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HIGH-PERFORMANCE MODEL ORDER REDUCTION IN COMPUTATIONAL MULTISCALE FRACTURE

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Abstract. Multiscale modeling of fracture displays a large potential to incorporate, through multi-scale computational homogenization methods (FE2), the complexity of the material meso/micro structure in the modeling of propagating material fracture at the macro-scale. However, it presently suffers the burden of its enormous, multiplicative, computational cost, since the computational complexity (number of the involved operations) has a multiplicative character i.e.: it is the product of the number of the involved sampling points at every scale.

A powerful, and conceptually simple, multiscale computational model for fracture has been recently presented by the authors in (Oliver J., Caicedo M., Roubin E., Huespe A.E., and Hernandez J.A.: Continuum approach to computational multiscale modeling of propagating fracture. *Computer Methods in Applied Mechanics and Engineering*, 294:384–427, 2015.) and applied to some 2D benchmarks. However, its extension to actual, real-life, 3D problems appears nowadays unaffordable, in terms of the computational time, even by resorting to high performance computing (HPC) strategies (e.g. parallel computing in powerful computer clusters).

In this work, combination of two techniques: 1) low-dimension-space projection of the solution (reduced order modeling, ROM) and 2) reduced optimal quadrature (ROQ), leads to a high performance reduced order model (HPROM) of the original high fidelity (HF) multiscale fracture problem, which dramatically diminish the computational demand, at the cost of a very small additional error. The resulting speedup (up to 120 times in same of the considered benchmarks) and the displayed linear scalability of the obtained speedup, in terms of the problem complexity, make think of the HPROM techniques as feasible tools to break the tyranny of the scales. A possible setting, to take this type of technology to industrial purposes, is finally sketched.