The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

An Accurate, Robust, and Efficient Finite Element Framework for Anisotropic, Nearly and Fully Incompressible Elasticity

Elias Karabelas[1], Matthias A. F. Gsell [2], Gernot Plank [2], Gundolf Haase [1] and Christoph M. Augustin[2]

[1] Institute for Mathematics and Scientific Computing, Karl-Franzens-University Graz, Graz, Austria, elias.karabelas@uni-graz.at
[2] Gottfried Schatz Research Center: Division of Biophysics, Medical University of Graz, Graz, Austria, christoph.augustin@medunigraz.at

Keywords: *Stabilized finite element methods, anisotropic materials, quasi-incompressibility, soft biological tissues, cardiac electromechanics*

Fiber-reinforced soft biological tissues are typically modeled as hyperelastic, anisotropic, and nearly in-compressible materials. To enforce incompressibility a multiplicative split of the deformation gradient into a volumetric and an isochoric part is a very common approach. However, due to the high stiffness of anisotropic materials in the preferred directions, the finite element analysis of such problems often suffers from severe locking effects and numerical instabilities. In this talk, we present novel methods to overcome locking phenomena for anisotropic materials using stabilized $\mathbb{P}_1$-$\mathbb{P}_1$ elements. We introduce different stabilization techniques and demonstrate the high robustness and computational efficiency of the chosen methods. We will present several benchmark problems comparing our approach to standard linear elements and show the accuracy and versatility of the methods to simulate anisotropic, nearly and fully incompressible materials. We are convinced that this numerical framework offers the possibility to accelerate accurate simulations of biological tissues, enabling patient-specfic parameterization studies, which require numerous forward simulations.