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LOCAL MICROMORPHIC NON-AFFINE ANISOTROPY DESCRIBING RELATIVE ELASTIC FIBRE-MATRIX KINEMATICS

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There has been increasing experimental evidence of non-affine elastic deformation mechanisms in biological soft tissues. These observations call for novel constitutive models which are able to describe the dominant underlying micro-structural kinematic aspects, in particular relative motion characteristics of different phases.
This contribution proposes a flexible and modular framework based on a micromorphic continuum encompassing matrix and fiber phases. In addition to the displacement field, it features so-called director fields which can independently deform and intrinsically carry orientational information. Accordingly, the fibrous constituents can be naturally associated with the micromorphic directors and their non-affine motion within the bulk material can be efficiently captured. Furthermore, constitutive relations can be formulated based on kinematic quantities specifically linked to the material response of the matrix, the fibres and their mutual interactions. Associated stress quantities are naturally derived from a micromorphic variational principle featuring dedicated governing equations for displacement and director fields. This aspect of the framework is crucial for the truly non-affine elastic deformation description.
In contrast to conventional micromorphic approaches, any non-local higher-order material behaviour is excluded, thus significantly reducing the number of material parameters to a range typically found in related classical approaches. In the context of biological soft tissue modeling, the potential and applicability of the formulation is studied for a number of academic and experimental examples featuring anisotropic fiber-reinforced composite material composition to elucidate the micromorphic material response as compared with the one obtained using a classical continuum mechanics approach.