6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Digital Volume Correlation using Quartic FEM Interpolation and Global Optimization

Nico van Dijk, Dan Wu, Cecilia Persson and Per Isaksson

Department of Engineering Sciences, Uppsala University, Box 534, 75121 Uppsala

Key Words: *DVC, FEM interpolation, Global optimization, Trabecular bone.*

Estimating deformation fields at the microscale of trabecular bone remains challenging because of 1) the complex porous structure, and 2) the large subdomains necessary for reasonable accuracy.
In this contribution we present a novel Digital Volume Correlation method (DVC) based on a displacements-field interpolation with quartic finite elements, also called 27-node bricks, and a global optimization procedure. This particular choice of interpolation provides for increased freedom of the displacement field in each subvolume and is convenient for overlapping subvolumes for robust solutions.
The global optimization maximizes the normalized correlation for all subvolumes using the nodal degrees of freedom of the displacement interpolation as design variables and a spline interpolation of the grayscale values. A good starting point for the global optimization procedure is obtained using an initial FFT-based DVC step. This procedure can be executed without any regularization yielding decent results. The results can be improved by adding curvature penalization, similar to the work of Barber and Hose [1].
The approach has been tested on a number of different benchmark problems using bone samples. For duplicate scans, the accuracy and precision of the proposed DVC technique is comparable to ShIRT-FE as reported by Palanca *et al.* [2]. Tests on scans of human trabecular bone, taken at the Paul Scherrer Institut, including imposed and actual deformation are ongoing. In Figure 1, the results of such a test is shown using an imposed Gaussian displacement field.

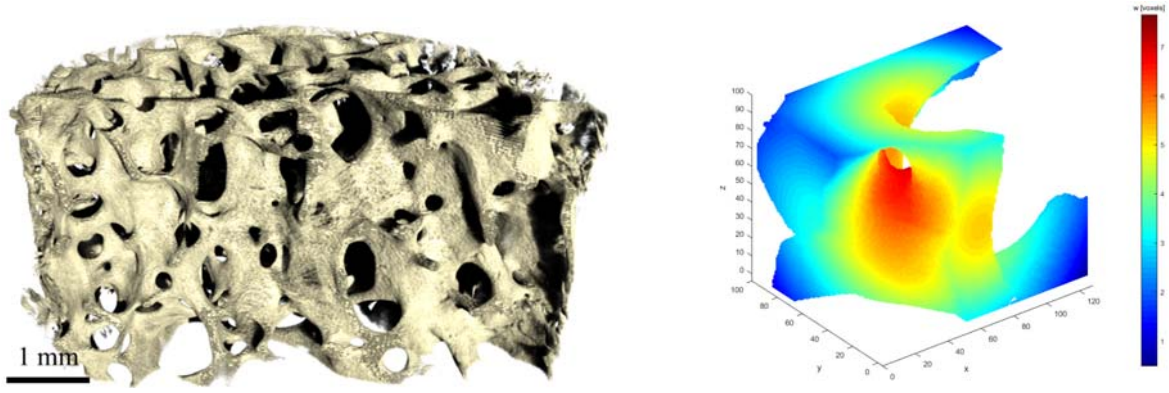

Figure 1: Image of human trabecular bone and the obtained Gaussian displacement field for a small part. We acknowledge the Paul Scherrer Institute for provision of TOMCAT beamtime.

REFERENCES

[1] Barber, D. and Hose, D. (2005). Automatic segmentation of medical images using image registration: diagnostic and simulation applications. J Med Eng Technol, 29(2):53–63.
[2] Palanca, M., Tozzi, G., Cristofolini, L., Viceconti, M., and Dall'Ara, E. (2015). Three-dimensional local measurements of bone strain and displacement: comparison of three digital volume correlation approaches. J Biomech Eng, 137(7):071006.