

MAE Seminar Series

Towards Lifting of the Curse of Dimensionality in Fokker-Planck Equation

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Abstract

Fokker-Planck equation (FPE) has long remained the sour grapes on the tree of tools for design and analysis of randomly excited systems. While FPE captures the exact description of uncertainty propagation through dynamical systems driven by white noise, it has remained analytically and numerically unsolvable for most systems of interest. The greatest obstacle in its successful numerical solution is the so called curse of dimensionality, which causes the size of the discretized Fokker-Planck operator to grow exponentially with dimensionality of the underlying system. This talk will present two variants of a meshless technique based on the partition of unity finite element method (PUFEM), namely standard-PUFEM and particle-PUFEM that constitute confident progress towards breaking of the curse of dimensionality. Equipped with local p-refinement, the particle version of PUFEM significantly reduces problem size (for example, by 3 orders of magnitude over traditional FEM for 4-state systems) for comparable accuracy of FPE approximation. Coupled with a preprocessing step involving modal analysis and spurious mode rejection, a semianalytical method has been developed that provides FPE transient response in real time, independent of initial state distribution. This leads to two major developments: 1.) FPE can now be solved for highly nonlinear and relatively high dimensional systems on small computers; and 2.) FPE can now be used directly in Bayes filtering for nonlinear systems, especially in scenarios involving long durations of propagation between successive measurements. Conclusion: It is not yet time to open a bottle of wine, but the grapes sure are ripening.

Speaker Bio

Mrinal Kumar is a PhD candidate in Aerospace Engineering at Texas A&M University, working under the supervision of Dr. Suman Chakravorty and Dr. John L. Junkins. He received his Bachelor of Technology degree in Aerospace Engineering from the Indian Institute of Technology, Kanpur, India in 2004 and has since been working towards his PhD. He received the 2007 AIAA Open Topic Graduate Research award and the 2007 George Bush Presidential Library Travel Grant. His paper at the 2006 Astrodynamics Specialist Conference in Keystone, Colorado was given the best paper in conference award. His current research interest lies in developing efficient numerical tools for the Fokker-Planck equation and its application to nonlinear filtering.

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2:00 pm – 3:00 pm