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Design Optimisation of Structures using A Nodal Density-Based SIMP Method

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This paper proposes an alternative topology optimization method for the optimal design of continuum structures, which involves a multilevel nodal density-based approximant based on the concept of conventional SIMP (solid isotropic material with penalization) model. First, to construct a material density field with global smoothness over the design domain, a family of Shepard interpolation scheme is applied as a non-local nodal density interpolation. The new nodal density field possesses non-negative and range-bounded properties to ensure a physically meaningful approximation of topology optimization design. Second, the density variables at the nodes of finite elements are used to interpolate elemental densities, as well as corresponding element material properties. In this way, the nodal density field by using the non-local Shepard function method is transformed to a practical elemental density field via a local interpolation with the elemental shape function. The low-order finite elements are utilized to evaluate the displacement and strain fields, due to their numerical efficiency and implementation easiness. So, the proposed topology optimization method is expected to be efficient in finite element implementation, and effective in the elimination of numerical instabilities, e.g. checkerboards and mesh-dependency. Numerical example in topology optimization are employed to demonstrate the effectiveness of the proposed method.

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