Plenary Lecture

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Title: Advances in Linear and Nonlinear Reduced-Order Modeling for Time-Critical Applications and Emerging Technology Trends

In many applications, high-fidelity time-dependent numerical simulations remain so computationally intensive that either they cannot be used as often as needed, or are more often used in special circumstances than routinely. This is the case, for example, for turbulent CFD computations at high Reynolds numbers. Consequently in many engineering fields, the impact of Computational Mechanics on time-critical operations such as design, design optimization, and control, to name only a few, has not yet fully materialized. For such operations, this full impact will perhaps be enabled first by advanced reduced-order modeling (ROM) methods — that is, methods that find approximate realizations using smaller computational models — which can faithfully reproduce the essential features of the larger computational models at a fraction of their computational cost, and most importantly, are capable of capturing the critical behavior of the engineering systems of interest. In this talk, new methods for constructing linear and nonlinear fluid, structural, or fluid-structure interaction ROMs based on Galerkin and Petrov-Galerkin projection schemes will be presented. The concept of a database of ROMs will be motivated, and an innovative interpolation method for adapting pre-computed ROMs to parameter changes in near real-time will be highlighted. This interpolation method is based on appropriate manifolds, their tangent spaces, and concepts from differential geometry. The lecture will conclude with a brief reporting on the successful application of all discussed computational methodologies to the support of the aerodynamic design of a Formula 1 car and the flutter flight testing of a fighter aircraft. These two real-life examples highlight the potential of the developed ROM methodologies for bridging Computational Mechanics to time-critical applications and modern assistive technologies.

Brief Biography:
Dr. Charbel Farhat is the Vivian Church Hoff Professor of Aircraft Structures at Stanford University where he is also Chairman of the Department of Aeronautics and Astronautics, Professor of Mechanical Engineering, Professor in the Institute for Computational and Mathematical Engineering, and Director of the Army High Performance Computing Research Center. Professor Farhat is the recipient of several prestigious awards including the IEEE Computer Society Gordon Bell Award (2002), the IACM Computational Mechanics Award (2002), the Department of Defense Modeling and Simulation Award (2001), the USACM Computational and Applied Sciences Award (2001), the IACM Award in Computational Mechanics for Young Investigators (1998), the USACM R. H. Gallagher Special Achievement Award for Young Investigators (1997), the IEEE Computer Society Sidney Fernbach Award (1997), the CRAY Research Award (1990), and the United States Presidential Young Investigator Award (1989). He is a Fellow of the ASME (2003), IACM (2002), World Innovation Foundation (2001), USACM (2001), and AIAA (1999). Professor Farhat is an Editor of the International Journal for Numerical Methods in Engineering and serves on the technical assessment boards of several national research councils and foundations.