Stochastic Design Optimization in Nonlinear Vibrations

Abstract: The optimal design of nonlinear features in dynamical systems have shown great promise and is currently an intense research area. For instance, nonlinear energy sinks (NESs), the nonlinear counterpart of a tuned-mass damper, have become extremely popular in vibration mitigation. Nonlinearities are also important in the development of metamaterials where the tailoring of local nonlinearities can lead to performances and behaviors not encountered in nature. The use of nonlinearities has markedly extended the realm of design possibilities and, in conjunction with strides in additive manufacturing, it is an area that has yet to deliver its full potential.

However, the computational design of nonlinear dynamic systems is tedious because responses are highly sensitive to uncertainties and are often non-smooth. This hampers the use of traditional computational design approaches, which are mostly focused on the reduction of computational burden to perform optimization or uncertainty quantification. This presentation will provide an overview of the challenges and introduce a stochastic design optimization tailored specifically for nonlinear dynamics problems.

Two main applications of the framework will be considered. The first one is the optimal design of NESs for vibration mitigation. NESs are able to reduce vibrations by capturing energy through an irreversible transfer of energy from the system to which they are attached. This “energy pumping” is characterized by an activation threshold and a marked discontinuity in the NES efficiency. Results of a NES design used to mitigate sub- and super-critical limit cycle oscillations (LCOs) (i.e., oscillations which happen before and after the linearly predicted flutter point) in a nonlinear aeroelasticity problem will be presented. The second problem deals with the optimal design of a chain of nonlinear resonators with the purpose of tailoring the chain’s band gaps to mitigate vibrations. Band gaps are frequency ranges within which waves do not propagate. For both applications, uncertainties in the design variables (e.g., nonlinear stiffness) as well as random parameters (e.g., loading conditions) are considered.

Bio: Dr. Samy Missoum is a Professor in the Aerospace and Mechanical Engineering Department at the University of Arizona. He is the Director of the Computational Optimal Design of Engineering Systems (CODES) laboratory. He obtained his PhD in Mechanical Engineering from the National Institute of Applied Sciences in Toulouse, France in 1999 and was a Post-Doctoral Research Associate at Virginia Tech (1999-2002). He is an expert in computational design optimization, and probabilistic design. His main research interest is the development of methods for the design optimization and uncertainty quantification of complex systems. He is an Associate Fellow of the AIAA and was an Associate Editor for the ASME Journal of Mechanical Design.

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Zoom Link: email eperumala@arizona.edu