# Modular Subspace-based System Identification and Damage Detection on Large Structures

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## Summary

In Operational Modal Analysis (OMA) of large structures it is often needed to process sensor data from multiple non-simultaneously recorded measurement setups, especially in the case of large structures. In order to obtain global modal parameters (natural frequencies, damping ratios, mode shapes) with covariance-driven Stochastic Subspace Identification (SSI), the data from all the setups is normalized, merged and processed together. With this "Pre Global Estimation Re-Scaling" (PreGER) approach the global modal parameters are obtained automatically, but lots of data is processed at the same time, which can easily lead to memory problems when dealing with a big number of measurement setups and sensors. In this paper, a new efficient variant of the PreGER algorithm is presented that avoids the numerical explosion of the calculation by using a modular approach, where the data from the measurement setups is processed setup by setup and not at the same time. Furthermore, a new efficient variant of the subspace-based stochastic damage detection for multiple measurement setups is presented and we show the efficiency of the identification and damage detection algorithms on a relevant industrial example.

**Keywords:** Stochastic subspace identification; data merging; damage detection.

## 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. Moreover, damage detection using null space based stochastic subspace detection techniques has also been proved to be useful in structural health monitoring during the last decade. The main motivation in this paper is output-only structural identification and damage detection in vibration mechanics for large structures when several successive data sets are recorded, with sensors at different locations in the structure. For such measurements, memory problems arise easily with a big number of sensors and data sets. In this paper, an approach to process and merge the sensor data for the covariance-driven Stochastic Subspace Identification with the PreGER method [1, 2] in a modular way is presented and also adapted to damage detection.

## 2. Reference-based stochastic subspace identification (SSI)

### 2.1 Single Setup

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

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

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