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Variational adaptivity for finite-deformation elasticity with local maximum-entropy approximants: locality and node location adaption

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ABSTRACT

An attractive feature of meshfree methods, based on the MLS approximants for instance, is the flexibility they offer in constructing shape functions from a node set, without the need for an explicit connectivity. Furthermore, the support of the shape functions can be also set by the user. However, this freedom is also a drawback, in that the accuracy of the solutions often strongly depends on the appropriate choice of node set and support size. This paper deals with the variational adaption of the function space generated by local maximum-entropy approximants, in the context of finite-deformation elasticity. This approximation space is defined by the location of a set of nodes, and the specification of a thermalization parameter on each node, which sets the locality of the corresponding shape function. The method we present completely optimizes this function space for a given number of nodes, i.e. we perform $r-$adaption and we also optimize for the support of the shape functions at each node. A key technical fact behind this method is that the local maximum-entropy approximants allow for an easy calculation of the sensitivities with respect to the locality parameter, and are defined for any positive value of this parameter. The adaptive method seeks to minimize the energy functional with respect to the node set and to the thermalization parameters over the reference configuration of the domain. The energy minimization with respect to the referential nodal positions equilibrates the configurational forces acting on the nodes, while the minimization with respect to the thermalization parameters equilibrates the configurational forces conjugate to the locality of the shape functions. We derive general expressions for both kinds of configurational forces for materials described by a strain energy function. We compare different numerical strategies to solve the nonlinear optimization problem. We illustrate the convergence characteristics of the proposed methods by way of selected numerical test, both for two and three-dimensional domains.

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