京都大学 KYOTO UNIVERSITY
Graduate School of Engineering/Department of Civil and Earth Resources Engineering
Laboratory of Infrastructure Innovation Engineering

Uncertainty Analysis in System Identification with EOV

Xinda Ma, *Drive for robust SHM Diagnostic Systems*

【Background】

The dynamic features of mechanical system are often basis of vibration-based structural health monitoring (SHM). For reliable performance of vibration-based SHM, it is crucially important to distinguish abnormal changes in modal parameters caused by structural damage from environmental and operational variation (EOV). Moreover, even though there are strategies to take EOV into account, most identification methods originally provide only the best estimates of modal parameters. To develop a robust SHM strategy for purpose of damage identification, it is important to know the accuracy of those estimates.

【Objective】

Investigate strategies to cope with multiple sources of uncertainty in system identification for SHM application through importation of mathematical techniques. For this moment, the study strives to quantify the EOV effect on modal parameters and the uncertainty in system identification.

【Approach】

For uncertainty quantification of system identification, a Bayesian system identification method based on MAR (multiple autoregressive modeling) and its variants is investigated to approach the statistical feature of modal parameters, which is supposed to serve as a reference of identification quality.

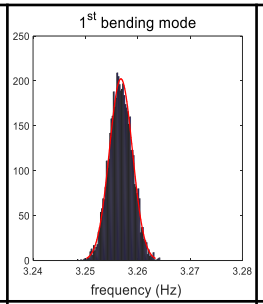
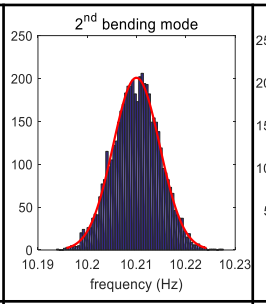
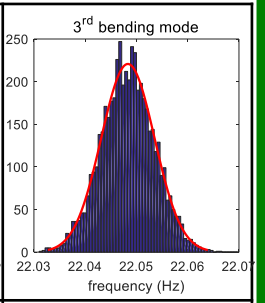
On the other hand, with temperatures measured at different locations of the bridge, regression models such as Gaussian process regression are applied to formulate the correlation that quantifies the temperature effect on identified modal frequencies variation.

【Publication】

X. Ma, C.W. Kim and Y. Goi : Long-term vibration and temperature monitoring on a steel plate girder bridge, 7WCSCM, 22 - 25 July 2018, Qingdao, China.

【Results】

i. A Monte Carlo method based on the MAR and Bayesian inference was performed to quantify uncertainty in modal frequency identification of the first 3 modes of Hakko bridge.

Histogram of frequency	1st bending mode	2nd bending mode	3rd bending mode
			
μ	3.25678	10.21000	22.04830
σ	0.0022	0.004731	0.005197
c.o.v	6.7551×10^{-4}	4.6337×10^{-4}	2.3571×10^{-4}

ii. A model based on Gaussian process was built to correlate temperature change to seasonal and daily modal frequency variation. It is able trace the variation of modal frequencies due to environmental temperature change.