The Center for Control, Dynamical Systems, and Computation
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Presents

An Approximation Theory for Model Validation

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Abstract:

The availability of trustworthy analytical tools is, clearly, a critical requirement for analytical certification or qualification and for useful prognosis. The concept of model validation has been introduced with the aim of providing a quantitative description of the proximity between model prediction and the physical reality it purports to represent, and can thus be viewed as a building block towards tackling challenges in analytical certification and prognosis. A challenge in model validation has been to separate the reasons for observed discrepancies between predictions and observations, and thus pave the way for model improvement, in case a model fails to be valid.

This presentation will describe recent successful efforts for constructing stochastic models that permit the segregation of some key errors associated with typical model-based predictions. These include errors stemming from calibration using limited data, errors associated with finite sample size in a Monte Carlo run, and errors associated with spatio-temporal discretizations of governing equations. In addition, the stochastic models we construct permit the evaluation of sensitivities with respect to model structure and provide information regarding the most critical components of the model form where refinement of the physics and constitutive behavior may be warranted.

Our approach is based on using the Polynomial Chaos representation of a stochastic process, together with the associated mathematical structure and operations, to construct a functional representation of the solution in terms of the various sources of uncertainty. An innovative parameter estimation technique is developed that permits the quantification of the robustness of this construction with respect to additional observational data, and to propagate this sensitivity to model prediction. By judiciously selecting the sources of uncertainty to go into this functional representation, the various sources of error described above can be accounted for and the impact of each one of them on the prediction quantified. I will describe these concepts in the context of several applications from across science and engineering.

About the Speaker:

Roger Ghanem is a Professor in the departments of Aerospace & Mechanical Engineering and Civil Engineering at the University of Southern California. He has a PhD in Civil Engineering from Rice University and has co-authored a book on stochastic finite element methods and over 80 refereed journal publications. He has served as principal investigator on projects funded by DoD, DoE, DoC, and NSF. Ghanem serves on the Board of Governors for the ASCE Engineering Mechanics Institute. Ghanem's research addresses issues of probabilistic modeling and analysis with particular emphasis on probabilistic calibration and characterization, model validation, prognosis, and confident performance prediction for complex systems.