Rimple Sandhu

Title

Bayesian Model Selection and Parameter Estimation For a Nonlinear Fluid-structure Interaction Problem

Abstract

In this thesis, we present a Bayesian model selection and parameter estimation scheme for the time domain system identification of a single-degree-of-freedom, nonlinear oscillatory system involving non-trivial fluid-structure interactions using wind-tunnel data. The overall modelling scheme involves three stages: a) selecting a candidate model set; b) estimating their model parameters; c) selecting the optimal model. A backward elimination based stepwise procedure is adopted to form a candidate set whose members are compared using marginal likelihood or evidence calculated using the Chib-Jeliazkov method. The parameter estimation is performed using the Bayesian inference, whereby a Monte Carlo Markov Chain (MCMC) based adaptive
Metropolis-Hastings (M-H) algorithm is employed to sample from the joint posterior distribution of the parameters. The Bayesian inference algorithm involves a state estimation problem which is carried out using the Extended Kalman Filter (EKF). To exploit the high performance computing (HPC) platforms, the distributed implementation of the adaptive M-H sampling algorithm is carried out using Message Passing Interface (MPI). The wind tunnel test of a nonlinear aeroelastic oscillator is conducted for validation and application of the proposed modelling scheme. Initially, a numerical study is performed by mimicking the oscillator response from the wind tunnel test to contrast the performance of the model selection via marginal likelihood with asymptotic methods such as Akaike's Information criterion (AIC), Bayesian Information criterion (BIC) and Information Complexity (ICOMP). Using the model selection scheme, the optimal model of the aeroelastic oscillator is identified using the wind-tunnel test. The optimal model can be used to understand and predict the aeroelastic interactions of the coupled system.

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