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Structural Damage Identification from Noisy Modal Data Using a Variable-Weight Optimization Method

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ABSTRACT

Many damage identification methods attempt to minimize a no-linear error function between the analytical and measured modal parameters. Commonly, the presence of noise is difficult to avoid when dealing with experimental data. The objective function is a non-linear function of the updating parameters and the noise-polluted measurement data. Because the objective function can be freely defined, the updating results are depended on the choice of residues accordingly. For such an inverse problem, the main problem is the multiplicity of parameter estimation solutions arising from using spatially sparse and noise-polluted data.

This paper focuses on how to depress the effects of noise in parameter identification optimization problems. A variable-weight optimization method is presented according to the alterability of the objective function composition. The method adopts a combined error function with variable weighting coefficient and varies the coefficient gradually for a series of optimization problem. For each optimization stage with certain weighting coefficient, the last solution is used as the current initial value. The random initial value method is used to reduce the initial dependency. The optimum sensitivity method and Monte Carlo method are used to analysis the probability distribution of the identification results. Because the effects of noise vary with the weighting coefficients, the identification result can be improved by investigating the varying weight track.

Some numerical simulations for a shear-mass structure model are also given. The structural damage is translated into a reduction of the local stiffness. From the measured natural frequencies and corresponding mode shapes of vibration, selected stiffness parameters in the finite element model are adjusted in such a way that the computed modal quantities match the measured quantities using the above variable-weight method. Comparison of optimization results for different weighting coefficient reveals the profound effects of noise and the numerical simulations produce very satisfactory results in terms of the capacity to depress the effects of noise in parameter identification optimization problems.

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