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Can machine learning methods be used to create parametrized reduced models of vibro-acoustic systems?

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The optimization of vibro-acoustic systems in terms of vibration or sound radiation requires many system evaluations for varying parameters. Often, material or geometric uncertainties have to be considered. Vibro-acoustic systems are typically large and numerically expensive to solve, so it is desirable to use an efficient parametrized surrogate model for optimization tasks. Classic reduced order modelling has already been used to create parametrized reduced models of vibro-acoustic systems (Aumann et al. 2019; van Ophem et al. 2019). In this contribution, we want to investigate the potential of using machine learning techniques, such as neural networks or regression models to create parametrized surrogate models for vibro-acoustic systems.

Swischuk et al. (2019) created parametrized surrogate models for a structural system combining reduced order modelling and machine learning methods. They used proper orthogonal decomposition (POD) for non-linear systems in the time domain to generate the POD coefficients and trained their surrogate model with a neural network and different regression methods to map parameter sets to POD coefficients. Their resulting surrogate model is used for real-time structural damage evaluation. We want to pursue a similar approach for vibro-acoustic systems in the frequency domain. Using a classic model order reduction method, we extract the dominant modes of systems with given parameter sets and use them to train a surrogate model. The model shall be trained to find the proper poles of the reduced system given an unknown set of parameters. Using the poles, a reduced order model for this parameter set can be created and evaluated efficiently. Its response can also be transformed to obtain the full system's response and can be used for optimization tasks.

Such a surrogate model can be used, for example, to optimize the radiation characteristics of a violin, which heavily depends on the thickness of its corpus and the used materials. Another application is system identification. The surrogate model can be trained to map obstacle locations in an acoustic cavity to its response to a defined excitation. In an inverted process, the trained model can then test an actual response resulting from an obstacle against possible obstacle locations to find its actual position.

References:

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Authors: AUMANN, Quirin (Technical University of Munich, Chair of Structural Mechanics); MÜLLER, Gerhard (Technical University of Munich, Chair of Structural Mechanics)

Presenter: AUMANN, Quirin (Technical University of Munich, Chair of Structural Mechanics)

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