A three-dimensional Lagrangian fully explicit approach for fluid-structure interaction problems

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ABSTRACT

In the present work, a partitioned approach for the solution of the FSI problem is proposed. Partitioned approaches are particularly interesting for the application to real engineering problems because of the possibility to make use of existing software. Moreover, explicit methods can be advantageous in many large scale applications characterized by fast dynamics and/or a high degree of nonlinearity.

The fluid domain is here discretized with an explicit weakly compressible Particle Finite Element Method (PFEM) [1] while the solid domain with a standard finite element method. The PFEM has shown its capability in dealing with free surface flows and large displacements of the solid interface [e.g.1, 2]. 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. When the mesh becomes too distorted, a fast remeshing algorithm is used to redefine the connectivities. A novel efficient mesh smoothing technique has been developed to produce a regular fluid mesh guaranteeing a reasonably large stable time increment for the explicit solver. This smoothing algorithm is fully explicit and parallelizable, because it exploits the same architecture of the fluid solver thanks to an elastic analogy. SIMULIA Abaqus/Explicit has been used for the solution of the structural domain.

The coupling between the fluid and solid domains make use of the built-in Abaqus co-simulation engine and it is treated with a GC Domain Decomposition approach [3]: the problem is solved independently on each subdomain and then 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 guarantees a strong and explicit coupling at the interfaces [4].

3D large scale tests will be presented to validate the proposed coupling technique and to confirm that the proposed method can be appealing for applications in a variety of engineering problems.

REFERENCES

[1] Cremonesi, M., Meduri, S., Perego, U. and Frangi, A. An explicit Lagrangian finite element method for free-surface weakly compressible flows. *Comp. Particle Mech.* (2017) DOI: 10.1007/s40571-016-0122-7

[2] Oñate, E., Idelsohn, S.R., del Pin, F. and Aubry, R. The Particle Finite Element Method. An Overview. *Int J Computational Method* (2004) **1**:267-307.

[3] Combescure, A. and Gravouil, A. A time-space multi-scale algorithm for transient structural nonlinear problems. *Mecanique et Industries* (2001) **2**:43-55.

[4] Meduri, S., Cremonesi, M., Perego, U., Bettinotti O., Kurkchubasche, A. and Oancea, V. A partitioned fully explicit Lagrangian finite element method for highly nonlinear fluid-structure interaction problems *Int J Numer Meth Eng* (2018) **113**:43-64