FEniCS 2022 abstract: SOniCS: Interfacing SOFA and FEniCS for advanced constitutive models

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The Simulation Open Framework Architecture (SOFA) is a software environment for building simulations with a particular focus on real-time medical applications, e.g. surgery. Its scope is far broader than the FEniCS Project, encompassing e.g. rigid body dynamics, interfacing with haptic devices, contact and visualisation. Naturally, it also includes some finite element models of soft tissue mechanics, but these capabilities are currently ‘pre-baked’ and limited to a few simple constitutive models.

The goal of this work is to incorporate state-of-the-art code generation tools from the FEniCS Project into SOFA in order to hugely increase SOFA’s capabilities in terms of soft tissue mechanics. To this end we have developed a new SOFA plugin named SOniCS. For adding a new material model in SOniCS, the user describes its strain energy density function using UFL (Unified Form Language) syntax. Then, using FFCx (FEniCSx Form Compiler) we generate the C code associated with the kernels corresponding to the automatically differentiated cell-local residual and stiffness forms. Finally, we assemble these kernels in SOFA into global tensors and solve the resulting non-linear systems of equations.

The result is that it is now possible to straightforwardly implement complex material models such as the Holzapfel-Ogden anisotropic model into SOFA, and to use them alongside SOFA’s existing strong feature set in medical simulation.

References:

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