Isogeometric collocation in acoustics: higher-order boundary conditions, plane-wave enrichment and applications in shape optimization.

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Abstract

In this work we present some applications of isogeometric collocation (IGA-C) in time-harmonic acoustics; in particular, for problems in unbounded domains.

First, we investigate the influence of the absorbing boundary conditions (ABC) on the overall behavior of the solution. We compare ABCs of two types: (a) Bayliss–Gunzburger–Turkel (BGT), where the Sommerfeld radiation condition is approximated on the fictitious boundary by an operator of arbitrary high order (we implemented orders 1 - 4), and (b) boundary conditions based on the Karp's (Wilcox) expansion with the arbitrary high number of terms. IGA-C allows implementation of both approaches: in (a) due to higher continuity of NURBS basis functions, higher order derivatives can be evaluated at collocation points, in (b) due to the tensor-product structure of NURBS, the boundary functions can be parameterized using the same shape functions as the solution in the domain and directly employed in the governing system of equations.

Next, we demonstrate how the approach can be combined with the plane wave enrichment to handle problems for higher frequencies. We examine a few benchmark problems to demonstrate how the parameters, such as the mesh size, order of polynomials, number of plane waves and the number of collocation points can be chosen for a given frequency to achieve the optimal performance of the method.

Finally, we show some problems of acoustic shape optimization, where IGA-C (as a solver for the direct problem) allows to significantly reduce the time of simulations.

Keywords: isogeometric analysis, NURBS, collocation