Special Program in Applied Mathematics and Applied Mechanics

Computational Fluid–Structure Interaction Analysis of Wind Energy and Biomedical Applications

2014 - 02 - 19 (Wed.)
13:00 - 15:00
308, Mathematics Research Center Building (ori. New Math. Bldg.)

It is well known that computational mechanics has played a successful role in the development and understanding of complex engineering systems such as crash analysis in the automotive industry, as well as design and evaluation of commercial and military aircraft. It has also become a powerful and desirable tool in the improvement of surgical planning as well as in the investigation of the factors influencing the onset and progression of cardiovascular diseases. It has also been shown in many research areas that the effect of fluid–structure interaction (FSI) is appreciable in the state-of-the-art simulations. Fluid–structure interaction occurs when movable or deformable structures interact with internal or surrounding fluid flows. It is one of the most important and challenging multiphysics problems, with respect to both mathematical modeling and computational methods.

This work will present a robust and accurate computational FSI framework with emphasis on nonmatching interface discretizations. The coupled FSI formulation is derived using the augmented Lagrangian approach and naturally accommodates nonmatching fluid–structure interface discretizations. The Lagrange multiplier field is defined on the fluid–structure interface and is responsible for the coupling of the two subsystems. In deriving the final FSI formulation, we formally eliminate the interface Lagrange multiplier, arriving the weakly enforced formulation of the kinematic and traction constraints at the fluid–structure interface. The developed technique can be extended to handle objects that are in relative motion and share a sliding interface, and to introduce a new variational immersed-boundary framework for FSI. The proposed FSI framework is applied to contemporary engineering applications in different scales, from offshore wind turbine analysis under realistic wind conditions to tri-leaflet heart valve simulation under physiological pressure. The simulation results will be shown and challenges such as wind turbine rotor–tower interaction and dynamic leaflet contact and impact will also be discussed in detail.

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