Department of Mathematics

University of Houston

Scientific Computing Seminar

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A locally anisotropic fluid-structure interaction remeshing strategy for thin solids with application to a hinged rigid leaflet

Thursday, March 31, 2016
1:30 PM- 2:30PM
Room 646 PGH

Abstract: In this seminar, I will discuss the use of some common mixed finite elements in the context of a 2D locally anisotropic remeshing strategy for the fluid-structure interaction of incompressible fluids and thin structures (i.e., codimension-1). The approach is close in philosophy to immersed approaches for interface problems, in particular [1]. More precisely, to change the minimal possible fraction of elements of an a-priori given mesh I remesh only the triangles that are cut by the structure. Furthermore, with this approach, essential constraints between the fluid and the solid may be strongly enforced in the finite element spaces and it should be fairly easy to allow the fluid stress to be discontinuous across the structure. On the contrary to [1], a notable feature of the proposed remeshing strategy, is the presence of anisotropic triangles (i.e., flat triangles), for which it is known that the standard finite element method for elliptic problems may be used (see, e.g., [2]). However, for mixed elements, most of the inf-sup stability proofs in the literature require isotropic meshes and only a few results are available on distorted triangles. Because I aim at solving fluid-structure interaction problems with thin structures, discontinuity in the pressure is highly desirable, considering that the discontinuity in the pressure field across the structure is straightforwardly enforced with such mixed elements. However, I will show that such elements (Fortins and Crouzeix-Raviarts elements, in the present seminar) have inf-sup issues on flat triangles in the context of the proposed remeshing strategy, despite the results in [3]. I will show that mixed elements with continuous pressures (such as Hood-Taylor) behave much better. I will also discuss briefly conditioning issues and possible stabilization strategies. Finally, I will present numerical results on simple test cases (with the incompressible Stokes problem) and more complex ones, such as the fluid-structure interaction of a rigid leaflet with a fluid modeled by the incompressible Navier-Stokes equations.

References

[1] R. van Loon, P. Anderson, and F. van de Vosse. A fluid-structure interaction method with solid-rigid contact for heart valve dynamics. Journal of Computational Physics, 217:806–823, 2006.
[2] I. Babsŭka and A. Aziz. On the angle condition in the finite element method. SIAM J. Numer. Anal., 13(2):214–226, 1976.
[3] T. Apel and S. Nicaise, The inf-sup condition for low order elements on anisotropic meshes, Calcolo 41 (2004), 89-113.

This seminar is easily accessible to persons with disabilities. For more information or for assistance, please contact the Mathematics Department at 743-3500.