An efficient pcg based multigrid strategy for crack propagation simulations in heterogeneous materials using 3D images: material properties and interface effects

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Numerical modeling of fracture is one of the most powerful ways to let researchers understand and predict failure of cracked structures. The phase field modeling is a widely used computational fracture model due to numbers of advantages. However, performing 3D phase field modeling with real μ-structures is still expensive and complicated due to numbers of challenges, *e.g.* memory requirement, mesh complexity [1].

Based on our previous work on image-based simulations for thermal and mechanical problems [2, 3]. A matrix-free type preconditioned conjugate gradient solver based multigrid method was proposed in our work [4] to perform the phase field modeling. With the strategy developed in [4], we can automatically and efficiently perform the 3D phase field modeling of fracture at the microscopic scale using CT images without making geometrical hypothesis.

In this talk, we will present our recent results obtained on considering the presence of the interface between different materials, during the crack propagation simulations, using the efficient strategy developed in [4]. The micro-macro interactions are also demonstrated by studying the influences of materials properties at the microscopic scales. The importance to consider the presence of interfaces is approved by the good agreement found between the simulation and the experiment.

References

[1] T. T. Nguyen, J. Yvonnet, M. Bornert, C. Chateau, F. Bilteryst, E. Steib, Large-scale simulations of quasi-brittle microcracking in realistic highly heterogeneous microstructures obtained from micro ct imaging, *Extreme mechanics letters*, 17:50–55, 2017

[2] X. Liu, J. Réthoré, M.-C. Baietto, P. Sainsot, A. A. Lubrecht, An efficient strategy for large scale 3D simulation of heterogeneous materials to predict effective thermal conductivity, *Computational materials science*, 160:265–275, 2019

[3] X. Liu, J. Réthoré, M.-C. Baietto, P. Sainsot, A. A. Lubrecht, An efficient finite element based multigrid method for simulations of the mechanical behavior of heterogeneous materials using CT images, *Computational Mechanics*, 66(6):1427–1441, 2020

[4] X. Liu, J. Réthoré, A. A. Lubrecht, An efficient matrix-free preconditioned conjugate gradient based multigrid method for phase field modeling of fracture in heterogeneous materials from 3D images, *Computer Methods in Applied Mechanics and Engineering*, 388:114266, 2022