# An isogeometric fictitious domain method for trimmed Kirchhoff–Love shells using extended B-splines and Nitsche's method

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## ABSTRACT

Shells are curved, thin-walled structures and due to their high bearing capacity, they occur in a wide range of applications. In general, the high bearing capacity is a result of the curved shape of the shell, which can become rather complex. A convenient and effective way to model such complex geometries is to use a computer aided design (CAD) software, where the geometry is defined with trimmed tensor product surfaces. We propose an isogeometric fictitious domain approach for the analysis of linear Kirchhoff-Love shells with trimmed geometries. Three major issues are addressed such that higher-order convergence rates are enabled: (1) accurate integration of the trimmed surface, (2) conditioning of the stiffness matrix due to trimmed basis functions and (3) enforcement of boundary conditions along trimming curves.

Firstly, for the integration of the trimmed surfaces, the approach outlined in [1] is used, where higher-order finite elements are used as integration cells. The presented procedure enables an optimal higher-order accurate integration of the trimmed patches with multiple trimming curves. Secondly, the conditioning issue is solved with the usage of extended B-splines as described in [2]. Lastly, the boundary conditions are weakly enforced with the non-symmetric Nitsche's method. The advantage of this version of Nitsche's method in the context of trimmed surfaces is that no additional stabilization is necessary. Therefore, the issue with large stabilization parameters in bad cut scenarios, i.e., when trimming curves cut the knot spans awkwardly resulting in small supports, is circumvented.

The underlying Kirchhoff–Love shell model is based on the tangential differential calculus (TDC), as described in [3]. The TDC-based formulation allows a more compact implementation of the corresponding Nitsche terms, which is significantly simplified compared to the classical approach based on local coordinates.

The resulting approach can handle multiple trimming curves, is robust even for complex boundaries and simple, because only one user-defined parameter for the extended B-splines is required. Furthermore, the numerical results confirm optimal higher-order convergence rates in the residual errors providing that the solution is sufficiently smooth, and performs as expected if classical benchmark tests, e.g., the Scordelis–Lo roof, are considered.

## REFERENCES

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