Multidisciplinary Simulation, Estimation, and Assimilation Systems

Seminar Series

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Low-dimensional modeling of high-Reynolds-number flows

Abstract: Computational fluid dynamics (CFD) has become an indispensable tool for many engineering applications. Unfortunately, high-fidelity CFD simulations are computationally prohibitive for time-critical applications such as design optimization and flow control. There are significant scientific and engineering benefits in developing and studying low-dimensional representations of flow systems that retain physical fidelity while substantially reducing the size and cost of the computational model. Low-dimensional modeling of high-Reynolds-number flows is challenging however. In the standard proper orthogonal decomposition (POD) and Galerkin projection approach, the derived models are almost always inaccurate and often unstable. In practice, these models are stabilized with empirical subgrid-turbulence terms. This approach is undesirable because these auxiliary terms modify the system dynamics. In this talk, an alternative strategy to low-dimensional modeling of high-Reynolds-number flows is proposed. We generalize the POD-based Galerkin method for post-transient flow data by incorporating Navier-Stokes equation constraints. In this method, the derived Galerkin expansion minimizes the residual like POD but with additional optimization constraints ensuring stability of the dynamical system. The proposed Galerkin method is illustrated with several test cases.

Friday, Dec. 13, 2013

12:00PM; Rm. 5-314

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