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# Frequency-domain acoustic wave modeling via unstructured isogeometric analysis: performance and pollution study

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Many works have shown the usefulness of Isogeometric Analysis (IGA) [1] for the solution of the Helmholtz equation. In particular, the increased regularity of B-spline functions and their uniform shape often translate into a better precision per degree of freedom, a wider spectral convergence and a consequently reduced numerical pollution compared to standard finite element (FE) approaches (see, e.g., [2]).

Recent advances in unstructured spline spaces [3] have allowed a new, fully unstructured IGA paradigm to emerge, with some interesting applications to explicit-time wave propagation [4]. This scheme, based upon an unstructured point cloud, allows to produce IGA patches with full regularity and arbitrary domain topology. Moreover, these patches can be coupled via discontinuous Galerkin (DG) terms, yielding a fully unstructured multi-patch DG-IGA, or even the usual DG scheme as a limiting case.

In this work, we explore the usefulness of this new paradigm for frequency-domain wave propagation. In particular, we study the convergence and spectral properties of this unstructured IGA multi-patch scheme on some selected models. We focus on its behavior with respect to the point cloud density and the number of degrees of freedom, and we analyze its computational performance, precision and numerical pollution. We also show how the generalized topology of domains allowed by this point-cloud formulation allows to go beyond the usual tensor-product IGA geometries.

Finally, we give some perspective on how the meshfree character of this formulation can be used to recover the location of sharp discontinuities starting from a smooth initial model.

## REFERENCES

- [1] T. J. R. Hughes, J. A. Cottrell, and Y. Bazilevs, *Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement*, CMAME (2005).
- [2] G. C. Diwan and M. M. Shadi, “Pollution studies for high order isogeometric analysis and finite element for acoustic problems”, *Comp. Meth. Appl. Mech. Eng.*, 350 (2019).
- [3] H. Barucq, H. Calandra, J. Diaz, and S. Frambati, “Polynomial-reproducing spline spaces from fine zonotopal tilings”, *J. Comp. Appl. Math.*, 402 (2022).
- [4] S. Frambati, “Unstructured isogeometric analysis with applications to seismic wave propagation”, *PhD thesis*, Universtié de Pau et des Pays de l’Adour (2021).