Hierarchical Bayesian Model Updating for PC Girder Bridge

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【Background】

Classical non-hierarchical Bayesian methods generally assume that uncertain model parameters are time-invariant random variables, with their uncertainties arising solely from model error and measurement noise. However, these assumptions may not hold for bridges in the operational phase because the structural dynamic characteristics can fluctuate significantly due to varying operational loads. As a result, recent research has shifted from conventional Bayesian methods to hierarchical Bayesian methods.

【Objective】

This study aims to develop a hierarchical Bayesian model updating framework for quantifying structural parameter uncertainties using modal parameters under operational states. Transitioning from a non-hierarchical to a hierarchical Bayesian approach allows for a more comprehensive quantification of uncertainties arising from measurement errors, model inaccuracies, and inherent structural variability.

【Approach】

In this study, a hierarchical Bayesian model updating framework is proposed to quantify parameter uncertainties in prestressed concrete (PC) girder bridges using modal parameters. This approach estimates the posterior probability density functions (PDFs) of model parameters, characterized by their mean and covariance matrix, which are defined as hyperparameters. Additionally, modeling errors are quantified through the covariance matrix of the error function.

【Publication plan】

・A journal paper that summarizes the research findings of this study.

【Results】

The initial values of $\bar{\boldsymbol{\theta}} = \boldsymbol{\theta}/a$ (with a = 34 GPa) were set to 1.1·$\boldsymbol{e}_6$ ($\boldsymbol{e}_6$ denotes a unit column vector of length 6). A total of 10,000 samples were generated using the MH within Gibbs sampler, with the first 6,000 samples discarded to account for the burn-in period.

Samples from the first three dimensions of the posterior distribution