Confidence Intervals on Modal Parameters in Stochastic Subspace Identification

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Summary

In Operational Modal Analysis, the modal parameters (natural frequencies, damping ratios and mode shapes) obtained from Stochastic Subspace Identification (SSI) of a structure, are afflicted with statistical uncertainty. For evaluating the quality of the obtained results it is essential to know the appropriate confidence intervals of these figures. In this paper we present algorithms that automatically compute the confidence intervals of modal parameters obtained from covariance-driven SSI of a structure based on vibration measurements. With these new algorithms we compute the confidence intervals of the modal parameters of some relevant industrial example.

Keywords: Stochastic subspace identification, confidence intervals, mode shape.

1. Introduction

Subspace-based linear system identification methods have been proven efficient for the identification of the eigenstructure of a linear multivariable system in many applications. Our main motivation in this paper is output-only structural identification in vibration mechanics. The problem consists in quantifying the uncertainty related to the identified modal parameters (natural frequencies, damping ratios and mode shapes) of a structure subject to ambient unmeasured vibrations. The modal parameters are afflicted with a statistical uncertainty due to measurement noise, unstationarities in the excitation, ...

In [1] a detailed description of the uncertainties of the modal parameters can be found. In this paper, an alternative scheme for the uncertainty calculation of the mode shape is presented and compared to the approach in [1]. Both approaches are applied to a simulated bridge deck.

2. Reference-based stochastic subspace identification

2.1 State space model

We consider a linear multi-variable output-only system described by a discrete-time state space model

$$\begin{cases} X_{k+1} = AX_k + V_{k+1} \\ Y_k^{(\text{ref})} = C^{(\text{ref})} X_k \\ Y_k^{(\text{mov})} = C^{(\text{mov})} X_k \end{cases} \tag{1}$$

with X_k the state vector at time instant k; $Y_k^{(\text{ref})}$ the observed output vector of the reference sensors; $Y_k^{(\text{mov})}$ the observed output vector of all the sensors minus the reference sensors; $C^{(\text{ref})}$ the observation matrix with respect to the reference sensors; $C^{(\text{mov})}$ the observation matrix with respect

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