Constrained hexahedral mesh smoothing for Finite Element modelling from 3D image data

Mauricio Reyes[1], Xabier Larrea[1], Steven Boyd[2], Miguel A. Gonzalez[1] and Philippe Büchler[1]

1. University of Bern, Bern, Switzerland
2. University of Calgary, Calgary, Canada

Abstract

Automatic volumetric meshing algorithms on computerized tomography (CT) data have shown to be of great value for Finite Element (FE) modeling since they provide a fast and non-invasive way to study structural behavior. The interest on these methods has grown more since the apparition of microfocus CT (μCT) due to its high resolution, allowing assessment of mechanical behavior at a high precision. The basic meshing approach of generating hexahedra per voxel has the problem of producing jagged edges. Smoothing of the mesh can be then performed by using the Laplacian operator, but this method produces mesh shrinkage, which is unwanted in FE studies. In this paper an automatic meshing and smoothing algorithm for FE meshes from 3D image data is presented. The method includes a regularization step to assure good element's shape based on a quality measure. The method is based on low-pass signal filtering using transfer functions approximated by Chebyshev polynomials, resulting in a fast and computationally efficient method being extended here for FE meshes. Although theoretically applicable for any type of mesh element, results are presented here for hexahedra meshes obtained from synthetic and real data obtained from μCT of bone trabecula. For both, the smoothing process was evaluated based on the quality of the elements after smoothing, stress distribution, and volume preservation.