Reliable Condition Assessment of Structures Using Uncertain or Limited Field Modal Data

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Abstract

In this paper a new method for reliable condition assessment and damage detection of structures is presented. The method uses a stochastic finite element analysis along with uncertain or limited field modal data (quantified as bounded random variables) for a structure for estimating any damage occurred to the structure. The basic steps in this new development is to (1) construct a finite element (FE) model, including stiffness and mass matrices, of the undamaged structure, (2) quantify the uncertainty in the measured modal data as bounded random variables, (3) perform Monte-Carlo simulations to obtain the FE model of existing structure through iterative optimization method used in estimating the stiffness of the damaged structure, (4) utilize the element stiffness matrices in each realization to identify the damage members based on the difference between a structural element stiffness for the "as built condition" and "damaged condition", and (5) determine the bounds on the location, as well as the extent of damage, that caused the degradation of the system. A numerical illustration is presented to demonstrate the capability of the method to detect the location and extent of the damage. It has been shown that, in the presence of uncertainty in, or with limited information on, the modal data, the method is capable of determining the bounds on location and extent of damage.