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Fast and efficient MPM solver for strain localization problems

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Strain localization problems, i.e., shearbandings, have received a lot of interest, especially when strain softening is disregarded from the elasto-plastic consistution relationship. Indeed, reproducing correctly oriented shear bands without softening allows to overcome the mesh-depenency problem. Our work focuses on a Material Point Method (MPM) implementation of strain localization to i) study the behavior of shear bands in order to ii) assess the capabilities of this quite recent numerical method.

To study strain localization and shear banding, we developped an efficient numercial Material Point Method (MPM) solver in Matlab, based on the Update Stress Last (USL) scheme enriched with the Generalized Interpolation Material Point (GIMP) variant, which fixes a major flaw of any MPM solver: the cell-crossing error due to discontinuous gradient of the basis functions. This home-made solver allows us to study strain localizations in either a fixed or continuously deforming continuum. The algorithm solves explicitly momentum equations in an updated lagrangian manner similarly to an explicit FEM solver. We therefore investigate the compression of an elasto-plastic domain under pure shear condition, thus reproducing the geometrical settings and pure shear conditions used in Duretz et al. (2018). Strain softening is disregarded since we do not want any mesh dependence within the solver. A Mohr-Coulomb yield criterion was selected and plasticity was computed by a return mapping algorithm, i.e., we did not use consistent tangent operator. Localization is triggered by a weaker circular inculsion in the center of the domain..

Preliminary results demonstrates the suitability of the MPM solver to reproduce the correct shearbanding behavior under compression, for both static and dynamic meshes. The higher the resolution, the more accurate are the shear bands. Naturally, this implies future implementations of the solver in a GPU-accelerated environment to increase the numerical resolution.