COMPUTATIONAL BIOMATERIALS AND BIOMECHANICS VU HOMEWORK ASSIGNMENT WS2023

Intravoxel analysis of clinical CT scan

The assignment is based on the scientific paper entitled "Patient-specific fracture risk assessment of vertebrae: A multiscale approach coupling X-ray physics and continuum micromechanics" [1], a PDF of which is available on TUWEL.

Based on the last two digits of the *Matrikelnummer*, each student is provided with a list which assigns to each and every grey value between 0 and 256, the number of times this very grey value would occur in "student-specific" clinical CT (*histogram_Y00.txt* to *histogram_Y99.txt*).

The value GV_{max-1} shall be the same as given in the paper, $GV_{max-1} = 156$.

The homogenization step associated with Figure 5(f) of [1], mathematically given through Eq.(48) of [1], is provided as a MatLab file (*hom_exvas_to_macro.m*), also available on TUWEL.

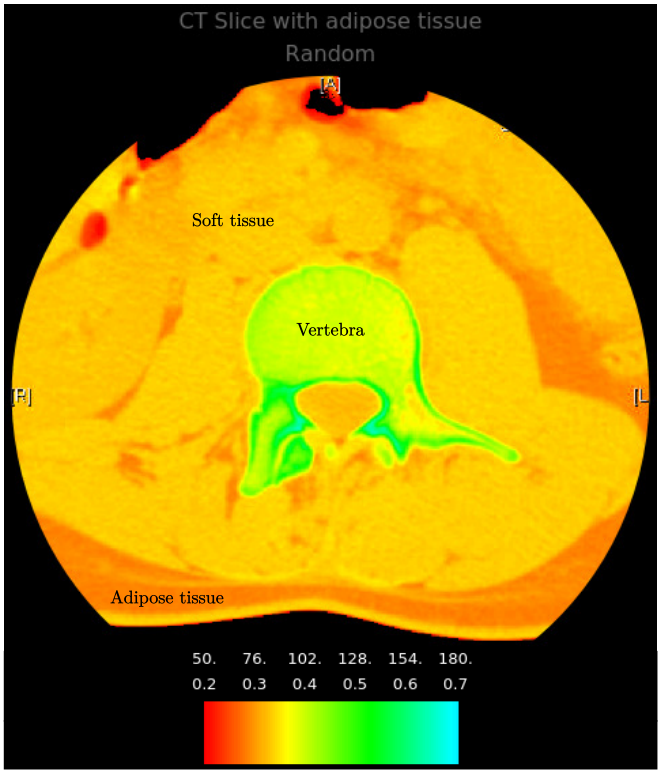

Figure 1: Color representation of CT-slice through human vertrebra

Based on the aforementiuoned information and data, the following tasks are requested:

- Plot a histogram of the grey values making up the "student-specific" clinical CT
- Plot a probability density function of the grey values making up the "student-specific" clinical CT
- Identify the values GV_{fat}, GV_{soft}, GV_{thr}, and GV_{max}

- Consider GV_{soft} as being relevant for the vascular porosity, and use the average rule for attenuation-related grey values in order to come up with a probability density function for the vascular porosity found in the bony regions of the "student-specific" clinical CT
- Plot a histogram for the voxel-specific longitudinal elastic modulus found in the bony regions of the "student-specific" clinical CT; note: study the given Matlab file, and consider the components of the Hill tensor $\mathbb{P}$ for a cylindrical inclusion in a transversely isotropic matrix as given in [2]
- Prepare a scientific report explaining all the steps necessary for coming up with the answers to the items before, together with computer code for the calculation and plotting steps

References

[1] R. Blanchard, C. Morin, A. Malandrino, A. Vella, Z. Sant, C. Hellmich *Patient-specific fracture risk assessment of vertebrae: a multiscale approach coupling X-ray physics and continuum micromechanics*, International journal for numerical methods in biomedical engineering 32 (2016); e02760

[2] C. Hellmich, J. Barthélémy, L. Dormieux *Mineralcollagen interactions in elasticity of bone ultrastructure a continuum micromechanics approach*, European Journal of Mechanics A/-Solids 23 (2004); 783-810

Administrative comments

The report and the computer code compressed to a ZIP-file needs to be uploaded to TUWEL until Feb 15, 2024.

Upon initial feedback concerning the grading, an improved report can be sent in until Feb 28, 2024.