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A probabilistic damage identification approach for structures with uncertainties under unknown input

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ABSTRACT

To avoid the false positives of damages in the deterministic identification method induced by uncertainties in measurement noise, a probabilistic method is proposed to identify damages of the structures with uncertainties under unknown input. The proposed probabilistic method is developed from a deterministic simultaneous identification method of structural physical parameters and input based on dynamic response sensitivity. The deterministic simultaneous identification method is first derived. The effect of uncertainties caused by measurement noise on the identified parameters is then investigated. The statistical parameters of the identified structural parameters are calculated. The damage index is derived from the statistical parameters of the physical parameters of intact and damaged structure. The probability of identified damage, defined as the probability of identified structural stiffness smaller than that of intact structure, is further derived using the probability method. A twelve-story building and a nine-bay three-dimensional frame structure are, respectively, analyzed numerically and experimentally using the proposed method. The research results indicate that the probabilistic simultaneous identification method for damage and input can decrease the false positives of damages in contrast with the deterministic method under intensive measurement noise, and it can also achieve an accurate identification for structural unknown input.

1. Introduction

Parameter identification from structural vibration information and structural damage identification based on the identified structural parameters have been receiving more and more attention from researchers in the last few decades. Most of conventional parameter identification methods are applicable when both output and input of the system are known. However, input to structures is difficult to be precisely measured in practice. This limits the practicability of these conventional identification methods. Therefore, parameter identification only from structural output responses becomes an important aspect of the ongoing research in the field of system identification for engineering structures. If the input can be simultaneously identified together with the structural parameters, the identification process becomes a so-called simultaneous identification problem [1–10]. After the simultaneous identification is successfully performed, the identified structural parameters can be used to achieve damage detection of structures. The identified input can reflect the interaction

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