Nonparametric identification for time-varying physical parameters and nonlinear restoring force based on UKF and Sage-Husa algorithm

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Abstract. With the help of an UKF and Sage-Husa adaptive filter algorithm, a nonparametric NRF and time-varying structural parameters simultaneous identification approach is presented for multi-degree-of-freedom (MDOF) structures under known dynamic loadings using partially available acceleration responses, where the NRF is expressed with a Hermite polynomial model in a nonparametric way. The performance of the proposed approach is studied in the context of a numerical example consisting of a nonlinear MDOF frame structure with a magnetorheological (MR) damper on the fourth story mimicking nonlinear behavior. The MDOF frame is a time-varying parameter model which inter-story stiffness parameter varies with time. Effect of acceleration measurement noise levels on identification results is investigated. Results show that the proposed method can identify the time-varying structural parameters, unknown dynamic responses and NRF exhibiting a strong nonlinear behaviour in a nonparametric way.

Introduction

Structural nonlinearity identification plays key roles in post-event damage detection for engineering structures excited by strong dynamic loadings. Due to high complexity and individuality of structural nonlinearities, it is difficult to provide an exact parametric mathematical model in advance to describe the nonlinear behaviour of a structural member or a substructure under strong dynamic loadings in practice. Identifying the nonlinear restoring force (NRF) of an engineering structure instead of the stiffness in a nonparametric way where no exact parametric mathematical model for NRF is required is more attractive. Additionally, structural physical parameters often vary gradually due to the degradation of material properties or damage initiation and development and engineering structures are usually time-varying systems. Limited studies on the identification approaches for time-varying structural parameters of nonlinear structure have been attempted [1,2]. Traditional unscented Kalman filter (UKF) can only identify time-invariant structural parameters. For time-invariant parameters of nonlinear structures, Zhao et al. [3, 4] proposed nonparametric methods for identifying NRF. Therefore, it is crucial to propose a nonparametric identification method for structural NRF and time-varying structural parameters based on partially measured dynamic responses.

Results and discussion

In this study, time-dependent inter-story stiffness of nonlinear structures is considered. Identified results show that the proposed identification method can effectively identify time-varying structural parameters, unknown dynamic responses and NRF in a nonparametric way. Figs. 1 and 2 show the identification results of the gradually varying stiffness parameters of the 2th floor and the NRF provided the MR damper on the 4th floor.

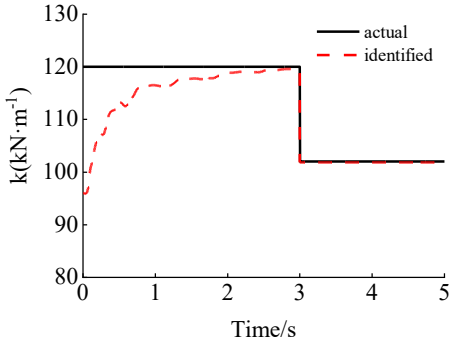

Figure 1: Identification of gradually varying stiffness parameters of the 2th floor

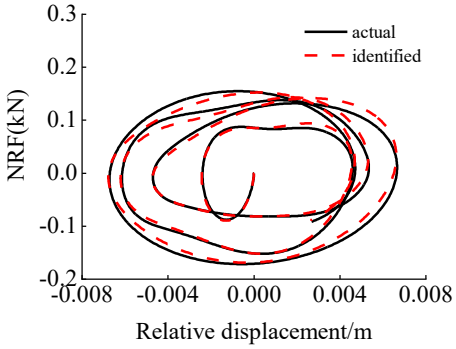

Figure 2: Identified NRF provided MR damper on the 4th floor

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