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UNSTRUCTURED MULTI-PATCH DG-IGA FORMULATION FOR WAVE PROPAGATION

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Wave propagation problems in geophysics and in engineering often require different tools. In geophysics, one has to contend with heterogeneous and often discontinuous physical properties determined by subsoil structures such as strata and salt domes, often represented via unstructured meshes. Recent works highlighted the advantages of discontinuous Galerkin (DG) schemes, able to achieve high-order approximations while relying on block-diagonal matrices, well-suited for parallelization. Engineering simulations, on the other hand, often involve homogeneous materials with complex, but known, geometries. Isogeometric analysis (IGA) [1], which replaces polynomial bases by B-spline (or NURBS) bases coming from CAD models, has been shown to have higher efficiency per degree of freedom, better convergence in high energy modes and an improved CFL condition for wave propagation.

Recent works have started to bridge the chasm between these two worlds, by formulating a DG scheme over disconnected IGA patches, retaining the numerical advantages of the IGA formulation while allowing for the block-diagonal mass matrix characteristic of DG methods [2]. However, the tensor-product structure of conventional B-spline patches is not well-suited for applications in the natural sciences, where CAD models are not available, discontinuities are often localized and can have arbitrary topology, and inverse problems require a highly flexible geometric description.

We propose an innovative multi-patch DG-IGA scheme based on unstructured splines promising to recover the good numerical properties of the standard multi-patch DG-IGA scheme, while allowing for more flexible and local geometry description. We improve on the known construction algorithms for multivariate B-spline bases [3] and exploit knot multiplicity to carve out disconnected sub-regions of our simulation domain, that are coupled via DG fluxes. We show that our approach can reproduce, for extreme choices of parameters, both the pure DG scheme on unstructured meshes, and a pure IGA scheme, thus allowing to fine-tune the level of domain decomposition and thus the size of the blocks in the mass matrix. Finally, we evaluate the performances of this novel scheme in wave propagation applications.

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