A coupling scheme for fluid-structure interaction using SPH and FEM: the novel sliding boundary particle approach

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ABSTRACT

We present a novel numerical formulation for solving fluid-structure interaction (FSI) problems where the fluid field is spatially discretized using smoothed particle hydrodynamics (SPH) and the structural field using the finite element method (FEM) [1]. As compared to fully mesh- or grid-based FSI frameworks, due to the Lagrangian nature of SPH this framework can be easily extended to account for more complex fluids consisting of multiple phases and dynamic phase transitions. Moreover, this approach facilitates the handling of large deformations of the fluid domain respectively the fluid-structure interface without additional methodological and computational efforts. Altogether, this method is suitable for FSI applications in some areas of biomechanics, e.g., modeling digestion in the human stomach [2]. To achieve an accurate representation of interaction forces between fluid particles and structural elements also for strongly curved interface geometries, the novel sliding boundary particle approach [1] is proposed to ensure full support of SPH particles close to the interface. The coupling of the fluid and the structural field is based on a Dirichlet-Neumann partitioned approach, where the fluid field is the Dirichlet partition with prescribed interface displacements and the structural field is the Neumann partition subject to interface forces. To overcome instabilities inherent to weakly coupled schemes an iterative fixed-point coupling scheme is employed [3]. Finally, several numerical examples in form of well-known benchmark tests are considered to validate the accuracy, stability, and robustness of the proposed formulation.

REFERENCES

