A Neural Network Based Homogenization Approach

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ABSTRACT

Modern composite materials combine the properties of different constituents in order to design a material with significantly improved and beneficial characteristics. These synergetic effects result from the interactions of the particular constituents under consideration of the underlying meso- or microstructure. In order to design a material with the desired characteristics, numerical investigations are used to understand and optimize the effective behavior on the macro scale. For that purpose, a sufficient numerical model of a representative volume element (RVE), describing the microstructure of the composite, is constructed. The developed RVE model is tested under several loading scenarios and the corresponding macroscopic mechanical response is obtained. This method is called numerical material testing (NMT).

In terms of homogenization, the knowledge gained from the NMT can be used to formulate an effective macroscopic constitutive model as it is shown in Terada et al. [1]. However, to find a proper mathematical formulation of such a model is often very challenging and time consuming. In order to overcome this issue, neural networks offer the opportunity to learn and approximate the mechanical composite behavior obtained from the NMT. Especially for time and history dependent materials, recurrent neural networks allow the consideration of long-term dependencies [2]. Hence, a properly trained neural network can be utilized in macroscopic structural finite element simulations to substitute constitutive equations for the composite. It enables a convenient and general approach to multiscale analysis for complex and highly nonlinear materials.

In this contribution, a framework for the described neural network based homogenization approach is presented. Moreover, the capabilities and limitations of the method are exemplary shown.

REFERENCES

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