Numerical simulation of coupled problems in the context of the parallel *hp*-adaptive finite cell method

J. Jomo*, M. Carraturo*,†, L. Hug,*
S. Kollmannsberger,* R. P. Mundani * and E. Rank*,‡

* Chair for Computation in Engineering
Technical University of Munich
Arcisstr. 21, 80333 Munich, Germany

† Department of Civil Engineering and Architecture
University of Pavia
via Ferrate 3, 27100 Pavia, Italy

‡ Institute for Advanced Study
Technical University of Munich
Lichtenbergstr. 2a, 85748 Garching, Germany

ABSTRACT

The numerical simulation of coupled problems is particularly challenging in the presence of non-linearities in the equation system or when different scales in both space and time have to be resolved. These challenges can become especially daunting when trying to simulate large coupled problems in engineering practice e.g. crack propagation in industrial specimens and artifacts or when simulating residual stresses in the process of metal additive manufacturing. A combination of adaptive finite element techniques, immersed methods and parallel computing can be used to mitigate some of the challenges present in the simulation of these coupled problems.

Our contribution presents a computational framework aimed at efficient coupled simulations through the combination of the finite cell method, multi-level *hp*-refinement and parallel computing. The finite cell method [1] is a high-order immersed method suited for the numerical analysis of domains with a complex geometry while the multi-level *hp*-refinement scheme [2] allows local mesh adaptation without the trouble of constraining hanging nodes. Using these two discretization techniques in an MPI-parallel setting results in a flexible and scalable framework which can be used for a wide-range of geometrical models and physics.

The structure and performance of our numerical framework will be shown for various coupled problems such as in simulations of fracture growth computed by means of a phase field approach and in the simulation of additive manufacturing processes.

REFERENCES

[1] Düster, A. and Parvizian, J. and Yang, Z. and Rank, E. *The finite cell method for three-dimensional problems of solid mechanics.* Computer Methods in Applied Mechanics and Engineering 2008.

[2] Zander, N. and Bog, T. and Kollmannsberger, S. and Schillinger, D. and Rank E. *Multi-level hp-adaptivity: high-order mesh adaptivity without the difficulties of constraining hanging nodes.* Computational Mechanics 2015.