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Generality Of Nonparametric Simultaneous Identification Approaches For Nonlinear Restoring Force And Mass Of Mdof Structures

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After decades of development of structural health monitoring (SHM) technologies and identification approaches for large scale and complicated engineering structures, damage prognosis (DP) has been recognized as the final goal of SHM where both structural remaining load-carrying capacity and service life forecasting play key roles. The initiation and development of damage in any engineering structures under strong dynamic loadings such as typhoons and earthquakes generally lead to nonlinear behavior. Instead of stiffness, nonlinear restoring force (NRF) can describe the whole initiation and development procedure of damage in engineering structures. Moreover, it is usually a hard task to describe the NRF of various engineering structures in a general mathematical parametric model in prior due to their individuality and diversity. Identifying the NRF of real engineering structures in a nonparametric way is attractive for the purpose of DP. Additionally, in most identification approaches using extracted eigenvalues and modal shapes, it is required that the structural mass is known for stiffness identification. But it is always difficult to estimate structural mass due to the existence of live load in practice. In practical engineering, it is difficult to measure the full response of a structure due to the limitation of the number of sensors. In this paper, a simultaneous NRF and mass identification approach in a nonparametric way is presented for multi-degree-of-freedom (MDOF) structures under different dynamic loading scenarios using partially available acceleration responses. The NRF is expressed with different polynomial models including the Legendre polynomial model and the Double Chebyshev polynomial model in a nonparametric manner. A memory fading extended Kalman filter with a weighted global iteration (MF-EKF-WGI) is used to determine the location of nonlinearity. The performance of the proposed approach for both NRF and mass identification is numerically illustrated with a MDOF frame structure equipped with a magnetorheological (MR) damper using known external excitations and partially available noise-contaminated acceleration measurements. The effect of different noise levels and different initial estimation errors for structural mass on the identification accuracy and convergency is investigated. The comparison of the identification results when different polynomials are used. Identified results demonstrate that the excellent performance and robustness of the proposed method to simultaneously identify the structural parameters, unknown dynamic responses and NRF in a nonparametric way.