A displacement-based fluid-structure interaction model equipped with explicit streamline integration of nodal positions for alleviating time step restrictions
Conference on Numerical Methods in Engineering – CNM 2017

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ABSTRACT

An updated Lagrangian fluid-structure interaction model is proposed. Displacement is chosen as the primary kinematic variable for the fluid domain in order to facilitate uniqueness of kinematic variables for the FSI problem, taking into account that structures (solids, membranes, rotation-free shells) are typically described in terms of displacements.

The main novelty of the model consists in the use of the explicit streamline integration for predicting the configuration of the fluid domain prior to the implicit solution of the conservation equations. It is shown that this prediction considerably alleviates the time step size restrictions faced by the former Lagrangian models [1-5] due to the possibility of an element inversion within one time step. On the other hand, the implicit solution of the governing equations after the explicit prediction and corresponding correction of the mesh position ensures that the resulting configuration respects the governing equations (which was not the case in the former velocity based approaches equipped with the streamline integration, such as [6] where only velocity, but not the mesh position is corrected in the implicit step).

The method is validated and compared with conventional approaches. Time step size and corresponding Courant numbers leading to optimal behaviour in terms of computational efficiency are identified. For more details the reader is referred to [7].

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