MECHANICAL ENGINEERING DEPARTMENT

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Feedback Flow Control: Towards Practical Applications

by

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Wednesday, December 13, 2006
3:30-4:30 p.m.
Room 1130 ME
Refreshments will be available at 3:15 p.m. in Room 1130 ME before the seminar

ABSTRACT — We are developing feedback control methods based on the use of Proper Orthogonal Decomposition (POD) and Stochastic Measurement (SM) for various flows including; that over a NACA 4412 airfoil, turbulent jets for noise reduction and 3D separated flow control over turrets for improving aero-optics. The NACA 4412 work, for example, involves using a combination of Particle Image Velocimetry (PIV) and multiple surface pressure measurements, processed through POD/SM algorithm, from which estimates of the velocity field via wall pressure alone are extracted. From such estimates knowledge of the state of the flow above the airfoil can be obtained (i.e., attached, fully separated or incipiently separated). Integral to the POD/SM algorithm is the measurement estimation of the global POD coefficients. Over the past 2.5 years or so we have demonstrated the utility of these time dependent coefficients, which are estimated from surface pressure only, for use in a simple proportional feedback loop (as the time series to drive the actuators) to keep the flow attached. This methodology is critical for implementation of realistic feedback flow control since surface measurements and not inflow measurements are required for most practical applications. The next step for more elaborate control involves the development of a model or plant for our system. To do so we are developing a set of ODEs for the POD coefficients from both direct Galerkin projection with computational results as well as through a novel moment method developed at CEAT/LEA in Poitiers France. The moment method involves training a non-linear system with the same form of non-linear ODE obtained with the Galerkin method but using as input either experimental or computational POD coefficients (here the POD eigenfuctions are projected using the data obtained from either simulation or PIV data). This provides a set of time evolution equations for the POD coefficients (our plant) directly without performing the Galerkin projection with the NS equations. The results of the simple proportional feedback NACA 4412 experiment will be presented as well as early results on the plant formulation based on POD eigenfunctions. We will also discuss progress being made on extending such feedback flow control tools to the jet noise problem as well as for 3D separated flow over the turret for improving aero-optics.

BIO — Mark Glauser, Professor of Mechanical and Aerospace Engineering, Syracuse University with his co-workers, post-docs, graduate and REU students, Glauser conducts major experimental, computational and theoretical efforts to apply low-dimensional models to turbulent and transitioning flows for understanding and control. The experimental results include obtaining difficult single and multi-point statistical quantities in the various turbulent and transitioning flows using PIV, hot wire, hot film and LDA/PDPA techniques. Flows studied range from high speed aerospace type applications to those around thermal breathing manikins within the micro-environment. Glauser has served as: Program Manager for the Turbulence and Internal Flows Program at AFOSR from 1996-1999; meeting Chair for the 56th APS Annual Meeting of the Division of Fluid Dynamics, November 2003; Technical Chair for the AIAA Summer Fluid Dynamics Meeting, June 2006; and as an ABET evaluator for Aerospace Engineering programs for the past 3 years. Since 2001, Glauser has been Associate Director for Research of the Syracuse University-led NY STAR Center for Environmental Quality Systems (EQS) (partners include: Clarkson, Cornell, RPI, SUNY at Buffalo, University of Rochester). Glauser has obtained more than 10 Million dollars in research funding as PI or Co-PI from AFOSR, NSF, NASA, EPA, Dantec, United Technologies and others. His current funding totals more than 6 Million dollars as PI or Co-PI. Glauser has published more than 100 peer-reviewed publications and conference proceedings and has presented more than 80 invited presentations and keynote talks worldwide. Glauser is a Fellow of ASME and the Institute of Physics (UK) and an Associate Fellow of AIAA.

Informal Faculty Luncheon: Wednesday, December 13, 2006, 12:00 noon. Meet in 1100 ME and walk to lunch with other faculty. Prof. Mark Glauser will be able to attend.