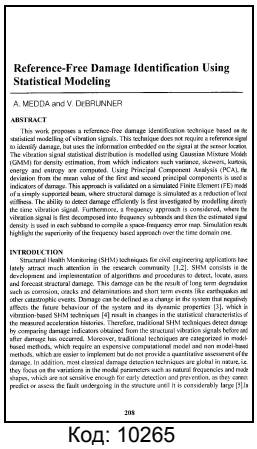

Reference-Free Damage Identification Using Statistical Modeling

A. MEDDA and V. DeBRUNNER

ABSTRACT

This work proposes a reference-free damage identification technique based on the statistical modelling of vibration signals. This technique does not require a reference signal to identify damage, but uses the information embedded on the signal at the sensor location. The vibration signal statistical distribution is modelled using Gaussian Mixture Models (GMM) for density estimation, from which indicators such variance, skewers, kurtosis, energy and entropy are computed. Using Principal Component Analysis (PCA), the deviation from the mean value of the first and second principal components is used as indicators of damage. This approach is validated on a simulated Finite Element (FE) model of a simply supported beam, where structural damage is simulated as a reduction of local stiffness. The ability to detect damage efficiently is first investigated by modelling directly the time vibration signal. Furthermore, a frequency approach is considered, where the vibration signal is first decomposed into frequency subbands and then the estimated signal density is used in each subband to compile a space-frequency error map. Simulation results highlight the superiority of the frequency based approach over the time domain one.

INTRODUCTION

Structural Health Monitoring (SHM) techniques for civil engineering applications have lately attract much attention in the research community [1,2]. SHM consists in the development and implementation of algorithms and procedures to detect, locate, asses and forecast structural damage. This damage can be the result of long term degradation such as corrosion, cracks and delaminations and short term events like earthquakes and other catastrophic events. Damage can be defined as a change in the system that negatively affects the future behaviour of the system and its dynamic properties [3], which is vibration-based SHM techniques [4] result in changes in the statistical characteristics of the measured acceleration histories. Therefore, traditional SHM techniques detect damage by comparing damage indicators obtained from the structural vibration signals before and after damage has occurred. Moreover, traditional techniques are categorized in model-based methods, which require an expensive computational model and non model-based methods, which are easier to implement but do not provide a quantitative assessment of the damage. In addition, most classical damage detection techniques are global in nature, i.e. they focus on the variations in the modal parameters such as natural frequencies and mode shapes, which are not sensitive enough for early detection and prevention, as they cannot predict or assess the fault undergoing in the structure until it is considerably large [5].a

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Ключевые слова:

Содержание.