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On the importance of identifying region-dependent hyperelastic material parameters for human brain tissue through finite element analyses

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Simulation models that can accurately predict the response of human brain tissue under mechanical loading are a valuable tool to advance prevention, diagnosis and treatment of neurological disorders. The accuracy of these models depends heavily on the underlying material model and its parameters. To aid in the development of such simulation models, we implemented and employed an inverse parameter identification scheme to generate a set of hyperelastic material parameters describing the regional mechanical behavior of human brain tissue.

The parameter estimation scheme utilizes a finite element model that implements a compressible formulation of the hyperelastic one-term Ogden model. The model is simultaneously fit to the multimodal experimental data from cyclic compression-tension and torsional shear tests. The experimental data available consists of the recorded response of 81 specimens. We extract the specimens from different morphological structures and identify region-specific parameters at two levels of refinement, divided into four or twelve regions, respectively.

The obtained parameters show the same qualitative trend for the shear modulus μ as reported by Budday et al. in [1]. A thorough statistical analysis of the created parameter set showed significant differences between the shear moduli of tested brain regions as well as between the tested brains. The obtained set of parameters is capable of improving the accuracy of mechanical brain simulations by capturing hyperelastic regional tissue properties.

REFERENCES

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