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An Eulerian Method for Fluid-Structure Interaction Simulation Applied to Wave Damping by Elastic Structures

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Abstract : A fully Eulerian method is developed to solve the problem of fluid-elastic structure interactions based on a 1-fluid method. The interface between the fluid and the elastic structure is captured by a level set function, advected by the fluid velocity and solved with a WENO 5 scheme. The elastic deformations are computed in an Eulerian framework thanks to the backward characteristics. We use the Neo Hookean or Mooney Rivlin hyperelastic models and the elastic forces are incorporated as a source term in the incompressible Navier-Stokes equations. The velocity/pressure coupling is solved with a pressure-correction method and the equations are discretized by finite volume schemes on a Cartesian grid. The main difficulty resides in that large deformations in the fluid cause numerical instabilities. In order to avoid these problems, we use a re-initialization process for the level set and linear extrapolation of the backward characteristics. First, we verify and validate our approach on several test cases, including the benchmark of FSI proposed by Turek. Next, we apply this method to study the wave damping phenomenon which is a mean to reduce the waves impact on the coastline. So far, to our knowledge, only simulations with rigid or one dimensional elastic structure has been studied in the literature. We propose to place elastic structures on the seabed and we present results where 50 % of waves energy is absorbed.

Keywords : damping wave, Eulerian formulation, finite volume, fluid structure interaction, hyperelastic material
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