6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

WAVELET-BASED MULTI-SCALE MODEL REDUCTION IN COMPUTATIONAL HOMOGENIZATION

Marc G.D. Geers[1], Rody van Tuijl[1], Joris J.C. Remmers[1], Cale Harnish[2], Karel Matouš[2]

[1] Eindhoven Univ. of Technology, Eindhoven, The Netherlands, mg@tue.nl
[2] Univ. of Notre Dame, Notre Dame, IN 46556, USA, kmatous@nd.edu

Key words: *Computational homogenization, Model reduction, Wavelets*

Computational Homogenization is a well-known multi-scale method to solve a macroscopic equilibrium problem, based on the underlying micro-scale equilibrium of heterogeneous material volume elements. The method is by now widely established and used for a variety of problems and materials. The approach consists in the solution of two nested boundary value problems, one at each scale. The equilibrium of representative volume elements is solved in selected macroscopic integration points. As a result, the method is computationally very expensive, both in terms of memory usage and CPU time. This seriously compromises its applicability to large problems. The algorithmic structure of the two-scale problem, and the solution of the micro-scale boundary value problems can be naturally exploited in a model reduction scheme [1].

This contribution proposes a novel method to accurately and efficiently reduce a microstructural mechanical model, as used in computational homogenization, using a wavelet based discretisation [2, 3]. The model enriches a standard Reduced Order Modelling (ROM) approach with a wavelet representation. Although the ROM approach reduces the dimensionality of the system of equations, the computational complexity of the integration of the weak form remains problematic. Using a sparse wavelet representation of the required integrands, the computational cost of the assembly of the system of equations is reduced significantly. This Wavelet-Reduced Order Model (W-ROM) is applied to the mechanical equilibrium of a microstructural volume element. The efficiency of the method in the computational homogenization setting is discussed and differences with existing hyper-reduction techniques are highlighted. Illustrative examples in 1D and 2D are presented.

Acknowledgment
The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013) / ERC grant agreement n° [339392].

REFERENCES

[1] R.A. van Tuijl, J.J.C. Remmers, M.G.D. Geers, Integration efficiency for model reduction in micro-mechanical analyses. *Comp. Mech.* (2017) DOI 10.1007/s00466-017-1490-4.

[2] C. Harnish, K. Matous, D. Livescu, "Adaptive wavelet algorithm for solving nonlinear initial-boundary value problems with error control", Int. Jnl. Mult. Comp. Engng., *in press*, (2017).

[3] R.A. van Tuijl, C. Harnish, K. Matouš, J.J.C. Remmers, M.G.D. Geers, Wavelet Based Reduced Order Models for Microstructural Analyses. *In review* (2018)