NURBS-based isogeometric collocation for Kirchhoff-Love shells

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ABSTRACT

Isogeometric analysis (IGA) allows the Galerkin rotation-free discretization of Kirchhoff-Love shells, facilitating its use in thin-shell structure analysis. High-order NURBS basis functions in IGA are also sufficiently smooth to enable isogeometric collocation of partial differential equations, avoiding the time-consuming numerical integration of the Galerkin technique. The goal of this presentation is to apply this method to NURBS-based isogeometric Kirchhoff-Love (curved) shells.

This formulation is a fourth-order theory, meaning that two boundary conditions per edge are required. Consequently, at the corners, there are more equations than unknowns. To remedy this overdetermination, we provide a set of priority and averaging rules that cover all the possible combinations of adjacent edge boundary conditions (i.e. clamped, simple, guided and free supports). We highlight also the treatment of corner shear forces, which are specific to Kirchhoff-Love plates/shells.

As collocation positions, Greville and alternative superconvergent points are used for even and odd basis degrees p, respectively. Using those points, the L^2-error is known to decay as $\mathcal{O}(h^p)$ (h being the mesh size) for second-order problems, and we observe that the convergence order is $\mathcal{O}(h^{p-2})$ for a set of numerical plate and shell benchmarks. Additionally, no spurious oscillations in the solution field are observed while collocating Neumann boundary conditions, avoiding the use of the hybrid collocation-Galerkin method. Finally, the collocation method is shown to provide substantial gains in computational efficiency over a Galerkin approach for some Kirchhoff-Love shell configurations.

REFERENCES

[1] F. Maurin, F. Greco, L. Coox, D. Vandepitte, and W. Desmet, "Isogeometric collocation for Kirchhoff-Love plates and shells," *Computer Methods in Applied Mechanics and Engineering*, vol. 329, pp. 396–420, feb 2018.