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DISCONTINUOUS PETROV-GALERKIN METHODS FOR TOPOLOGY OPTIMIZATION

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Abstract: Discontinuous Petrov-Galerkin (DPG) methods constitute a modern class of finite element methods, which present several advantages when compared with traditional Bubnov-Galerkin methods, especially when the latter is applied to indefinite or non-symmetric problems. For example, under minimal assumptions about the solvability of a given boundary value problem (BVP) the method results in stable, symmetric and positive definite discrete problems for a very wide range of possible finite element approximations of the fields, involved in the problem's formulation. Additionally, as a by-product of the solution procedure, the method produces element-wise residual estimates, which can be utilized for adaptive mesh refinement or simply as a qualitative measure of infeasibility of a current solution approximation with respect to a given BVP. Our goal is to utilize these advantages of DPG methods in the context of topology optimization. Unfortunately, the direct application of DPG discretizations to the BVPs arising in topology optimization is hindered by the very unusual scaling of the residual, caused by the gigantic jumps in the coefficients of the governing differential equations. For example, in the canonical case of linearized elasticity with SIMP model the coefficient ratio between the "stiff" and "soft" phases is held at a billion, which is then further squared by Petrov-Galerkin methods based on minimizing the squared residual. We introduce a DPG method with appropriately scaled residual norm, which allows us to deal with big contrast ratios in the coefficients. We then apply this method to benchmark topology optimization problems appearing in linearized elasticity.