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Master's Thesis

Application of non-linear regression to rational surrogate models for efficient uncertainty quantification in the frequency domain

Motivation

Surrogate models enable efficient propagation of uncertainties in computationally demanding models of physical systems. We employ surrogate models to model the frequency response functions of linear structural dynamic models.

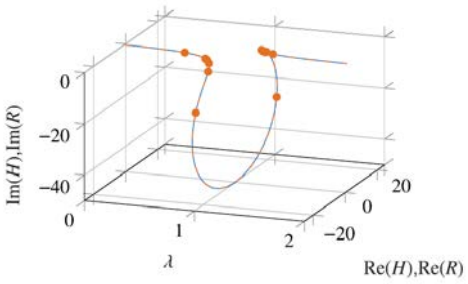

Figure 1: Rational approximation for the frequency transfer function of an SDOF system in blue. The orange line shows the original model output and the orange dots resemble the data points used for building the surrogate.

A standard approach for surrogate models is the polynomial chaos expansion. It is well known that standard PCEs of the frequency response present slow convergence around system eigenfrequencies, due to the highly nonlinear nature of the frequency response for low damping [1,2]. To overcome this issue, a rational approximation that expresses the system response as a rational of two polynomials with complex coefficients is proposed by [3]. The coefficients of the expansions are obtained through minimizing the squared absolute loss between the original model and the surrogate.

However, the regression approach used in there is based on a linearized residual formulation, which potentially leads to errors in the estimation of the surrogate model coefficients. For that reason, it is of interest to investigate a non-linear regression approach, to tackle the original non-linear regression problem.

Tasks

- Get familiar with the surrogate model and its application to uncertainty quantification
- Research on non-linear regression approaches and their applicability to complex-valued problems
- Implement promising algorithms or adapt existing solutions, including e.g. regularization methods
- Investigate the performance and error reduction compared to a linearized regression formulation
- Perform an extensive parameter study for different models

Supervisors

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