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A Single-Channel BSS-Based Method for Structural Health Monitoring of Civil Infrastructure under Environmental Variations

Authors : Yanjie Zhu, André Jesus, Irwanda Laory

Abstract : Structural Health Monitoring (SHM), involving data acquisition, data interpretation and decision-making system aim to continuously monitor the structural performance of civil infrastructures under various in-service circumstances. The main value and purpose of SHM is identifying damages through data interpretation system. Research on SHM has been expanded in the last decades and a large volume of data is recorded every day owing to the dramatic development in sensor techniques and certain progress in signal processing techniques. However, efficient and reliable data interpretation for damage detection under environmental variations is still a big challenge. Structural damages might be masked because variations in measured data can be the result of environmental variations. This research reports a novel method based on single-channel Blind Signal Separation (BSS), which extracts environmental effects from measured data directly without any prior knowledge of the structure loading and environmental conditions. Despite the successful application in audio processing and bio-medical research fields, BSS has never been used to detect damage under varying environmental conditions. This proposed method optimizes and combines Ensemble Empirical Mode Decomposition (EEMD), Principal Component Analysis (PCA) and Independent Component Analysis (ICA) together to separate structural responses due to different loading conditions respectively from a single channel input signal. The ICA is applying on dimension-reduced output of EEMD. Numerical simulation of a truss bridge, inspired from New Joban Line Arakawa Railway Bridge, is used to validate this method. All results demonstrate that the single-channel BSS-based method can recover temperature effects from mixed structural response recorded by a single sensor with a convincing accuracy. This will be the foundation of further research on direct damage detection under varying environment.

Keywords : damage detection, ensemble empirical mode decomposition (EEMD), environmental variations, independent component analysis (ICA), principal component analysis (PCA), structural health monitoring (SHM)
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