Engineering Risk Analysis Group
Prof. Dr Daniel Straub

State space Kriging model for emulating stochastic dynamical systems

Motivation and Objectives

Dynamical systems are widely used in modern engineering and applied science for modeling complex underlying physical phenomena. Although numerical simulation offers a way to predict and study the performance of complex structural systems, their performances are governed by various intrinsic uncertainties associated with the external loads and the model parameters, e.g., stiffness and damping. Uncertainty quantification (UQ) provides a general framework for studying the effect of these uncertainties to the system response quantities of interest (e.g., displacement and velocity), in which uncertain parameters are modelled probabilistically, e.g., using random variable, stochastic process and random field, and are propagated to system response quantities of interest based on the computational model. UQ of stochastic dynamical systems usually requires repeated evaluations of the computational expensive simulation model, which is infeasible in practice. To address this issue, surrogate models have been widely used to construct computationally efficient approximations of the expensive computational model.

This thesis aims at test the performance of the recently developed state space Kriging model[1] for emulating dynamical systems with both external stochastic excitation and random system parameters. The performance will be validated with benchmarks and compared to the state-of-the-art PC-NARX model[2].

Methodology

- Literature review on surrogate modeling of stochastic dynamical systems.
- Investigate the parameters of the state space Kriging model[1] to emulating stochastic dynamical systems with both stochastic excitation and random system parameters.
- Comparison with PC-NARX model[2].

Requirements

What previous knowledge and skills do you expect the student to bring to the project e.g.

- Good knowledge on structural dynamics.
- Good mathematical and programming skills (Matlab or Python)
- Strong analytical skills and an interest in uncertainty quantification and machine learning.

Starting date: Flexible, as soon as possible

Supervised by

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References

1. Cheng, K., Papaioannou, I., Lyu, M. and Straub, D., 2024. State Space Kriging model for emulating complex nonlinear dynamical systems under stochastic excitation. arXiv preprint arXiv:2409.02462.

2. Mai, C.V., Spiridonakos, M.D., Chatzi, E.N. and Sudret, B., 2016. Surrogate modeling for stochastic dynamical systems by combining nonlinear autoregressive with exogenous input models and polynomial chaos expansions. International Journal for Uncertainty Quantification, 6(4).