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Structural simulation of metal foams from CT scans using machine learning techniques in the cgFEM framework

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Metal foams, such as aluminium foam, are gaining interest from several industries, such as automotive and aeronautical, due to their acoustic properties, impact energy absorption, etc. Finite Element Method (FEM) models for the structural analysis of metal foams are difficult to obtain since the geometry is obtained from a Computerised Axial Tomography (CT-scan) and presents a high number of edges and irregular shapes.

In order to avoid the CAD generation, previous works propose to associate one element per voxel, whose elastic properties are related to the voxel colour [1], producing a model with an excessive number of elements. CellFEM [1] and cgFEM [2] allow several pixels to be associated with one single element keeping accuracy level, although the high number of integration points used makes this approach inefficient. In order to speed up cgFEM, this work proposes to carry out an off-line machine learning (ML) process based on feed-forward neural networks, which are trained prior to the analysis, using several elements containing a group of voxels.

JPEG compression uses the Discrete Cosine Transform (DCT) in order to express voxel colour of an image as a sum of sinusoidal waves that are function of position. During the off-line phase, the low frequency DCT coefficients of each training element are extracted and related to its homogenised elastic properties. This constitutes the basis of the training. As a result, a standard integration quadrature is used to speed up the FE analysis. Results show that the use of lowest level DCT coefficients is accurate enough for the aluminium foam images analysed, in terms of strain energy and displacements with respect to the reference solution of a standard FEM problem.[1]

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