Hierarchic Isogeometric Large Rotation Shell Elements Including Linearized Transverse Shear Parametrization

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ABSTRACT

Isogeometric Analyses using NURBS functions enable a smooth surface description with higher inter-element continuity which opens up new possibilities in the analysis of thin-walled structures. An important advantage is the straightforward implementation of classical theories, which require C^1-continuity, e. g. Kirchhoff-Love shell formulations, as demonstrated in [1]. Based on these simplest models, also shear deformable theories, like Reissner-Mindlin shell formulations, can be formulated in an elegant way. In [2] a hierarchic set of isogeometric shell finite elements is developed for the geometrically linear case, a priori avoiding shear locking within the framework of a pure displacement formulation.

In this contribution, two novel hierarchic isogeometric formulations for geometrically nonlinear shell analysis including transverse shear effects are presented (see also [3]). Both methods combine a fully nonlinear Kirchhoff-Love shell model with hierarchically added linearized transverse shear components. Thus, large rotations can be taken into account in a simple and straightforward way. The underlying assertion is that in practical applications the transverse shear angles are small, even for thick shells and large deformations. Various numerical experiments confirm this statement.

The two presented formulations differ in the way the transverse shear effects are included. The first formulation makes use of hierarchic rotations, while the second formulation uses hierarchic shear displacements. The corresponding hierarchic setting results in an additive strain decomposition into parts resulting from membrane and bending deformation and additional contributions from transverse shear. It requires at least C^1-continuous shape functions, which can be easily established within the isogeometric context based on NURBS, T-Splines, subdivision surfaces or other smooth spaces. This concept is intrinsically free from transverse shear locking. In the nonlinear case it dramatically facilitates representing large rotations in shell analysis.

REFERENCES

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