ISET Journal of Earthquake Technology, Paper No. 541, Vol. 56, No. 1, March 2019, pp. 1-10

ESTIMATION OF NORMAL MODES VIA SYNCHROSQUEEZED TRANSFORM

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ABSTRACT

The identification of mode shapes is an important but challenging task of vibration based system identification procedures. We propose a simple and robust procedure for extracting mode shape information from the vibration signatures of structures with particular reference to the earthquake excitation cases. A wavelet based synchrosqueezed transform technique is used to decompose the measured vibration response into individual modal response components. The modal frequencies and mode shapes are obtained from the analysis of these isolated modal components. The proposed scheme is validated by considering the response of UCLA Factor Building for a suite of three different ground motions.

KEYWORDS: Blind Source Separation, Modal Identification, System Identification, Synchrosqueezed Transform, Wavelet Transform

INTRODUCTION

Civil engineering systems comprise of massive structures, which have to withstand a variety of dynamic loads like wind, earthquakes, traffic, etc. Continuous operation of these systems, including several life line facilities, requires rigorous maintenance regime and also a mechanism to ascertain any changes in structural properties during regular operating conditions and also in extreme events such as strong earthquakes, high speed winds, etc. Several methods based on the analysis of vibration signatures of structures for assessing its health have been proposed in recent times to detect and identify damage in a structural system. The aim is to provide an early indication of physical damage for facilitating preventive maintenance (Doebling et al., 1996).

System identification is the process of estimating structural system parameters (physical, ormodal) through analysis of input and/or output data (Shiradhonkar and Shrikhande, 2011; Shrikhande, 2014). Due to difficulty in recording the input data in several instances such as wind, or traffic induced vibrations, some output only system identification techniques have been developed, namely, random decrement (Ibrahim, 1977), natural excitation (James III et al., 1993), eigensystem realization algorithm (Juang and Pappa, 1985), subspace identification (van Overschee and de Moor, 2012) frequency domain decomposition (Brincker et al., 2001), and a few wavelet-based techniques (Staszewski, 1997; Lardies and Gouttebroze, 2002; Yang and Nagarajaiah, 2015). Hilbert-Huang transform (HHT) has also been used for iterative empirical mode decomposition to extract intrinsic mode functions from the measured system response (Huang et al., 1998). A wavelet based Hilbert-Huang transform (HHT) technique has also been used in modal identification (Yang et al., 2003a, b).

While most of the processes provide a robust estimation of the natural frequency and damping, the estimation of mode shapes has remained a challenging proposition. The problem of modal identification is structurally similar to the problem of blind source separation (BSS), wherein a set of independent sources are sought to be separated from an uncertain mixture of these sources as shown in Figure 1. The general BSS problem statement can be defined as: