Mechanical Systems and Signal Processing 25 (2011) 2336–2357

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

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

Environmental effects on the identified natural frequencies of the Dowling Hall Footbridge

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ARTICLE INFO

Article history:
Received 16 June 2010
Received in revised form
11 March 2011
Accepted 12 March 2011
Available online 21 March 2011

Keywords:
Structural health monitoring
Vibration monitoring
Temperature effects on natural frequencies
System identification
Automatic modal analysis
Damage detection

ABSTRACT

Continuous monitoring of structural vibrations is becoming increasingly common as sensors and data acquisition systems become more affordable, and as system and damage identification methods develop. In vibration-based structural health monitoring, the dynamic modal parameters of a structure are usually used as damage-sensitive features. The modal parameters are often sensitive to changing environmental conditions such as temperature, humidity, or excitation amplitude. Environmental conditions can have as large an effect on the modal parameters as significant structural damage, so these effects should be accounted for before applying damage identification methods. This paper presents results from a continuous monitoring system installed on the Dowling Hall Footbridge on the campus of Tufts University. Significant variability in the identified natural frequencies is observed; these changes in natural frequency are strongly correlated with temperature. Several nonlinear models are proposed to represent the relationship between the identified natural frequencies and measured temperatures. The final model is then validated using independent sets of measured data. Finally, confidence intervals are estimated for the identified natural frequencies as a function of temperature. The ratio of observed outliers to the expected rate of outliers based on the confidence level can be used as a damage detection index.

1. Introduction

Major structural failures in recent years have brought the need for improved infrastructure monitoring and maintenance to public attention [1]. The nation's roadways include more than 600,000 bridges [2] which are normally monitored by visual inspections. In many cases, accurate assessment of a bridge's performance is not really possible by these visual inspections. The American Society of Civil Engineers issued its Report Card for America's Infrastructure in 2009 [3], giving bridges an overall grade of "C." A key statistic determining this grade is the number of bridges classified as either "structurally deficient" or "functionally obsolete." Nationwide, more than 26% of bridges fall into at least one of these classifications. Structural Health Monitoring (SHM) can help to maintain and improve the transportation system by providing accurate, timely, and objective information about the condition of bridges [4]. Continuous vibration monitoring is one strategy for SHM. In such a monitoring system, the vibration responses of a bridge due to traffic, wind, and other sources of ambient excitation are measured. From the measured response, the dynamic modal parameters

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doi:10.1016/j.ymssp.2011.03.005