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## Lipschitz Regularization For Softening Material

Nicolas Chevaugeron<sup>1</sup>, Nicolas Moës<sup>1,2</sup>

<sup>1</sup> Centrale Nantes, GeM, UMR 6183, 44321 Nantes, France.

<sup>2</sup>Institut Universitaire de France (IUF), 75005 Paris, France.

nicolas.chevaugeron@ec-nantes.fr, nicolas.moes@ec-nantes.fr

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The Lip-field approach is a new regularization method for softening material models. It was presented first in [1] providing one-dimensional simulations for damage and plasticity and was recently extended and implemented for two-dimensional problems [1]. In the Lip-field approach, the mechanical problem is formulated as the minimization of an incremental potential, function of the displacement field and internal variables. The potential itself is not regularized and has essentially the same form as in a local formulation. It does not contain any term depending on the spacial variations of the internal variables (like the Laplacien) as is the case in typical phase-field approach [3, 4]. In the Lip-field approach, the regularization comes from the addition of a **Lipschitz** constraint on the damage field. In other words, the difference between the damage values at any two points must be less than the distance them, divided by a characteristic length. A discrete version of the Lipschitz constraint in the context of the finite element-method is constructed, defining a convex discrete subspace. Then a resolution scheme is presented, based on an iterative staggered scheme. The displacement field is sought for a given damage field by minimizing the potential with regards to the displacement, leading to classical equilibrium equations. Then at fixed displacement, the damage field is the minimizer of the potential, under the discrete Lipschitz constraint, the latter leading to a convex minimization, with convex constraint, solvable with standard interior point cone programming. In order to drastically reduce the complexity, we detail the construction of bounds of the subdomain where the constraint need to be explicitly unforced. The contribution is concluded by two-dimensional examples demonstrating the capability of the approach.

### REFERENCES

- [1] Moës, N. and Chevaugeron, N. Lipschitz regularization for softening material models: The Lip-field approach. *Comptes Rendus - Mécanique*, (2021) **349**: 415–434.
- [2] Chevaugeron, N. and Moës, N. Lipschitz regularization for fracture: the Lip-field approach. *preprint-arxiv*, (2021), <https://arxiv.org/abs/2111.04771>
- [3] Amor, H., Marigo, J.-J. and Maurini, C. Regularized Formulation of the Variational Brittle Fracture with Unilateral Contact: Numerical Experiments, *J. of the Mech. and Phys. of Sol.*, (2009) **57**: 1209–1229
- [4] Miehe, C. and Welschinger, F. and Hofacker, M., Thermodynamically Consistent Phase-Field Models of Fracture: Variational Principles and Multi-Field FE Implementations, *Int. J. For Num. Meth. in Eng.*, (2010), **83**: 1273–1311