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Multiscale modelling of shell structures with artificial neural networks

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By using multiscale methods, the effective material behavior of complex microstructures is acquired within a numerical homogenization scheme. In [1], the authors develop a coupled two-scale shell model, which is capable of capturing the mechanical behavior of heterogenous shell structures. In order to surpass the time consuming two-scale model, alternative approaches aim to replace the local boundary value problem with suitable surrogate models.

Developing material models by means of artificial neural networks (ANN) on the basis of stress-strain data has become a popular alternative to conventional approaches. In [2], an ANN is trained with experimental data and is used as material model within structural finite element calculations. Alternatively for heterogenous structures, the effective stress-strain data can be gained numerically, which shall be considered here.

In this contribution, the ANN defines the relationsip between the effective shell strains and stress resultants, obtained from an RVE, for a non-linear shell model. The computional performance is compared to material models based on analytical and multiscale solutions. Special focus is set on the influence of the ANN material tangent, which includes studies on the ANN convergence behavior within a Newton iteration scheme and its impact on e.g. limit points in stability analysis within finite element calculations.

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