SVM-based Decision Boundaries for Design Optimization and Reliability Assessment

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Abstract: The simulation-based design of complex systems is hampered by several hurdles such as large computational times, the difficulty to evaluate sensitivities, the potentially acute sensitivity of responses to uncertainties, and the presence of multiple failure modes. This considerably limits the blind use of traditional optimization and probabilistic methods.

The seminar will introduce a classification-based strategy that facilitates design optimization and reliability assessment by constructing explicit boundaries (constraints or limit-state functions) in terms of the design and random variables. The boundaries are constructed using a Support Vector Machine (SVM) and are iteratively refined using an adaptive sampling scheme. This methodology does not require response approximations and is therefore ideal for problems with discontinuities and binary outputs. For instance, an SVM can be used to construct a stability boundary that separates stable and unstable configurations. In addition, the approach provides a flexible way to assess probabilities of failure and to manage a large number of failure modes.

The presentation will first introduce fundamental notions related to SVM and adaptive sampling. This will then be followed by more recent developments based on multifidelity analyses, Probabilistic SVM, and Kriging. Several test examples and applications will be provided to demonstrate the generality and efficiency of the approach.

Biographical Sketch: Dr. Missoum’s current main research interests are focused on the development of original approaches in probabilistic optimal design, uncertainty quantification, and model updating. He is a member of the AIAA MDO (Multidisciplinary Design Optimization) and NDA (Non Deterministic Approach) Technical Committees. Dr. Missoum earned his M.S. in Computer Aided Engineering from Strathclyde University, Glasgow, Scotland in 1995 and his Ph.D. in Mechanical Engineering from the National Institute of Applied Sciences (INSA) at Toulouse, France in 1999. From 1999-2002 he was a post-doctoral research associate at the Aerospace and Ocean Engineering Department at Virginia Tech, and from 2002-2005 he was an Assistant Professor at the Mechanical Engineering Department of Leonardo da Vinci University, France. From 2005-2011 he was an Assistant Professor at the Aerospace and Mechanical Engineering Department at the University of Arizona, Tucson, and from 2011 to the present he is an Associate Professor at the Aerospace and Mechanical Engineering Department at the University of Arizona, Tucson.