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Implementation and evaluation of non-local integration scheme for numerical modelling of fracture processes.

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Fracture propagation in brittle rock is widely studied in classical theory of linear elastic fracture mechanics; however, this neglects dissipation in the fracture zone.
Micro-cracking, plasticity and other dissipative processes imply non-linearities in the constitutive response. To study such non-linear effects, we developed a plastic-damage model and implemented a non-local finite element method.
We employed configurational mechanics arguments to compute fracture energy.
The implementation of the non-local integration method is done in OpenGeoSys-6 finite element open-source software.
Several techniques for computation of the non-local integrals are presented and major performance bottlenecks and memory access patterns as well as cache locality are discussed.
Furthermore, we investigate possibilities for MPI parallelization of the non-local integration.

Numerical results are compared to acoustic emission detection experiments on Adelaide black granite and demonstratethat the size of the fracture process zone plays a significant role in fracture development and in the global load-displacement response.
Through configurational mechanics, we achieve better estimates of fracture energy when crack-tip dissipation is non-negligible, ultimately improving the interpretation of experiments designed to highlight the dominant physical mechanisms driving fracture.

Additionally, we achieved sufficient speedup of the non-local algorithm compared to the more standard approaches of the non-local integral computations.
The higher numerical efficiency opens up new possibilities in terms of large-scale, three-dimensional and parallelized analyses.

References:

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