An isogeometric solid shell element for large strain problems

Pablo Antolin¹, Annalisa Buffa², Josef Kiendl³, Marco Pingaro¹, Alessandro Reali¹, ², Giancarlo Sangalli¹, ²

¹ Università degli Studi di Pavia, Italy
² IMATI-CNR, Pavia, Italy
³ Technische Universität Braunschweig, Germany

pablo.antolinsanchez@unipv.it, annalisa@imati.cnr.it, j.kiendl@tu-braunschweig.de, marco.pingaro@iusspavia.it, alessandro.reali@unipv.it, giancarlo.sangalli@unipv.it

The simulation of thin structures like shells is an important class of problems which can be effectively tackled by means of Isogeometric Analysis (IGA). In this work, we focus on the family of shell formulations referred to as “solid shells”, where the simulation of shell-type structures is performed by means of a mesh of 3D solid elements, with typically only one element through the thickness. Solid shells are particular attractive because, on the contrary of bivariate shells, they allow simple treatment of double-sided contact situations and coupling with 3D solid elements. In addition, standard 3D constitutive models can be readily used without the need of model reduction procedures or special interfaces. However, we have to highlight that using a single element through the thickness calls for special treatments to alleviate the unavoidable presence of (shear, curvature thickness, and membrane) locking phenomena. Taking inspiration from standard finite elements, several cures for locking have been already proposed in the literature and others may be considered, ranging from \( B \) to enhanced strains. An interesting and inexpensive approach in this sense could be found within the family of Assumed Natural Strains (ANS), which have already been proven to be effective within the IGA framework.

Within this context, we herein present a novel ANS solid shell formulation for the analysis of large strain problems. The formulation is fully consistent and general, and allows to obtain results comparable to those attained by cubic elements (practically locking-free but expensive) using a much cheaper quadratic approximation. Extensive numerical testing proves the good behavior of the proposed formulation in different demanding situations.