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Adaptive meshing for phase-field fracture simulations

Cracks are discrete geometrical features which cause discontinuities, making them hard to describe with continuum mechanics. One approach to overcome this challenge, is using so-called phase-field fracture finite element models, cf. [1]. With this technique, the discrete cracks are described as a smoothly varying damage field, often called a smeared crack. This methodology is very flexible; it can capture crack branching and merging and consider arbitrary complex geometries. However, the disadvantage is that a very fine mesh is required around the crack. If the crack path is known beforehand, it is feasible to have a very fine mesh in the crack path. However, apart from in simple academic examples, the crack path is often unknown, and it is not possible to know where the mesh needs to be fine before running the simulation. This calls for so-called adaptive meshing techniques (cf. e.g. [2]), where the mesh is updated as the crack progresses, making the simulation computationally feasible.

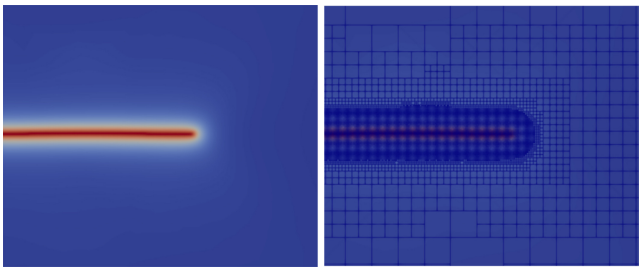

Figure 1: Adaptive meshing for phase-field fracture [3]

In this project, we aim to implement adaptive meshing using Ferrite.jl for phase-field simulations. The project has four main steps,

- Literature review of adaptive meshing techniques, focusing on phase-field fracture simulations
- Implementation of adaptive meshing scheme for linear elasticity
- Extend the adaptive meshing to phase-field fracture using the micromorphic model in [1]
- Performance comparison, analysis and optimization

For a master thesis, all four steps are expected to be completed. For a specialization project, steps 1-3 are considered sufficient.

References

[1] Ritukesh Bharali et al. “A micromorphic phase-field model for brittle and quasi-brittle fracture”. In: *Computational Mechanics* (2023). DOI: 10.1007/s00466-023-02380-1.

[2] M. Cecilia Rivara. “Algorithms for refining triangular grids suitable for adaptive and multigrid techniques”. In: *International Journal for Numerical Methods in Engineering* 20.4 (1984), pp. 745–756. DOI: 10.1002/nme.1620200412.

[3] Adrien Jaccon et al. “Adaptive mesh refinement and cycle jumps for phase-field fatigue fracture modeling”. In: *Finite Elements in Analysis and Design* 224 (Oct. 2023). DOI: 10.1016/j.finel.2023.104004.