High-order polytopal finite element methods based on DPG

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As a continuation of the Discontinuous Petrov-Galerkin (DPG) finite element methodology for polygonal meshes, labeled PolyDPG, initially derived in 2D as a conforming discretization of the ultraweak variational formulation of boundary value problems [3], we now present PolyDPG for polyhedra. This 3D version is characterized by preserving the higher-order nature of other DPG versions, but with a non-conforming discretization of traces. Utilizing one of the ultraweak variational formulations for linear elasticity [2], we apply the method to that problem. A proof of the discrete stability for the compressible case is developed. This analysis closely follows the ideas by Heuer et al. [1] on non-conforming DPG. Our numerical experiments show optimal convergence rates, using different polynomial orders under a variety of polyhedral meshes. As an application, we investigate a 3D linear elasticity model of the deformation in a composite material, which presents high contrast between the properties of the matrix and the aggregate.

[1] Norbert Heuer, Michael Karkulik, and Francisco-Javier Sayas. Note on discontinuous trace approximation in the practical DPG method. Comput. Math. Appl., 68(11):15621568, 2014.

[2] Brendan Keith, Federico Fuentes, and Leszek Demkowicz. The DPG methodology applied to different variational formulations of linear elasticity. Comput. Methods Appl. Mech. Engrg., 309:579609, 2016.

[3] Ali Vaziri Astaneh, Federico Fuentes, Jaime Mora, and Leszek Demkowicz. High-order polygonal discontinuous PetrovGalerkin (PolyDPG) methods using ultraweak formulations. Comput. Methods Appl. Mech. Engrg., 332:686711, 2018.