Modal frequency-environmental condition relation development using long-term structural health monitoring measurement: uncertainty quantification, sparse feature selection and multivariate prediction

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Abstract
The goal of structural health monitoring is to infer structural health status using available measurement. It is well accepted that structural modal frequency can be utilized as an indicator revealing health status of a monitored structure, but this indicator exhibits substantial seasonal variation due to changing environmental conditions (such as temperature and humidity). There are three critical issues in modal frequency-environmental condition relation development: 1) a significant level of uncertainty in both structural dynamical responses and environmental factors; 2) huge number of possible components of input features of environmental factors; 3) capability of multivariate prediction on modal frequencies of several modes. This paper develops an updated version of the Sparse Bayesian Learning (SBL), enhancing the efficiency in the hyperparameter optimization process, with capabilities in uncertainty quantification, sparse feature selection and multivariate prediction. The approach is utilized for modal frequency-environmental condition relation development of a reinforced concrete building based on one-year measurement. It turns out that the optimal multivariate sparse model can depict the pattern between the modal frequencies of the first three modes and the environmental conditions with high fitting capacity and low error sensitivity.

Keywords
Bayesian inference, environmental conditions, sparse feature selection, modal analysis, structural health monitoring

1. Introduction

The goal of structural health monitoring (SHM) is to infer structural health status using available measurement [1-7]. The development of SHM relies on the innovation on sensing