Acoustic Scattering with the Isogeometric Boundary Element Method

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ABSTRACT

Isogeometric analysis [1] (IGA) of acoustic scattering on unbounded domains has, as in many other fields, shown promising results. In [2] we obtained very good results using isogeometric infinite elements both for solving scattering of rigid spheres and acoustic-structure interaction problems. We verified numerically toward the exact solution given in [3] that IGA using full regularity splines (C^{p-1}) of order p, achieved significantly less errors than classical infinite elements using C^0-Lagrange polynomials of same polynomial order. However, methods that introduce an artificial boundary (infinite element method, PML-method, ABC-operators etc.) to handle the unbounded domain introduce the problem of surface-to-volume parametrization between the scatterer and the artificial boundary, reducing the quality of the bridge between design and analysis provided by IGA. As the boundary element method (BEM) avoids this problem in only requiring a parameterization of the scatterer, it represents the ideal bridge between design and analysis using IGA.

Building upon the work by Simpson et al. [4], we investigate the approximability of IGA and BEM (IGABEM) and the quadrature rules involved to evaluate the weakly singular integrals that emerges from the boundary integral equations. Both collocation method and Galerkin method will be used on several integral equations (including a regularized Burton-Miller formulation). We here restrict ourselves to 3D rigid scattering in homogeneous unbounded domains governed by the Helmholtz equation. The implementation is tested on a sphere and a torus before extending to a much more complicated submarine benchmark problem. Here, the submarine under consideration is the BeTSSi submarine [5], which represents an industrial challenging problem.

Our main finding is that IGABEM has superior accuracy over conventional BEM methods due to inter-element continuity offered by the spline basis. Moreover, the accuracy of BEM is highly dependent on the integration procedure which can even impact the convergence rates. A comparison between IGABEM and classical methods will be offered on the BeTSSi submarine.

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