Performance of isogeometric analysis for 2D Helmholtz problems: A study of dispersion characteristics, convergence rates and efficient quadrature

Laurens Coox[a,*], Elke Deckers[a], Jeroen Gyselinck[a], Dirk Vandepitte[a], Wim Desmet[a]

[a]: KU Leuven – Dept. of Mechanical Engineering, Celestijnenlaan 300b - box 2420, B-3001 Leuven (Belgium)

*: Corresponding author; tel.: +32 16 32 28 47; e-mail: laurens.coox@mech.kuleuven.be

This work studies the potential of NURBS-based IsoGeometric Analysis (IGA) for use in dynamic problems, more specifically 2D Helmholtz problems. The dispersion characteristics of IGA discretizations are investigated and compared to those of classical Finite Element Analysis (FEA). This is done by studying both the eigenvalues and the eigenmodes of simple 2D domains governed by a Helmholtz equation. It is found that IGA exhibits advantageous properties as compared to standard FEA discretizations, but that both the domain geometry and the parametrization have a large influence on the dispersion error for IGA. Simulations are also carried out on a less trivial problem domain – with boundary geometries that cannot be exactly described by standard FEA discretizations. Multiple frequencies are investigated and frequency response functions computed. Convergence rates are studied, both on a per-degree-of-freedom basis and on a computation time basis. Results are each time benchmarked against standard FEA results. In order to more fully exploit the higher continuity of IGA discretizations, a nearly optimal quadrature rule for NURBS-based IGA developed by Auricchio et al. is implemented, and the computational efficiency is compared to that obtained when using a standard Gauss rule. The results show that the higher complexity introduced by this nearly optimal quadrature compensates for the lower required number of quadrature points, and seems to limit its practical use.