MAX-PLANCK-INSTITUT
FÜR DYNAMIK KOMPLEXER
TECHNISCHER SYSTEME
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CSC Seminar

SPEAKER

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TITLE

Sparse Bayesian Learning for Rational Surrogate Models in the Context of Structural Dynamics

ABSTRACT

Surrogate models enable efficient propagation of uncertainties in computationally demanding models of physical systems. We employ surrogate models that draw upon polynomial bases to model the stochastic response of structural dynamics systems. In linear structural dynamics, the system response can be described by the frequency response function. In [1] we proposed a rational approximation that expresses the system frequency response as a rational of two polynomials with complex coefficients. We showed that the proposed model is able to capture accurately the highly nonlinear nature of the frequency response function, especially for structures with low damping. To estimate the coefficients of the approximation, a non-intrusive regression approach that can be coupled easily with existing deterministic solvers was introduced. However, to accurately estimate all coefficients of the polynomials in the numerator and the denominator, a large number of system evaluations is required in order to avoid overfitting. This is especially critical in high dimensional problems where the number of coefficients becomes excessively high. In order to extend the applicability of the proposed surrogate model to higher dimensional problems, we introduce a sparse learning approach that retains only the polynomial terms that contribute significantly to the predictability of the surrogate. In particular, we employ a sparse Bayesian learning approach with a hierarchical prior construction that follows the formalism of the relevance vector machine approach in [2]. This results in a regularized minimization problem, which is sequentially solved for the hyperparameters of the prior and likelihood function, and the unknown coefficients. To accelerate convergence, we apply a pruning of the coefficients following the algorithm of [2]. We demonstrate the applicability of the method on the frequency response function of an algebraic frame model.

REFERENCES

[1] F. Schneider, I. Papaioannou, M. Ehre and D. Straub, Polynomial chaos based rational approximation in linear structural dynamics with parameter uncertainties. Submitted to Computers & Structures, 2019.

[2] Tipping, M. E., Sparse Bayesian learning and the relevance vector machine. Journal of Machine Learning Research, pp. 211-244, 2001.

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seminar room Prigogine