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A ‘quasi-discrete’ model of fracture in geomaterials

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Motivation
A large variety of geomaterials used in civil engineering exhibits a quasi-brittle behavior. The understanding and the prediction of the cracking and the failure behavior of these materials in construction and building applications are of the highest interest in order to ensure their structural safety and to estimate the load bearing capacity of existing historical buildings.

Numerical challenge
Fracture is a phenomenon bridging multiple scales.

Most numerical models for quasi-brittle fracture using continuum scale constitutive laws remain limited by their high complexity or computational cost. The prime purpose of this project is to propose a multi-scale scheme which bears high efficiency coupled to simplicity to attenuate these common drawbacks.

A ‘quasi-discrete’ approach
The principle of the proposed formulation is a coupling between numerical scale transition techniques and a discrete description of equilibrium on the structural level. The structure is composed of assembled cells (unit volume of microstructure) in both behavioral and geometrical sense. The deformation of a cell is imposed by the displacements of its control points, which are the only representation of a cell that appears on the structural scale. Different cellular boundary conditions can be considered to allow realistic crack propagation and branching in the cell and on the structural level (cross-talk between neighboring cells).

Application to masonry

Deformed configuration of a compressed, sheared masonry wall. (Only the brick contours are plotted for QD, the underlying FE mesh of each cell is omitted for the sake of clarity.) Crack initiation is shown by arrows. Load-displacement curves agree well.

Conclusions and outlook
The proposed scheme benefits from a natural representation of fracture on the structural scale (simplicity) and from a potential easy adaptivity of this discrete network of points as a function of crack propagation in the underlying microstructure (efficiency). Adaptivity on the macroscale based on force-displacement type relations will be investigated in a future work. As a first step a selectivity condition will be defined which leads to conduct a cell computation only when a particular cell exhibits a nonlinear response. The ‘quasi-discrete’ approach is first applied to periodic microstructures (masonry) with the ultimate goal to extend it to heterogeneous random microstructures (concrete).

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