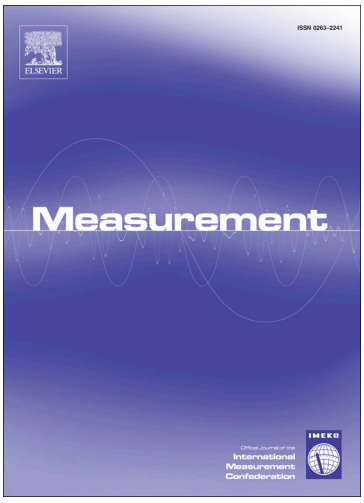

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The Fourier Spectral Poincare Map Method for Damage Detection via Single Type of Measurement

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Abstract

This paper deals with the problem of vibration health monitoring based on Poincare map method, which has been numerically and experimentally verified as an effective tool in damage assessment. We aim to introduce the Fourier-spectral derivative method into the Poincare maps method. Thereafter, a damage detection method via single type of measurement is developed. The proposed improvement focuses on the reconstruction of state space via single type observation, namely only deflection responses are obtained and the velocity and acceleration responses are estimated by numerical derives. In order to address the unstable problem of numerical derivatives, the Fourier-spectral derivative method is introduced into calculations and hence the robust estimations of velocity and acceleration responses are obtained to reconstruct the corresponding Poincare maps in state space. The proposed method is validated by numerical and experimental investigations.

1. Introduction

The vibration-based damage assessment technologies are suitable for structural health monitoring due to its on-line property. In the past decade, many kinds of damage assessment methods were developed and applied in various engineering fields [1-4]. In order to provide an accurate damaged model severing as the baseline in application, some researchers investigated the modeling and model updating methods [5, 6]. Based on the modeling technologies, the dynamic properties of the inspected structures, like natural frequency [7, 8], mode shape [9-11] and response [12, 13], can be obtained and used for damage evaluation.

The classical methods identify damage by detecting the frequency shift or the singularity induced by defects. The frequency shift can provide a reasonable damage indication, Zhang [14] and Xiang [15] investigated this problem and proposed the corresponding evaluating approach. Zhang's work focuses on the objective frequency search in database by optimization, and Xiang developed a novel frequency estimation method for cracked two-dimensional structures. Yan and Gao [16] investigated the above problem from different view, that is, detecting the harmonic components related to the non-linear effect in Fourier spectrum. Besides frequency shift, mode shape is also widely employed, especially for damage localization. In Katunin's work [17, 18], the spatial B-spline wavelet is employed in damage detection to address the boundary effect issue. In the work [19], Katunin and Przystalka further proposed the fractional order spatial wavelets, based on which the performance of the wavelet damage detection methodology is improved by optimizing the wavelet parameters. In order to combine the superiority of the frequency and mode shape-based method, the hybrid multi-step method was proposed by Gillich [20-22] and Xiang [23-25]. To address the noise robustness problem, Cao et al. [26-29] proposed the wavelet modal curvature method.

It is known that the presence of damage can be identified by the nonlinear effect in the registered signals [30-35].

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