Identification of nonlinear damping using nonlinear subspace method

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Abstract. In this paper, the identification problem is discussed for damping nonlinearity. In practical applications, nonlinear damping is widespread, which is inevitable in the vibration response. Within the wide range of nonlinear damping mechanisms, friction is surely one of the most common, and with a high impact on the dynamical behaviour of structures. Two common kinds of friction are investigated: Coulomb friction and quadratic friction. Nonlinear damping parameters are identified by nonlinear subspace identification, where the damping nonlinearity of the system is considered as a feedback force applied to the underlying linear system and is identified utilizing the time domain data. The robustness of the proposed method is discussed. Two simulation examples are conducted to verify the effectiveness of the nonlinear subspace identification. Results confirm the effectiveness of the methodology in identifying damping nonlinearities.

Introduction

In engineering, structures often exhibit nonlinear behaviour. Nonlinear damping is a common nonlinear type, which may lead to difficulties in predicting the system response. Therefore, it is essential to identify the nonlinear damping parameters from the measured vibration data.

The reader can refer to the extensive review of Noël et al. [1] about the developments in nonlinear system identification during the past ten years, emphasizing the progress realized over that period. As for nonlinear damping, an identification method based on the harmonic balance analysis was implemented in [2], considering softening and hardening behaviors. It is highlighted that damping identification can be a tricky task also in the linear case, as studied by Naylor et al. [3], characterizing the nonproportional damping distribution of a multi-degrees-of freedom system using the resonant decay method.

Among the several publications about the nonlinear system identification of structures, Marchesiello et al. [4] adopted the perspective of nonlinearities as internal feedback forces and proposed the nonlinear subspace identification technique (NSI). Given the robustness and efficacy of the subspace method, these nonlinear subspace algorithms open up new horizons for the identification of nonlinear mechanical systems.

In this paper, NSI is extended to identify the nonlinear damping. Two numerical examples are used to verify the proposed method.

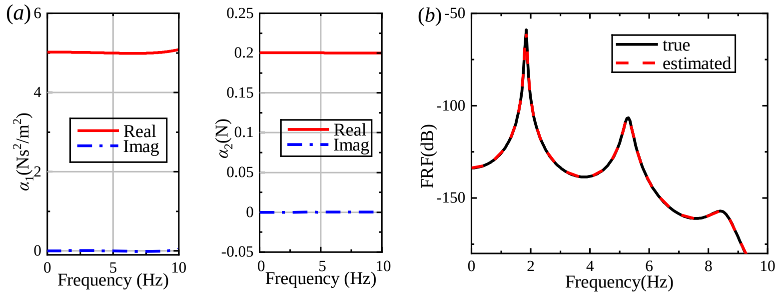

Figure 1: (*a*) Real and imaginary parts of the identified coefficients; (*b*) Underlying linear FRF

Results and discussion

Two common kinds of nonlinear damping are successfully identified by nonlinear subspace method. The effect of the measurement noise on the parameter estimation results is investigated by corrupting the previously generated output adding different Gaussian zero-mean noise. Results show that the proposed method can fully characterize the nonlinearities in the structure and effectively identify the nonlinear damping parameters.

References

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