A fully-explicit Lagrangian Finite Element Approach for the simulation of 3D fluid-structure interaction problems

Massimiliano Cremonesi[1], Simone Meduri[2], Umberto Perego[1]
[1] *Department of Civil and Environmental Engineering, Politecnico di Milano, Milano, Italy*
E-mail: massimiliano.cremonesi@polimi.it, umberto.perego@polimi.it

[2] *Phononic Vibes, Milano, Italy*
E-mail: simone.meduri@polimi.it

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In the present work, fluid-structure interaction (FSI) problems are solved with a partitioned explicit approach. Partitioned approaches are particularly interesting for the reuse of existing software for both fluid and structure sub-problems; furthermore, explicit methods can be advantageous in real engineering problems characterized by fast dynamics and high degree of nonlinearity.

The fluid sub-problem is solved with an explicit version of the Particle Finite Element Method (PFEM) [1], while the solid sub-problem is solved with a standard finite element approach. Thanks to its Lagrangian nature, the PFEM can efficiently deal with free surface flows and large displacements of the fluid-solid interface [e.g.1, 2]. The fast remeshing algorithm, typically used to overcome the possible large distortion of the fluid mesh, has been coupled with a novel efficient mesh smoothing technique to guarantee a regular fluid mesh with a reasonably large stable time increment. SIMULIA Abaqus/Explicit has been used for the solution of the structural domain.

The Abaqus co-simulation engine has been used to couple the fluid and solid domains using a GC Domain Decomposition approach [3]. The two sub-problems are solved independently and then they 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 fluid-solid interfaces. Moreover, this approach guarantees a strong and explicit coupling at the interfaces [4].

Large scale 3D tests will be presented to validate the proposed approach 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.* **4***, page 357-369 (2017)*

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

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

[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* **113***, page 43-64 (2018)*