Accepted Manuscript

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PII: S0045-7825(16)31599-7
DOI: http://dx.doi.org/10.1016/j.cma.2017.03.042
Reference: CMA 11399

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 16 November 2016
Revised date : 15 March 2017
Accepted date : 30 March 2017

Please cite this article as: O. Rokoš, et al., eXtended variational quasicontinuum methodology for lattice networks with damage and crack propagation, *Comput. Methods Appl. Mech. Engrg.* (2017), http://dx.doi.org/10.1016/j.cma.2017.03.042

eXtended Variational Quasicontinuum Methodology for Lattice Networks with Damage and Crack Propagation

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Abstract

Lattice networks with dissipative interactions are often employed to analyze materials with discrete micro- or meso-structures, or for a description of heterogeneous materials which can be modelled discretely. They are, however, computationally prohibitive for engineering-scale applications. The (variational) QuasiContinuum (QC) method is a concurrent multiscale approach that reduces their computational cost by fully resolving the (dissipative) lattice network in small regions of interest while coarsening elsewhere. When applied to damageable lattices, moving crack tips can be captured by adaptive mesh refinement schemes, whereas fully-resolved trails in crack wakes can be removed by mesh coarsening. In order to address crack propagation efficiently and accurately, we develop in this contribution the necessary generalizations of the variational QC methodology. First, a suitable definition of crack paths in discrete systems is introduced, which allows for their geometrical representation in terms of the signed distance function. Second, special function enrichments based on the partition of unity concept are adopted, in order to capture kinematics in the wakes of crack tips. Third, a summation rule that reflects the adopted enrichment functions with sufficient degree of accuracy is developed. Finally, as our standpoint is variational, we discuss implications of the mesh refinement and coarsening from an energy-consistency point of view.

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