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NUMERICAL MODELLING OF FIBRE REORIENTATION AT SOFT TISSUE

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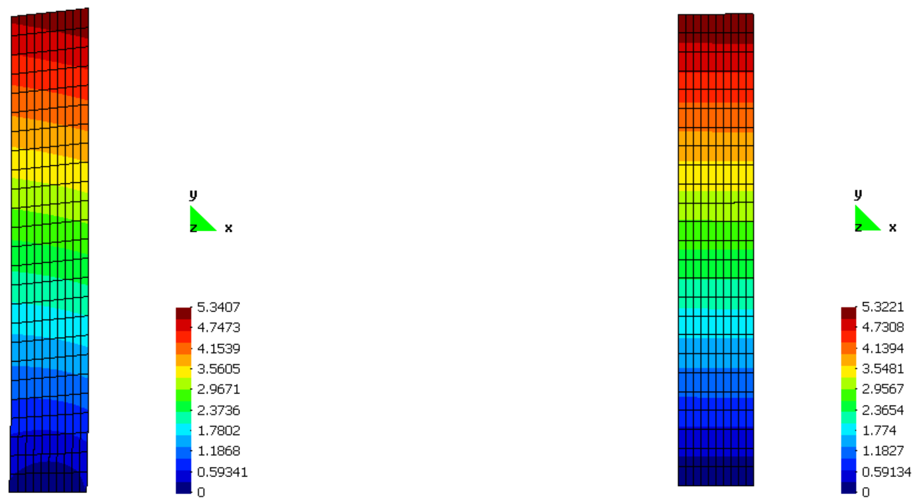
ABSTRACT

This contribution deals with development of a hyperelastic and thermodynamically consistent model for soft tissue that is able to describe reorientation of collagen fibers during a deformation process. To be specific, we are examining only the continuum scale reorientation of collagen fibres under the constant mass. A uniform distribution of fibers in the tissue matrix is assumed. Theirs dimension is measured in μm therefore at continuum level we consider only the orientation at continuum points. Two independent groups of the collagen fibres are taken into consideration. The frame of the formulation is inspired by material model developed in [1]. In the formulation of the soft tissue anisotropic behaviour we are using adjusted form of the strain energy function that can be found besides other in [2, 3]. Accordingly, the anisotropic response is described by two isotropic expressions modelling the matrix and two groups of the fibres separately. Thus, the strain energy function is decomposed into two parts which are related to the matrix, and to the collagen fibres. The collagen architectures are assumed to align with the stress field within the tissue. The initial fibres orientations are defined by structural tensors that are reoriented according to the loading by means of the rotation tensor. The change of the rotation tensor is described by using a well known exponential map procedure. The reorientation function is introduced which is assumed to be a linear function of thermodynamical force deriving from dissipation inequality according to the second law of thermodynamics. However, a more accurate reorientation function should be proposed in the future work which should be verified with appropriate experimental results.

Efficiency of the proposed formulation is demonstrated using a uniaxially loaded soft tissue strip, Figure 1. The strip is loaded in the *y* direction on the upper edge, while at the lower edge it has suppressed displacements in the y-direction. The collagen fibres have initial position of 15° with respect to the *y* axis. Two calculations are performed, with and without reorientation mechanism, Figure 1 a) and b). As can be observed, a

significant influence of reorientation mechanism on the deformed configurations is visible. As well, the change of the fibre orientation during the loading process is shown by Figure 2. Herein, β_x, β_y and β_z define angles of the fibres with respect to the axes *x*, *y* and *z*, respectively. Initial position of the fibres is the lowest line on Figure 2.



a) b)

Figure 1. Deformed configuration without (a) and with reorientation mechanism (b)

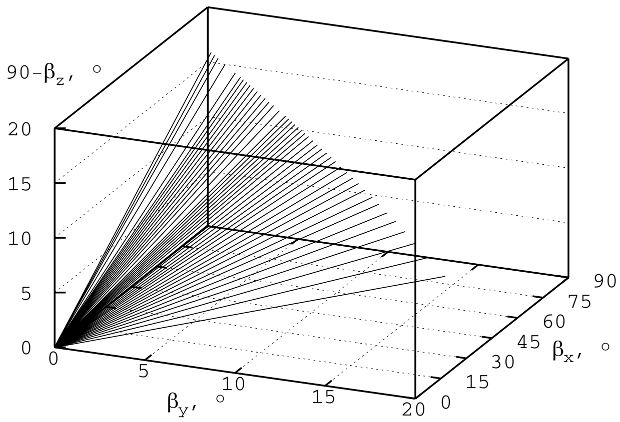


Figure 2. The change of the fibre orientation

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