A generic constitutive implementation of a large strain formulation for modeling hyperelastic materials

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Abstract

In this work we describe a generic framework for evaluating the mechanical equilibrium of hyperelastic materials. This is carried out using a spatial variational formulation for the momentum equation which is linearized by means of a Newton-Raphson scheme. The iterative algorithm is such that for a given load, the equilibrium is reached in the deformed spatial configuration. The main feature of our approach is based on the evaluation of the second order stress tensor and of the fourth order constitutive tangent tensor using finite differences. That is, given a strain energy potential we compute, by means of a second order finite difference centered scheme, the first (stress) and second (tangent matrix) derivatives. In this way, a generic computational implementation in the context of Finite Elements is achieved, making possible to change the material behavior just changing the procedure that evaluates the elastic function and without reprogramming the entire numerical element structure. The developments are performed for compressible and incompressible materials, and some implementation issues are presented and discussed. The method is validated and then used for computing the mechanical response of fiber-reinforced materials in the context of the analysis of arterial tissues.

Key words: Hyperelastic materials, Soft tissues, Constitutive modeling, Large strains.