Two-scale homogenization of nonlinear solids undergoing large deformations

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ABSTRACT

This work presents a model order reduction framework for the purpose of two-scale homogenization in the presence of both geometrical and material nonlinearities. The effective material laws are efficiently approximated,

$$\overline{\mathbf{K}} \;\mapsto\; \overline{\mathbf{T}}_K = \frac{\partial \overline{W}_K}{\partial \overline{\mathbf{K}}},\; \overline{\mathbb{C}}_K = \frac{\partial^2 \overline{W}_K}{\partial \overline{\mathbf{K}} \partial \overline{\mathbf{K}}},$$

where the kinematic quantity $\overline{\mathbf{K}}$ may stand for the deformation gradient, the Green strain, the stretch tensor, or any other quantity with respect to which a stored energy function $\overline{W}_K$ can be formulated. An important feature is the generality of this method with respect to the prirmary variable of the problem setting.

The approximation is two-staged, extending the RNEXP method [1] to the regime of geometrical nonlinearity.

In the *first stage*, the original balance equations are solved by a Reduced Basis model. It captivates with both its numerical efficiency and its methodological simplicity.

In the *second stage*, in silico data generated during the first stage is interpolated by means of a dedicated kernel-based method. This means in particular that the effective material law can now be evaluated in an iteration-free manner.

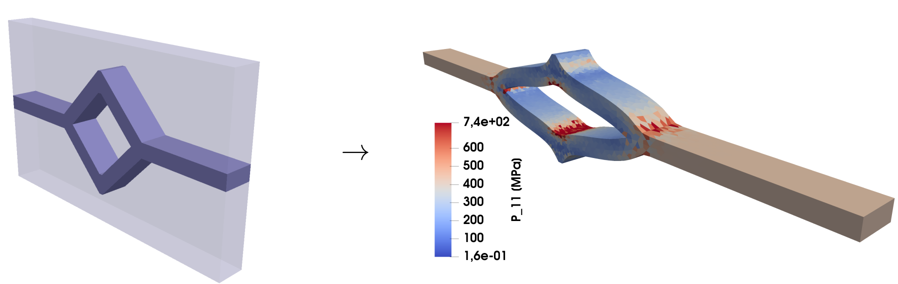

Figure 1: Example of a deformation with pronounced geometric stiffening.

Figure 1 exemplifies a scenario in which geometric nonlinearities dominate the effective properties, that are accurately reproduced by our method.

REFERENCES

[1] Fritzen, F. and Kunc, O. Two-stage data-driven homogenization for nonlinear solids using a reduced order model. *European Journal of Mechanics / A Solids* (2018) **69**:201–220