Mechanical Systems and Signal Processing 25 (2011) 1159–1173

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

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

Non-parametric simultaneous identification of both the nonlinear damping and restoring characteristics of nonlinear systems whose dampings depend on velocity alone

T.S. Jang

Department of Naval Architecture and Ocean Engineering, Pusan National University, Pusan 609-735, South Korea

ARTICLE INFO

Article history:
Received 29 January 2010
Received in revised form
17 July 2010
Accepted 4 November 2010
Available online 2 December 2010

Keywords:
Velocity-dependent nonlinear damping
Non-parametric simultaneous identification
Lack of stability
Regularization
Accurate mathematical modeling
Acceleration response

ABSTRACT

This paper presents a general method, which is aimed at identifying both the nonlinear damping and restoring characteristics of nonlinear oscillation systems in which the nonlinear damping is characterized as a function of velocity alone. The method developed for this simultaneous identification involves the non-parametric identification of nonlinear systems. Both system displacement and velocity responses are required for its implementation. However, the numerical approach to this method results in the instability of the numerical solutions, which also means that the solutions identified lack of stability properties. This difficulty is solved by employing a stabilization technique (or regularization). Although the method presented herein is built on the basis of the measurement of the system displacement and velocity responses, a conceptual systematic procedure is also proposed to describe how the system's acceleration response can be used for simultaneous identification. Finally, an example involving a highly nonlinear system is presented to demonstrate the proposed method's workability for simultaneous nonlinear system identification.

1. Introduction

The system identification of mathematical models of nonlinear physical systems has received increasing attention over the past few decades. Appropriate mathematical modeling through identification plays a central role in natural sciences and engineering. For example, the success of extending precise predictions such as nonlinear simulation studies to various loading environments is based on the availability of accurate mathematical modeling for computational mechanics purposes. Numerous excellent papers have been published on the subject of system identification. For example, Masri et al. [1] proposed a neural network-based procedure for the identification of nonlinear restoring characteristics, which was further developed for a wider applicable range and extended to multiple-degree-of-freedom systems [2,3]. A novel technique for the identification of nonlinearity using a fuzzy adaptive neural network [4]) and the Hilbert transform [5,6] has also been presented. With regard to nonlinear damping identification[7,8], Iourtchenko et al. [9] proposed an identification method for parametric excitation. They also developed a new procedure for the in-service identification of damping characteristics based on the stochastic averaging method [10]. A number of other research studies concerning the nonlinear modeling and impact identification also appear in the literature [11–16], which are usually involved in inverse problems that often occur in many branches of science and engineering [17–23].

E-mail address: taek@pusan.ac.kr

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doi:10.1016/j.ymssp.2010.11.002