Mechanical Systems and Signal Processing 25 (2011) 1559–1573

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

journal homepage: www.elsevier.com/locate/jnlabr/ymssp

An hybrid real genetic algorithm to detect structural damage using modal properties

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ARTICLE INFO

Article history:
Received 11 August 2008
Received in revised form
7 July 2009
Accepted 30 November 2010
Available online 7 December 2010

Keywords:
Damage detection
Genetic algorithm
Modal analysis
Damage penalization

ABSTRACT

An hybrid real-coded Genetic Algorithm with damage penalization is implemented to locate and quantify structural damage. Genetic Algorithms provide a powerful tool to solved optimization problems. With an appropriate selection of their operators and parameters they can potentially explore the entire solution space and reach the global optimum. Here, the set-up of the Genetic Algorithm operators and parameters is addressed, providing guidelines to their selection in similar damage detection problems. The performance of five fundamental functions based on modal data is studied. In addition, this paper proposes the use of a damage penalization that satisfactorily avoids false damage detection due to experimental noise or numerical errors. A tridimensional space frame structure with single and multiple damages scenarios provides an experimental framework which verifies the approach. The method is tested with different levels of incompleteness in the measured degrees of freedom. The results show that this approach reaches a much more precise solution than conventional optimization methods. A scenario of three simultaneous damage locations was correctly located and quantified by measuring only a 6.3% of the total degrees of freedom.

1. Introduction

The early detection of structural damage generates a wide interest in the civil, mechanical and aerospace engineering fields. Many recent studies focus on the application of vibration-based damage detection methods. While visual inspection fails to assess damage at early stages, vibration measurements are sensitive enough to detect damage even if it is located in hidden or internal areas.

Damage detection methods are classified according to the level of identification attempted [1]:

Level 1: Detecting the presence of damage in the structure;
Level 2: Determining the geometric location of the damage;
Level 3: Quantifying the severity of the damage;
Level 4: Predicting the remaining lifespan.

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doi:10.1016/j.ymssp.2010.11.020