Dynamic identification of a nonlinear beam through the Hilbert-Huang Transform

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Abstract. The inverse problem, i.e. the identification of the parameters of mechanical systems once the dynamical response to certain loads or initial conditions is known, e.g., from experimental recordings, is of wide technical interest. This is confirmed by the rich literature on the subject, mainly focused on the identification of linear systems, while examples on nonlinear systems are much rarer. However, the identification of nonlinear systems is a very challenging problem, aimed at capturing the magnitude of the nonlinearity which can strongly affect the system behavior. In this work, parameter identification of nonlinear continuous systems like beams is carried out through the use of Hilbert-Huang Transform, combined with analytical tools, like either Complexification Averaging or Multiple Scales Method.

Introduction

Beam models can account for nonlinear contributions, which may be regarded to describe different features. On the one hand, geometric nonlinearities are generally considered when moderately large displacements are attained, thus resulting in a coupled transversal and longitudinal behavior [1], where the longitudinal stretch assumes a crucial role depending on the boundary conditions [2]. On the other hand, material nonlinearities may be considered in the moment-curvature relationship: for instance, in pre-stressed reinforced concrete beams, the loss of pre-stress may lead to a piece-wise linear moment-curvature relationship; such a nonlinear feature is triggered as a moderately large curvature is achieved. This work is inspired by [3], where dynamic identification of a two d.o.f. nonlinear mechanical model is carried out, and it is motivated by the desire to extend those results to continuous nonlinear systems, like beams, using either Complexification Averaging (CX-A) or Multiple Scales Method (MSM) to necessarily support the outcomes of the Hilbert Huang Transform (HHT).

Results and Discussion

The dynamic identification of system parameters is achieved from numerically or experimentally data. Based on the literature procedure where CX-A is combined with the HHT to carry out parameter identification of a 2-d.o.f mechanical system, the use of the MSM is instead here proposed as an alternative analytical tool supporting the HHT outcomes. Validation of the technique with paradigmatic single- and multi-d.o.f. systems is accomplished as shown in Fig. 1. Then, the procedure is extended to deal with parameter identification of a

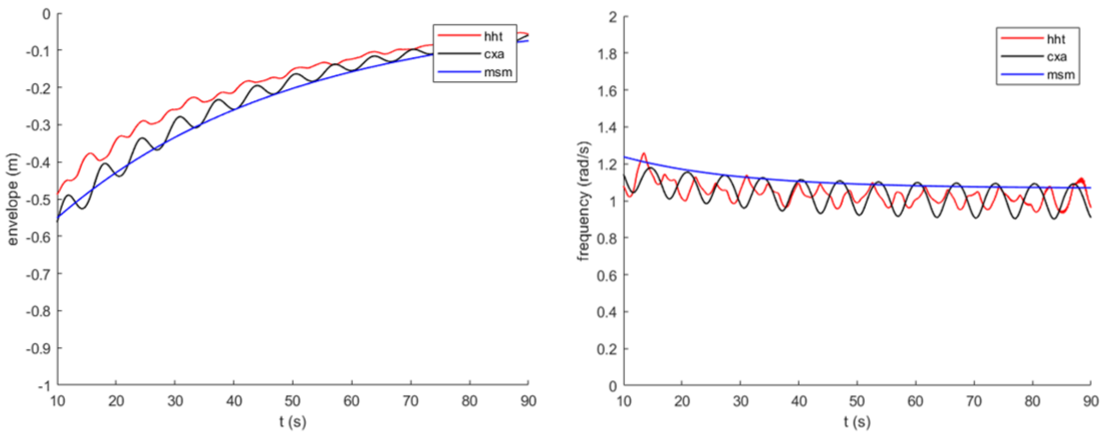

Figure 1: Results obtained with HHT, CXA, MSM, for a 2-d.o.f nonlinear system: envelope (left) and frequency (right)

nonlinear beam, where the MSM is applied in direct approach, i.e. directly tackling the nonlinear partial different equations of motion. Different boundary conditions are applied to the beam, in order to assess the validity of the procedure, as well as considering either geometrical or material nonlinearity. **Acknoweldgement**. This work is partially funded by the European Union - Next Generation EU, Mission 4 Component 2 Investment 1.1, in the framework of the project PRIN 2022 PNRR, "P2022ZT5X5 - Smart Under-Ground Infra-Structures for Secure Communities and Post-Disaster Emergency Response: Eco-Friendly Seismic Protection Solutions" (CUP: E53D2301762 0001, University of L'Aquila).

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