Isogeometric collocation approximations of acoustic wave problems

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ABSTRACT

In the last decades there has been an increasing attention to high order simulation of acoustic wave propagation by considering spectral, spectral elements and isogeometric (IGA) discretizations. Our previous work [1] investigated the approximation of 2D acoustic wave problems with proper absorbing boundary conditions by Galerkin IGA methods in space and Newmark's explicit schemes in time.

We extend now our study to IGA collocation explicit and implicit methods [2] in order to optimize the storage of stiffness and mass matrices and the computational costs. A detailed numerical study on both Cartesian and NURBS domains illustrate the stability and convergence properties of the IGA Newmark Collocation method with respect to all the IGA parameters, namely the local polynomial degree p, regularity k, mesh size h, and to the Newmark parameters Δt, β and γ.

The results show that the stability thresholds of the method depend linearly on h and inversely on p, confirming that the proposed IGA Collocation method retains the good convergence and stability properties of standard IGA Galerkin and spectral element discretizations of acoustic problems. Moreover, a detailed comparison of convergence errors, computational times, and matrix sparsity patterns show that IGA Collocation often outperforms IGA Galerkin, in particular in the case of maximal regularity $k = p - 1$ and for increasing NURBS degree p.

REFERENCES

[1] E. Zampieri and L. F. Pavarino. Explicit second order isogeometric discretizations for acoustic wave problems. *Computer Methods in Applied Mechanics and Engineering*, 348:776– 795, 2019.

[2] E. Zampieri and L. F. Pavarino. Isogeometric collocation discretizations for acoustic wave problems. *Computer Methods in Applied Mechanics and Engineering*, to appear, 2021.