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Talk announcement

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Joint finite element models for structures and continua at large deformations

In many applications, thin shell-like structures are integrated within or attached to volumetric bodies. This includes reinforcements placed in soft matrix material in lightweight structure design, or hollow, filled structures. Finite element simulations of such setups are highly challenging. A brute force discretization of structural as well as volumetric parts using well-shaped three-dimensional elements may be accurate, but leads to problems of enormous computational complexity even for simple models. An alternative is the usage of shell elements for thin-walled parts. However, the coupling to nodal volumetric elements is not straightforward due to the different nature of degrees of freedom in shell and volume elements.

Degrees of freedom of volume elements are usually defined through nodal displacements located at element nodes, resulting in H^1 compatibility. For shells, classical theories include not only displacement or position of the center surface, but also the surface normal. Thus, C^1 differentiability of the shell surface (and elements) is a prerogative. Coupling these different approaches is far from straightforward, and may easily lead to severe locking if not done carefully. Neunteufel and Schöberl proposed a mixed shell element where, apart from displacements of the center surface, bending moments are used as independent unknowns. These elements were not only shown to be locking free and highly accurate in large-deformation regime, but require only H^1 differentiability in the surface. They can directly be coupled to classical volume elements of arbitrary order by sharing displacement degrees of freedom at the center surface.

The present talk consists of three parts: first, an overview on modeling approaches in nonlinear continuum mechanics, as well as limitations of different (hyper-)elastic material laws, is given. Subsequently, the classical Kirchhoff-Love shell theory is introduced, and the notion of distributional curvatures is discussed. The latter allows us to define bending energies on surfaces with kinks, such that standard H^1 elements can be used on the shell surface. Last, the coupled modeling and simulation of problems with integrated shell-like structures is presented. The viability and accuracy of all formulations is confirmed by computational results.