Topology Optimization with Polymorphic Uncertainties using Artificial Neural Networks

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Abstract

Structural optimization is focused on the design of engineering structures using the construction material in an efficient way. Objectives are in general to minimize the self weight or to maximize the stiffness. Constraints with respect to the load bearing capacity and serviceability have to be considered such as the strength of materials and maximal displacements. The design variables are either shape parameters defining the dimensions of the structural members (shape optimization) or information about the material distribution defining the topolopy of the structure (topology optimization), see e.g. Sigmund and Maute (2013). A challenging problem in structural optimization is the consideration of aleatory and epistemic uncertain structural parameters and design variables (Valdebenito and Schuëller (2010)), which requires to define appropriate uncertainty measures to evaluate uncertain objective functions and uncertain constraints, see e.g. Mäck et al. (2019); Edler et al. (2019). In this paper, a topology optimization approach is presented, where aleatory and epistemic uncertainties are taken into account by random variables, intervals and probability boxes. Solving optimization problems with polymorphic uncertainties leads to a high computational effort. Here, the finite element simulation model of the topology optimization is replaced by artificial neural networks to approximate the stress and displacement constraints as well as the material density distribution in the design domain. An application for the topology optimization of a cantilever structure is presented.

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