Séminaire du laboratoire PIMM

Jeudi 27 mai 2021 à 13h30 sur Teams

Prof. Jan ZEMAN
Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague

présentera dans le cadre du séminaire ses travaux intitulés :

Wang tiles for modeling and simulation of heterogeneous materials

This talk summarizes our extension of the classical Periodic Unit Cell-based representation of material microstructure. Inspired by computer graphics, we adopt the formal concept of Wang tiles and propose to store microstructural information within a set of domains with predefined mutual compatibility instead of a single cell. Following simple assembly rules similar to those of jigsaw puzzles, our extension allows for almost instant generation of arbitrarily large stochastic samples with consistent spatial statistics.

We start with a brief introduction of the concept fundamentals and present methods suitable for compressing microstructural information into a set of tiles. Next, using statistical sampling and bounds provided by the Partition Theorem, we apply our approach in numerical homogenization to determine the Representative Volume Element size related to the user-defined significance level and the discrepancy between bounds on the apparent properties.

Finally, we present a reduced-order modeling strategy that exploits the repeating occurrence of individual tiles in generated microstructures. We pre-compute the collective characteristic response of the compressed microstructural representation to a macroscopic loading and extract a-priori microstructure-informed modes for the fluctuation part of a macroscopic solution. These modes are then inserted into a macroscopic numerical scheme utilizing a kinematical ansatz of the eXtended Finite Element Method. Using an illustrative 2D elliptic problem, we demonstrate that our scheme delivers less than a 3% error in both the relative L2 and energy norms already with only 0.01% of the unknowns compared to the fully resolved problem, with further improvements, e.g., by local refinement possible.

References

[1] Doškář, M., Novák, J. and Zeman, J. Aperiodic compression and reconstruction of real-world material systems based on Wang tiles. Phys. Rev. E (2014) 90:062118

[2] Doškář, M., Zeman, J., Jarušková, D., and Novák, J. Wang tiling aided statistical determination of ´ the Representative Volume Element size of random heterogeneous materials. Eur. J. Mech. A-Solids (2018) 70:280—295.

[3] Doškář, M., Zeman, J., Rypl, D. and Novák, J. Level-set Based Design of Wang Tiles for Modelling Complex Microstructures. Comput.-Aided Des. (2020) 123:102827.

[4] M. Doškář, J. Zeman, P. Krysl, and J. Novák: Microstructure-informed reduced modes synthesized with Wang tiles and the Generalized Finite Element Method, Comput. Mech. (2021), accepted for publication, arXiv:2010.02690