Department of Mathematics

University of Houston

Scientific Computing Seminar

Dr. Thomas Wick
ICES, University of Texas at Austin

Fluid-Structure Interaction with the Fluid-Solid Interface-Tracking/Interface-Capturing Technique using ALE and Fully Eulerian Coordinates with Application in Hemodynamics

Thursday, November 7, 2013
3:00 PM- 4:00 PM
Room 646 PGH

Abstract: In this talk, we investigate different formulations for fluid-structure interaction problems such as the arbitrary Lagrangian-Eulerian (ALE) approach, the fully Eulerian framework, and finally their coupling. The well-established ALE approach provides a simple (but powerful) procedure to couple fluid equations with solid deformations. In such a setting, the fluid equations are transformed to a fixed reference domain. However, the moving mesh becomes the critical part for large solid deformations or contact with walls or other solids. To overcome this deficiency, we present the novel fully Eulerian approach. The idea is the opposite way to the ALE method. The fluid equations are kept in their natural coordinates and the solid is transformed into the Eulerian framework. However, the interface is allowed to intersect mesh cells, which is the major challenge of this method. Each problem is formulated in a monolithic fashion that allows to compute sensitivities for a posteriori error estimation and gradient-based optimization. Time discretization is based on finite difference schemes whereas the spatial discretization is done with a Galerkin finite element scheme. The nonlinear problem is solved with Newton's method. Both frameworks are validated with benchmarks. Finally, as first application of our developments, the fully Eulerian approach is coupled with the ALE method (EALE), which is a specific example of the Fluid-Solid Interface-Tracking/Interface-Capturing Technique. This gives us the possibility to set up solid deformations in different coordinate systems, which is interesting for hemodynamic applications with flapping and moving boundaries such as arterial walls. A second application considers growth and closure of channels such as arteries, which is towards clogging and is of high importance in different fields.