Engineering Risk Analysis Group
Prof. Dr Daniel Straub

Data driven reconstruction of nonlinear stochastic dynamical systems via multivariate time delay embedding

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, they are computationally extensive. To reduce the computational cost, surrogate models have been widely used to construct computationally efficient approximations of the expensive computational model. However, existing surrogate model usually requires the system is fully observable, which is often too restrictive. Time delay embedding technique is a promising method for addressing this issue, which reconstructs a dynamical system with time histories of a single or a few observations. However, its performance highly depends on its parameters. This thesis aims at investigating the optimal parameters of multivariate time delay embedding method, including the time delay lag, number and locations of the multivariate state variables. The performance will be validated with benchmarks.

Methodology

- Literature review on multivariate time delay embedding theory
- Investigate the parameters of multivariate time delay embedding when combined with state space Kriging model

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

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2. Tan, Eugene, et al, 2023. Selecting embedding delays: An overview of embedding techniques and a new method using persistent homology." Chaos: An Interdisciplinary Journal of Nonlinear Science 33.3.
3. Garcia, S. P., & Almeida, J. S, 2005. Multivariate phase space reconstruction by nearest neighbor embedding with different time delays. Physical Review E—Statistical, Nonlinear, and Soft Matter Physics, 72(2), 027205.

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