A Variational Method to avoid Locking – Independent of the Discretization

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ABSTRACT

Since the pioneering contribution by Hughes and co-workers in 2005 [1], isogeometric methods received a great deal of attention in academia and industry. Besides promising results in a wide range of problems, standard isogeometric finite elements still suffer from the same locking effects as classical finite elements.

Hierarchic formulations, as presented in [2], lead to purely primal plate and shell formulations, intrinsically free from transverse shear locking, independent of the discretization. A corresponding primal formulation to avoid membrane locking has not yet been found.

Element formulations based on mixed methods also present very promising candidates to avoid the various locking phenomena present in (isogeometric) finite elements ([2], [3]). The major task in their development is the thorough choice of the corresponding stress or strain spaces. Too rich spaces do not fully remove locking, too poor spaces may introduce spurious modes. Furthermore, the choice of balanced stress/strain spaces usually requires several different (lower) spaces for their discretization. However, different spaces are neither efficient, nor "isogeometric". In addition, they are restricted to only one discretization, and the extension to advanced smooth discretization schemes like T-Splines, subdivision surfaces or meshless methods are either very complicated or hardly possible.

In this contribution, we present a new, unified concept to develop mixed finite elements, independent of the underlying discretization scheme. In particular, we present locking-free finite element formulations for continua, plates and shells, discretized by several different schemes like standard finite elements, isogeometric finite elements based on NURBS and meshless methods based on maximum-entropy approximants.

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