Center for Fluid Mechanics, Division of Applied Mathematics
Fluids, Thermal and Chemical Processes Group, School of Engineering
Joint Seminar Series

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Some Recent Challenges in Inverse Cardiovascular Mathematics

The development of numerical methods in incompressible fluid dynamics has received a strong impulse in the last 15 years from cardiovascular applications (see e.g. [1,2]). The combination of data coming from medical images and numerical solutions is a fundamental step for performing individual-based simulations, which is a key step in view of clinical applications of computational hemodynamics. This integration process has been enhanced in the last years by the development of both new imaging devices and numerical methods for processing medical images (see e.g. [2]). Measurements devices have been improved also for flow and pressure data. These data offer the possibility of a precise validation of the numerical simulations. However, beyond the validation, new challenges in the framework of computational hemodynamics come from the availability of these data: how is it possible to integrate noisy data/images and numerical computations for improving the reliability and the efficiency of simulations? This question is not new in other engineering fields, e.g. in meteorology. However, in the cardiovascular field it is a new topic, since the availability of data is relatively recent. New exciting mathematical challenges arise from this question. For instance, numerical simulation of fluid-structure interaction in the arteries is still a time consuming problem, not to mention the issue of accurate modeling of vascular mechanics. Introduction of images, which the displacement of the domain is retrieved from, is an alternative approach for solving the fluid problems in compliant domains. Combination of data and simulations required to solve inverse problems in registering the images for the accurate retrieving of the displacement. Inverse problems are encountered also when merging of results and measures is performed with a "control-based" approach. In this case, solution is obtained by a constrained minimization of the distance between computed solution and measures, the constraint being given by the incompressible Navier-Stokes equations (see e.g. [3]). In this talk, we will consider some examples of data assimilation in computational hemodynamics. In particular, we will present some techniques for estimating physical parameters such as vessel compliance, which is a crucial parameter for estimating vessels health. Emphasis will be focused on the analysis of the inverse problem and its numerical solution. This is a joint work with M. D'Elia, M. Perego, L. Mirabella, T. Passerini, (Emory), C. Vergara (University of Bergamo, Italy).

REFERENCES

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TUESDAY, OCTOBER 12, 2010
3:00 PM
Barus & Holley, Room 190