Compressible and incompressible material under large deformations

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In the development of new mechanical components the efficient usage of material resources is very important. Therefore one needs a fast and highly accurate simulation to predict the actual material deformations, that are caused by external loads and the material behaviour.

In this talk we want to focus on incompressible materials, see [1] and derive a possibility to numerically simulate this material in the context of large deformations. Although these rubber like materials are widely used in the industry the efficient simulation of such parts is still an open problem due to their special material properties. Since incompressible materials have an infinite bulk modulus they may change their shape but they keep their constant volume during any deformation. In our approach we treat this speciality by introducing a new variable, the hydrostatic pressure and by working with a mixed formulation.

From the equilibrium of forces in the deformed domain we develop the nonlinear weak form in the known initial domain. For linearisation we apply a modified Newton's method with incremental load steps. This yields a linear saddle point problem in every step. By means of the finite element method with a mixed ansatz via the Taylor Hood element we get a linear system of equations. Its structure invites the usage of an adjusted Bramble-Pasciak conjugate gradient method with suitable preconditioning. This simulation can be improved by using an adaptive mesh refinement with a residuum based error estimator and parallel strategies (e.g. with openMP).

Finally we want to present some results that show the combination of incompressible and compressible material.

References:

[1] Balg, M.; Meyer, A.: Numerische Simulation nahezu inkompressibler Materialien unter Verwendung von adaptiver, gemischter FEM. Chemnitz: Scientific Computing Preprints, 2010 (CSC/10-02)

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