Accepted Manuscript

Output-only modal estimation using sparse component analysis and density-based clustering algorithm

Haotian Zhou, Kaiping Yu, Yushu Chen, Rui Zhao, Ying Wu

PII: S0263-2241(18)30382-8
DOI: https://doi.org/10.1016/j.measurement.2018.05.002
Reference: MEASUR 5503

To appear in: *Measurement*

Received Date: 9 February 2018
Revised Date: 27 April 2018
Accepted Date: 1 May 2018

Please cite this article as: H. Zhou, K. Yu, Y. Chen, R. Zhao, Y. Wu, Output-only modal estimation using sparse component analysis and density-based clustering algorithm, *Measurement* (2018), doi: https://doi.org/10.1016/j.measurement.2018.05.002

Output-only modal estimation using sparse component analysis and density-based clustering algorithm

Haotian Zhou, Kaiping Yu*, Yushu Chen, Rui Zhao, Ying Wu

[1.] *School of Astronautics, Harbin Institute of Technology, Harbin, 150001, China.*

Abstract

This paper proposes a blind source separation (BSS) based modal parameter identification method. A density-based clustering algorithm is introduced to estimate the mode shapes even when the number of measured responses is less than the number of active modes. Different from other BSS methods using traditional clustering algorithms, the proposed method doesn't require the number of active modes. Natural frequencies and damping ratios are extracted from the modal responses recovered by smoothed l_0-norm algorithm. The method we proposed in this paper is validated by a five degree-of-freedom mass-spring-damper system. Free and random vibration responses of cantilever beams are analyzed by the proposed method. The comparison of the identified mode shapes and natural frequencies shows good performance of the proposed method in engineering application.

Keywords: Modal parameter estimation; Blind source separation; Density-based clustering; Sparse component analysis.

1 Introduction

Modal parameters, i.e. natural frequencies, damping ratios, mode shapes can be used to describe the dynamic property of a linear dynamic system. Modal analysis and identification methods have been widely used to characterize linear dynamic systems for many years [1]. Since the input of the system or the excitation is hard to measure, the output-only methods consequently have attracted much interests from structural dynamics community in recent decades [2][3], which include eigen realization algorithm (ERA) [4], stochastic system identification (SSI) [5][6], frequency domain decomposition (FDD) [7], AR model [8] and so on. Time-varying problems [9][10] is another hot research area, some of the mentioned methods have been modified for time-varying modal parameter identification [6][8]. The drawback of these methods is that they are sensitive to noise, and the system order is usually hard to determine.

The blind source separation (BSS) aims to separate the sources from mixed signals without prior knowledge of the mixing procedure or sources. The BSS technique has been widely applied in various fields, such as image processing [11], biomedical analysis [12], speech signal processing [13], communications [14]. Many BSS methods have been already applied for operational modal analysis (OMA) successfully. Independent component analysis (ICA) [15][16] assumes that the sources are statistically independent, and is introduced to separate the modal responses from the measured physical responses [17]. The ICA algorithm is only effective with weakly damped modes. To overcome this weakness, a second-order blind identification (SOBI) is introduced [18][19][20]. Some limitations of SOBI are listed and explained in [21]. Method addressed in [20] established a theoretical connection between SOBI and SSI.

Traditional BSS method can only handle determined or overdetermined case. When the number of sources exceeds the number of measurements, the problem turns

* Email address: yukp@hit.edu.cn