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Substructural Damage Identification of Shear Structures Based on Autoregressive Models

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Abstract

Damage identification based on vibration data generated by SHM systems has been extensively studied for several decades and the literature on the subject is rather immense. However, most of them are not feasible or practical for large scale civil structures due to the challenges such as high equipment costs, long setup time, difficulties in cabling and the long computation time. This thesis is devoted to overcome these problems by proposing a decentralized damage identification strategy based on the combination of substructural approach and autoregressive models, which is especially effective and economic for large scale shear structures.

Firstly, an improved substructure-based damage detection approach is proposed to locate and quantify damages in a shear structure, which extends from a previously established substructure approach. To improve the noise immunity and damage detection robustness under different types of excitations and realistic conditions, this paper proposes an ARMAX model residual-based technique to correct the former damage indicator. The results of simulation and experimental verifications show that the improved procedure works much better and more robust than previous method especially when it is applied to realistic problems.

Secondly, to seek the balance between the number of substructures and the computation intensity inside each substructure, a more flexible substructural damage identification approach is proposed in this study to identify structural damage including its location and severity, using changes in the first autoregressive coefficient

matrix as the damage indicator.

Moreover, to simplify the above studied method, the diagonal elements from changes in the first autoregressive coefficient matrix (CFAR) are extracted to construct the damage indicating vector (DIV). Then simulations are conducted to investigate the potential of the DIV algorithm for implementation on wireless smart sensor networks (WSSN), where the issues of scalability of the DIV approach are undertaken by utilizing a decentralized, hierarchical and in-network processing strategy.

Finally, the conclusion is given. The proposed substructural damage identification approach can satisfactorily locate and quantify the damage in both simulation and laboratory experiment. As the damage identification process can be independently conducted on each substructure, by utilizing some decentralized and hierarchical processing strategy, this method is promising and efficient for application on wireless smart sensor networks (WSSN) to perform SHM systems for large scale shear structures.