Data-based constitutive modelling at large strains

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ABSTRACT

Elastic behaviour of soft materials at large strains is usually computed using hyperelastic models to guarantee the absence of dissipation. These models consist of analytical expressions of the stored energy in which some (material) parameters are left free to allow the fitting of the predicted stress-strain behaviour to experimental data. There are hundreds of proposed stored energies for different polymers and soft biological tissues, and many methods to obtain the, usually non-unique, material parameters from experimental data.

WYPiWYG (What-You-Prescribe-is-What-You-Get) constitutive modelling is a purely phenomenological, data-based, model-free approach to model the behaviour of most types of soft materials at large strains. In WYPiWYG hyperelasticity, the overall shape of the stored energy is not imposed, but numerically obtained directly from experimental data solving the equilibrium and compatibility equations of the tests. The method does not employ material parameters, and for a given complete sets of tests defining the material behaviour, the solution is unique. WYPiWYG hyperelasticity is also consistent with the full infinitesimal theory for the given applicable material symmetries. The procedure may be applied to incompressible [1] and compressible [2] materials, either isotropic or anisotropic [3], and to damage mechanics [4]. It has been successfully applied to the mechanics of soft biological tissues [5]. It has also been used in viscoelasticity and may be used in plasticity of soft materials. In this work, we present recent advances in WYPiWYG constitutive modelling and show finite element simulations using the approach.

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