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Sparse Bayesian learning for system identification and damage assessment in structural health monitoring

System identification methods may be used to update a parameterized model of a structure based on features extracted from its measured data such as structural vibration responses or guided-wave/ultrasonic NDT signals. A common goal in applying system identification to structural health monitoring is to infer damage/flaw by updating structural model parameters. However, no structural model is an exact representation of a structure's behavior, because parameter estimation often gives non-unique results, raising the issue of model identifiability. A Bayesian framework has been developed that addresses this difficulty. The relative plausibility of all plausible values of the parameters based on the data is quantified by the posterior PDF (probability density function) coming from Bayes' Theorem. Another powerful feature of the Bayesian framework is that it implements an elegant and powerful version of Ockham's Razor, known as the Bayesian Ockham Razor. It trades off the fit to the data by the model against the amount of information extracted from the data and can automatically avoid over-fitting of the sensor data. Sparse Bayesian learning is a supervised learning framework that is very effective at implementing Bayesian Ockham Razor by achieving sparse representations in the context of regression and classification. We will give an overview of our recent progress of developing sparse Bayesian learning algorithms for performing sparse stiffness loss inference for vibration-based damage assessment and also for flaw detection using guided-wave/ultrasonic NDT signal processing. It will be shown that the incorporation of prior knowledge pertaining to the spatial sparseness of structural damage/flaw helps to suppress the possible occurrences of false and missed damage/flaw detections. Several nice features of our theory from both theoretical and computational perspectives will also be discussed. This research is a joint work with Prof. James L. Beck at the California Institute of Technology and Prof. Hui Li at the Harbin Institute of Technology.

Biography

Yong Huang has completed his Ph.D. in Engineering Mechanics at the age of 28 from Harbin Institute of Technology, China. He is the full professor of Civil Engineering at the Harbin Institute of Technology, China. He was a Postdoctoral Scholar and Visiting Associate in department of Mechanical and Civil Engineering at the California Institute of Technology during the periods of February 2012 until February 2013 and December 2014 until February 2017, respectively. He has over 50 technical publications that have been cited over 400 times, covering topics in structural health monitoring, signal processing, system identification, guided-wave testing, ultrasonic NDT, machine learning. In much of this research he uses a Bayesian probabilistic treatment of modeling uncertainty that is based on probability as a multi-valued conditional logic for quantitative plausible reasoning. He has been serving as an editorial board member of International Journal on Data Science and Technology.

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