The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

BAYESIAN SYSTEM IDENTIFICATION AND DYNAMIC VIRTUALIZATION USING INCOMPLETE NOISY MEASUREMENTS

D. Teymouri[1]*, O. Sedehi[1], L. S. Katafygiotis[1] and C. Papadimitriou[2]

[1] Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong SAR of China
dteymouri@connect.ust.hk, osedehi@connect.ust.hk, katafygiotis.lambros@gmail.com

[2] Department of Mechanical Engineering, University of Thessaly,
Leoforos Athinon, Pedion Areos, 38334 Volos, Greece
costasp@uth.gr

Key Words: *Bayesian Inference, Structural Identification, Uncertainty Quantification, Virtual Sensing.*

This study presents the application of Bayesian Expectation-Maximization (BEM) methodology, developed for coupled state-input-parameter estimation in linear and nonlinear structures [1]. The BEM is built upon a Bayesian foundation, which utilizes the EM algorithm to deliver accurate estimates for latent states, model parameters, and input forces while updating noise characteristics effectively. This feature allows for quantifying associated uncertainties using response-only measurements.

The proposed methodology is equipped with a recursive backward-forward Bayesian estimator that provides smoothed estimates of the state, input, and unknown model parameters during the Expectation step. Next, these estimates help calculate the most probable values of the noise parameters based on the observed data. This adaptive approach to the coupled estimation problem allows for real-time quantification of estimation uncertainties, whereby displacement, velocity, acceleration, strain, and stress states can be reconstructed for all degrees-of-freedom through virtual sensing.

The efficacy of the proposed algorithm in delivering estimates of the state, input, system and noise parameters in both linear and nonlinear dynamical systems is verified through numerical and experimental examples. It is demonstrated that the BEM accurately estimates the unknown parameters based on the measured quantities, not only when a fusion of displacement and acceleration measurements is available but also in the presence of acceleration-only response measurements.

REFERENCES

[1] D. Teymouri, O. Sedehi, L.S. Katafygiotis, C. Papadimitriou, A Bayesian Expectation-Maximization (BEM) methodology for joint input-state estimation and virtual sensing of structures. *MSSP* (Accepted for publication).