Mechanical Systems and Signal Processing 25 (2011) 2923–2937

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

journal homepage: www.elsevier.com/locate/ymssp

Recursive subspace identification for on-line tracking of structural modal parameter

Jian-Huang Weng, Chin-Hsiung Loh *

Department of Civil Engineering, National Taiwan University, Taipei 10617, Taiwan

ARTICLE INFO

Article history:
Received 13 August 2010
Received in revised form
13 March 2011
Accepted 17 May 2011
Available online 12 June 2011

Keywords:
Recursive subspace identification
Forgetting factor
LQ-factorization
Matrix operation

ABSTRACT

The objective of this paper is to develop an on-line tracking of system parameter estimation and damage detection techniques using response measurements. To avoid the singular-value-decomposition in data Hankel matrix, a new subspace identification algorithm was developed. Seismic response data of a 3-story steel frame with abrupt change of inter-story stiffness from the shaking table test was used to verify the proposed recursive subspace identification (RSI) method by using both input and output measurements. With the implementation of forgetting factor in RSI method the ability of on-line damage detection of the abrupt change of structural stiffness can be enhanced. Then, the recursive stochastic subspace identification (RSSI) algorithm is also developed for continuous structural health monitor of structure by using the output-only measurements. Verification of the proposed RSSI method by using the white noise response data of a 2-story reinforced concrete frame from its low level white noise excitation was used. Discussion of the subspace identification model parameters is also investigated.

1. Introduction

Development of structural diagnostic approaches, in-service monitoring of structures with sensor networks may serve to evaluate operational health of structures and estimate the remaining service life. Therefore, development of tools for the automatic identification of modal parameters based on the structural responses during normal operation is fundamental, as a success of damage detection algorithms depends on the accuracy of the modal parameters estimates. Generally, the changes of features in a structural system may due to the nonlinear inelastic response of structure or due to the structural damage subjected to severe external loading. An important objective of structural health monitoring (SHM) for civil infrastructure is to identify the state of the structure and to detect these changes when it occurred. Most important, it is essential to create robust routines to run an on-line basis, in order to have the evaluation of the structural health in almost real-time. It is especially helpful for the rapid assessment of critical infrastructures after the occurrence of natural disaster.

The on-line system identification and damage detection, based on vibration measurements, has received considerable attention recently. Various system identification and damage detection tools via signal analysis have been proposed in the literature. In parametric identification method, Kondo and Hamamoto [1] used ARMA model to identify the modal frequencies and modal shapes of the structure, and to detect the location of damages from changes of the curvature. Safak [2,3] used ARMAX model with Recursive Prediction Error Model (RPEM) to identify the real structure of linear time-varying

* Corresponding author. Tel.: +886 2 3366 4248; fax: +886 2 2739 6752.
E-mail addresses: D94521002@ntu.edu.tw (J.-H. Weng), lohc0220@ccms.ntu.edu.tw (C.-H. Loh).

0888-3270/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ymssp.2011.05.013