Finite Element Approximation of Ultrasonic Wave Propagation in Fluid-Structure Interaction

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Abstract

This contribution is the part of the research work on Adaptive Multigrid Methods for eXtended Fluid-Structure Interaction (eXFSI) Problem, where we introduce a monolithic nonlinear fluid-structure interaction (FSI) problem with the well-established arbitrary Lagrangian Eulerian (ALE) framework. The ALE approach provides a simple, but powerful procedure to couple solid deformations with fluid flows by a monolithic solution algorithm. In such a setting, the fluid problems are transformed to a fixed reference configuration by the ALE mapping. This research focuses on the newly developed mathematical model of a new FSI problem, which is referred to as Wave Propagation in Fluid-Structure Interaction (WpFSI). The WpFSI is a strongly coupled problem of acoustic and elastic wave equations, where wave propagation problems automatically adopted the boundary conditions from the previous time step. This model is used to design an off-live structural health monitoring (SHM) system in order to determine the coupled acoustic and elastic wave propagation in fluid-solid domains and their interface. The goal of this work is the development of concepts for the efficient numerical solution of WpFSI problem, the analysis of various fluid-solid mesh motion techniques, and comparison of different second-order time-stepping schemes. This work consists of the investigation of different time stepping scheme formulations. Temporal discretization is based on finite differences and is formulated as a one step-θ scheme, from which we can consider the following particular cases: the implicit Euler, Crank-Nicolson, shifted Crank-Nicolson and the Fractional-Step-θ schemes. The nonlinear problem is solved with Newton's like method, where the discretization is done with a Galerkin finite element scheme. The implementation is accomplished via the software library package DOpElib.

References

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