A fully explicit fluid-structure interaction approach based on PFEM and FEM

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ABSTRACT

The numerical simulation of fluid-structure interaction (FSI) problems involving free-surfaces is of great interest in many engineering applications. Particle-based methods, like PFEM, are particularly suited for the analysis of free-surface flows and fluid-structure interaction with large displacements of the interface. In the current work, a staggered approach for the solution of the FSI problem is proposed. The fluid domain is discretized with an explicit Particle Finite Element Method (PFEM) while the solid domain with a standard Finite Element Method (FEM). The weakly compressible formulation of fluid flow, originally proposed in [1] for the PFEM, allows for a fully explicit solution scheme. Thanks to the Lagrangian formulation, the free surface is directly defined by the current position of the particles, while the governing equations are imposed like in standard FEM [see e.g. 2, 3]. When the mesh becomes too distorted, a fast remeshing algorithm is used to redefine the connectivities. The structural domain is instead analyzed with a standard commercial explicit FEM (SIMULIA Abaqus\Explicit).

The coupling between the fluid and solid domains is treated with the GC Domain Decomposition approach [4]. On each subdomain the problem is solved independently and then the two solutions are linked at the interface using a Lagrange multiplier technique. The proposed method allows for different time-steps in the two subdomains and for non-conforming meshes at the interfaces between the solid and fluid domains. Moreover, this approach allows for an explicit coupling, without iterations, between the two subdomains.

2D test-cases will be presented to validate the proposed coupling technique. The explicit scheme for both the fluid and solid subdomains, together with the explicit treatment of the coupling, makes this method appealing for applications in a variety of engineering problems with fast dynamics and/or a high degree of non-linearity.

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