented by particles. The interaction with solid structures, modelled by Lagrangian finite elements, is a crucial issue in today's SPH approaches. In addition to a penalty-based formulation, a novel boundary representation by means of a consistent extension of the SPH domain is discussed.

In the following computational study, a fluid-filled, flexible container colliding with an obstacle is considered. The resulting motion of the fluid, the deformation of the container, and the contact forces are investigated.

Three solutions are compared: (i) The multibody code HOTINT is coupled with the particle simulator LIGGGHTS which includes an SPH implementation [3]. Both packages are available as open-source software. The results of this co-simulation are compared with two formulations implemented in the commercial software ABAQUS, i.e., the SPH formulation (ii) and the CEL approach (iii). A comparison of these solutions shows the various advantages and disadvantages of two simulation methods and the two software codes.

REFERENCES

[1] D.J. Benson, "Computational Methods in Lagrangian and Eulerian Hydrocodes," *Comput. Methods Appl. Mech. Engrg.*, Vol. **99**, pp. 235–394 (1992)

[2] J.J. Monaghan, "Smoothed particle hydrodynamics", *Rep. Prog. Phys.*, Vol. **68**, pp. 1703–1759 (2005)

[3] M. Schörgenhumer, P. Gruber, and J. Gerstmayr, "Interaction of flexible multibody systems with fluids analyzed by means of smoothed particle hydrodynamics", *Multibody Syst. Dyn.*, Vol. **30**, pp. 53–76 (2013)