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Reliability-based Design Optimization of Nonlinear Energy Sinks

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Abstract

Nonlinear Energy Sinks (NESs) are a promising technique for passively reducing the amplitude of vibrations, especially for use as energy pumping devices for buildings under seismic loading. Through nonlinear stiffness properties, a NES is able to passively and irreversibly absorb energy. Unlike the traditional Tuned Mass Damper (TMD), the NES has no inherent natural frequency, allowing the NES to absorb energy over a wide range of frequencies. The efficiency of the NES, however, is extremely sensitive to small perturbations in design parameters or initial conditions. In many cases, it has been observed that the most efficient NES designs are in fact very close to low efficiency regions in the design space. In addition, although a NES absorbs energy over a wide range of frequencies, it absorbs energy from a relatively narrow range of initial energies (compared to a TMD). This shortcoming of the NES can be avoided by combining several NES.

This work will present an optimization technique for NESs. In order to optimize NES devices, the high sensitivity of NES to uncertainty, with almost discontinuous behaviors, requires specific reliability-based design optimization (RBDO) techniques. In this work, a support vector machine classifier, insensitive to discontinuities, is used to construct the boundaries of the failure domain (low efficiency regions) through adaptive sampling and clustering. Several RBDO results for various NES configurations will be provided.

Keywords: nonlinear energy sinks; RBDO; SVM; clustering.