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SENSITIVITY ANALYSIS OF INVERSE ALGORITHMS FOR DAMAGE DETECTION IN COMPOSITES

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ABSTRACT

Vibration-based damage detection is a promising structural health monitoring technique for identifying delaminations in composite structures. However, its accuracy may be adversely affected by measurement errors and the discrepancy between the real composite structures and their numerical models. Therefore, it is of critical importance to study the effect of such noise on the prediction accuracy. The ideal way to do this is to analyze the noise effects based on real measurements on large number of specimens. However, evidently, this is cost and time intensive in terms of materials, manufacturing and labor. An alternative way is to add artificial noise to the structural dynamic parameters obtained from numerical model and study diverse cases using this modified numerical data. In this paper, different levels of random artificial noise (1%, 2%, 3% and 5%) are added to the numerical frequencies. In order to prevent any undesirable bias, 10 different sets of random noise, both uniformly and normally distributed, are employed at each noise level for the same frequencies. The frequency shifts from these 10 test cases (at each noise level) were then input into three inverse algorithms, namely graphical technique (GT), surrogate-assisted optimization (SAO) and artificial neural network (ANN), to predict the location, size and interface of delaminations in a composite beam. The predictions were subsequently compared to the actual damage parameters to evaluate the effect of the noise on the prediction accuracies. SAO and ANN were also tested with 100 cases of noise and then further with Monte Carlo simulation with 100,000 samples in ANN to verify the results. Additional noise sensitivity tests were carried out on beams with different delamination sizes and interfaces, to investigate the dependence of noise effect on the damage parameters themselves. Results show that the trends in prediction errors with increasing noise levels become more consistent as the number of samples increased. With 100,000 samples, the predictions by ANN with uniformly