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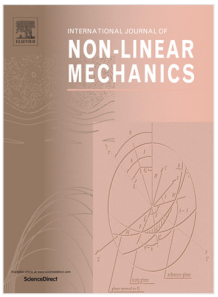

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A spectral decomposition approach for the mechanical statistical characterization of distributed fiber-reinforced tissues

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Abstract

We discuss a spectral decomposition formulation for the mechanical statistical characterization of the anisotropic strain energy density of soft hyperelastic materials embedded with distributed fibers. We consider a generalized angular probability density function (PDF) of the reinforcement built upon the local eigenvalue and eigenvector system of the Cauchy-Green deformation tensor. We focus our analysis to material models dependent on the fourth pseudo-invariant of the deformation, I_4, and to exponential forms of the fiber strain energy function. Within such a spectral reference system, we derive the closed-form expression of the PDF for I_4 generalizing the multi-value random variable transformation procedure recently developed in Gizzi et al. 2016. Our formulation bypasses the cumbersome extension-contraction switch, commonly adopted for shutting down the contribution of contracted fibers in models based on generalized structure tensors. Accordingly, we identify analytically the support of the fibers in pure extension for significant loading conditions. We can readily compute any statistics of the fourth pseudo-invariant and we can derive the direct definition of the average second Piola-Kirchhoff stress tensor according to the second order approximation.

Keywords: statistical fiber distribution, spectral decomposition, multivariate, fourth pseudo-invariant, fiber reinforced materials.