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Structural damage detection via adaptive dictionary learning and sparse representation of measured acceleration responses

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Abstract

Extracting damage-sensitive features from measured acceleration responses is still a big challenge in structural damage detection (SDD). In order to obtain the sparse representation of acceleration responses for damage identification, two dictionary learning methods and a damage indicator based on the change in mean sparsity (CMS) have been proposed in this paper. The first dictionary is empirical mode decomposition (EMD)-based dictionary generated by collecting a series of intrinsic mode functions (IMFs) while the second one is sparse coding (SC)-based dictionary learned by adaptively iterative optimization. The CMS is based on variation of sparse features set. Numerical simulations on a simply-supported beam and on a 31-bar planar truss under different damage severities illustrate the effectiveness of the proposed methods for sparse representation and the capabilities of the defined CMS for damage indication. Comparative studies show that the SC-based dictionary outperforms the EMD-based dictionary in sparse representation. Moreover, a series of SDD experimental verifications on a simply-supported beam with a rectangular tube section in laboratory provides a further support to the proposed methods potentially used in-site acceleration measurements.

Keywords Structural damage detection (SDD), sparse representation, empirical mode decomposition (EMD), sparse coding (SC), damage indicator

1 Introduction

Civil engineering structures, such as bridges and buildings, are significant infrastructures around the world, which are great foundation for development of society. In order to protect structures from serious damage, structural

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