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Finite Element Analysis of Fluid-Structure Interaction for Solids Undergoing Finite Deformations

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In this study, we carry out fluid-structure interaction analysis by integrating the finite element analysis of solid mechanics and the finite difference method of fluid mechanics. Here, numerical simulations of fluid-structure interaction are implemented to solve the large deformation problems for solids of hyperelastic materials immersed in fluids by introducing the interaction forces between the solids and the surrounding fluids. The main themes of this research include the formulations of mechanics which embrace conservation equations, kinematics descriptions and computing algorithms especially developed for elaborating fluid-solid interaction modeling. For boundary value problems in solid mechanics, we consider a hyperelastic material model with the Neo-Hookean material description including nonlinear material behaviors and large shape changes for an isotropic solid to understand mechanical responses of soft materials surrounded by fluids. For model problems of viscous incompressible fluid in fluid mechanics, the Navier-Stokes equations of the incompressible Newtonian fluids are utilized by introducing the finite difference operators, imposing the initial and boundary conditions, and subjecting the proper interaction forces between the solids and fluids. Finally, we anticipate that this technique will open doors for understanding more physics related to fluid-structure interaction such as physiological states of deformed biological specimens under environmental loadings in fluids.

Keywords: Finite element method of solid mechanics, computational fluid mechanics, fluid-structure interaction, soft materials, nonlinear elasticity of solids