A Finite Strain Discrete Dislocation Plasticity Model

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Introduction
For a wide range of ductile materials, plastic deformation occurs as a consequence of the collective motion of dislocations gliding on slip planes. This motion may lead to finite lattice rotations. Although the significance of lattice reorientations has long been recognized, discrete dislocation plasticity framework has been restricted to infinitesimal deformations.

Goal
Our goal is to develop a discrete dislocation (DD) framework which is capable of capturing finite lattice rotations and shape changes due to slip. This method gives us the tools for modelling different phenomena such as crack tip blunting, where the lattice rotations are not negligible (Fig. 1).

Challenges
As the displacement field on the slip plane is not unique, the derivatives of the displacement field and therefore the strain and stress fields become singular. Hence when solving for these fields we have to deal with singularities.

Method
The nonlinear finite deformation problem is solved by extending the superposition method of Giessen and Needleman [1] and applying a Total Lagrangian setting.

Results
As it was mentioned the displacement field is only piecewise continuous and therefore an iterative finite element procedure which is capable of detecting areas with singularities is needed (Fig. 2). At time $t = t_0$, our domain is in its undeformed configuration. As we increase the loading, dislocations start to appear and they continue to deform our domain by gliding.

Conclusions
1) We have presented a finite strain DD formulation capable of capturing shape deformations caused by dislocation slip.
2) Our results show that unlike in small strain DD, finite strain effects result in a size dependent tension-compression asymmetry.

References