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Finite element modelling of bone growth stimulation and its suitability for therapeutic, biomedical applications

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Imposed strain fields can stimulate bone growth. The stimulation of bone growth could be beneficial in future biomedical devices e.g. around implants.
The purpose of the presented *in silico* study was to investigate the mechanics of sintered metallic fibre networks embedded in surrounding bone tissue. The finite element (FE) simulations predicted the fibre deformation due to magnetic actuation and the imposed strain in the surrounding bone tissue.

The skeletons of six fibre network samples (fibre diameter $Ø_F$ = 40µm, sample volume V = 4×4×4 mm^3 or subsections) were run as FE simulations based on beam theory. The FE models were run locally and on the Cambridge High Performance Computing Cluster Darwin by the FE solver Abaqus.
The fibre skeleton geometries were acquired in a previously completed study by the application of a reduction algorithm to 3D computed tomography scans.

The obtained results predict an equivalent von-Mises strain $\varepsilon_{v.Mises}$ of 0.001 which is the required magnitude for the stimulation of bone growth. All investigated samples exhibited this value locally for an experimentally achievable magnetic induction vector $\vec{B}$ of less than 1.00 T (see Figure 1). In principle, the suitability of the design for the intended purpose is predicted.

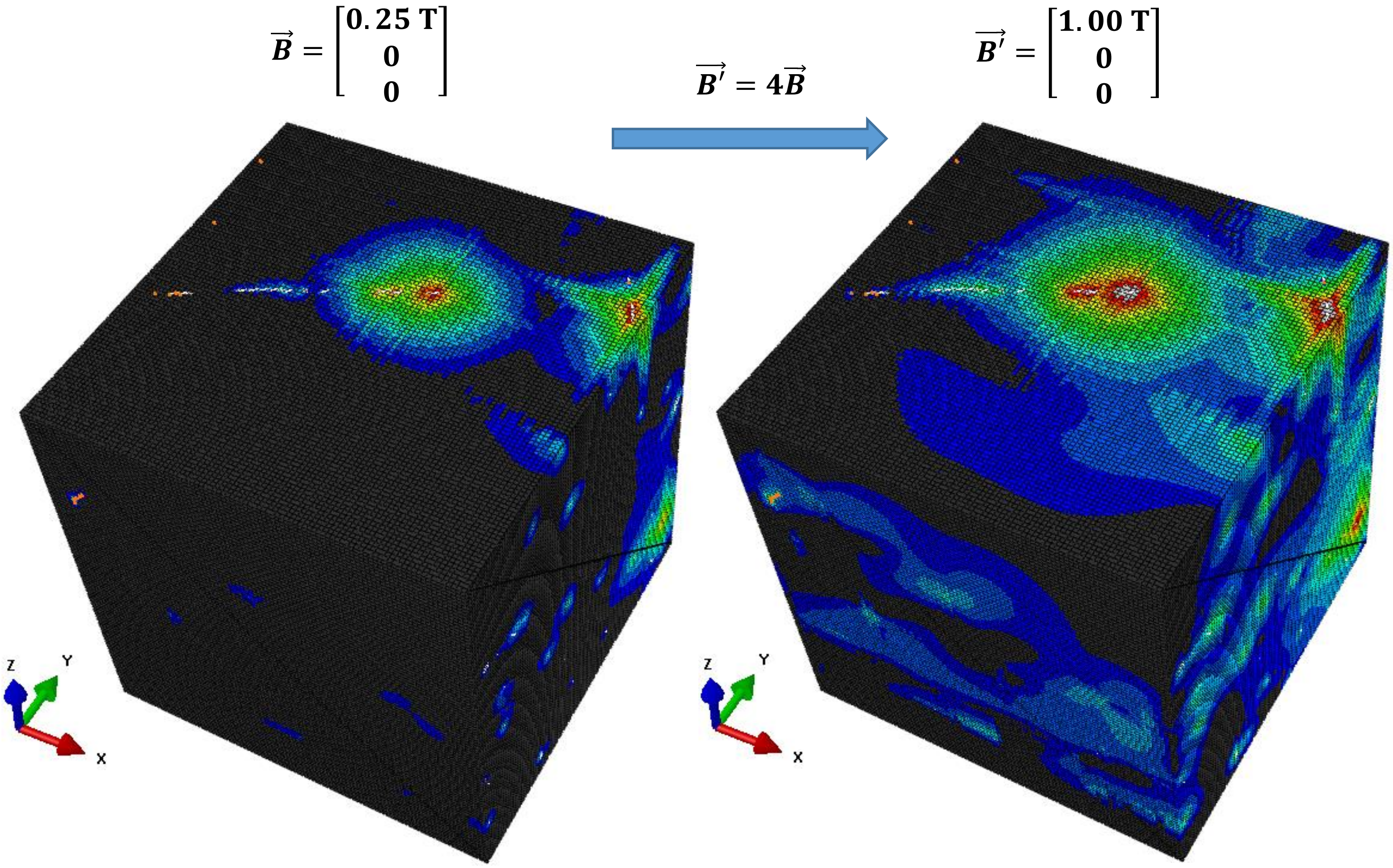

Figure 1: Strain field for magnetic induction vector $\vec{B}$ of 0.25 T and 1.00 T
Equivalent von-Mises strain $\varepsilon_{v.Mises}$ of magnitude 0.001 in ***green***

Aspects for future work will be the experimental confirmation of the obtained simulation results and an advanced non-homogeneous model for the bone tissue matrix.

References:

Bosbach, W. The mechanical and magnetic behaviour of sintered fibre networks and their suitability for a therapeutic, biomedical application (PhD thesis, University of Cambridge), viva examination on 20th March 2015 positive