Development of Integrated Fluid-Solid Interaction Models for Parametric Aeroelastic Analysis

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Abstract

Currently in most of the studies on aerodynamic or hydrodynamic structures, the body immersed in fluids is considered as rigid or limited deformation. In reality, deformable bodies can exhibit either elastic or non-linear hyperelastic deformation. This deformation, in turn, can actively change the flow pattern around it and vice versa. So, these Fluid-Solid Interactions are very dynamic in nature, continuously affecting each other's physical properties. For designing critical aerodynamic structures, studies of these interactions are very important and cannot be neglected. This study also finds application in biomimetics, like for example designing jellyfish robots or flapping wing Micro Aerial Vehicle. The working of heart valves, wind turbines, aerial and underwater vehicles rely upon these interactions.

Over the past decades, many numerical methods have been developed for solving this kind of multi-physics problems. Conventionally FSI problems were solved by Arbitrary Lagrangian-Eulerian methods. In the case of complex geometries, these methods involve tedious grid generation, which in turn may vary with time in case of deformable bodies. And the implementation of boundary conditions would become complicated in the case of strong coupling between the governing equations. So there is a need to develop a sophisticated yet a straightforward procedure to analyse deformable immersed boundary problems for application towards solving various real life and Aerospace and Mechanical Engineering problems. We are approaching the solution of the both domain in a staggered manner as the system of the fluid and the solid has been decoupled. Separate solvers can be used for the FVM based fluid and FEM based solids. The coupled code will be verified with the simple test case, and then the FEM model will be extended to the various aeroelastic configuration case. The main challenge is to integrate both these solvers, so that they exchange and share information of physical parameters in real time. For the validation purpose, we are going to refer some benchmark paper by Bathe et al. and Mitra et al. This paper would form a base for the development of a novel method for integration of FEM and FVM on an open source platform OpenFOAM-OOFEM. Finally parametric sensitivity analysis will be carried out for various aerofoil configuration. It is believed that the present research work will advance the understanding of complex hydrodynamics/aerodynamics interaction with deformable solids and will provide results of practical value to the scientific community and engineers.