Automatic mesh refinement of objects defined by images. Mesh efficiency study

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ABSTRACT

The advances in 3D scanning and computer systems during the last decades make it possible to carry out highly accurate numerical simulations of scanned objects. This is of special interest in patient specific simulations using the Finite Element Method (FEM) to, for example, predict bone fracture risk[1], and evaluate of bone quality parameters for the detection of osteoporosis, [2] and [3].

Our group has developed an immersed boundary method called Cartesian grid Finite Element Method (*cg*FEM) which has been used to solve structural problems whose geometry is defined by a CAD model. The Cartesian structure of the FE mesh used in *cg*FEM perfectly matches the voxel-based information of 3D image files like those from Computed Tomography scans (CT scans) or Magnetic Resonance Imaging (MRI). Each element of the Cartesian mesh embeds a series of voxels of the image. The stiffness matrix of each element takes into account the information of each of the voxels during the numerical integration process obtaining a homogenized behaviour of the different materials of the voxels in the element that avoid an explicit definition of the boundaries. The basic idea to do this consists of placing an integration point at the centre of each voxel and assigning material properties as a function of the image values defined at each voxel[4]. To avoid excessive errors due to the homogenization, elements containing voxels with considerably different values are automatically and recursively subdivided, thus providing an *h*-adapted mesh.

In this communication we present a study of the behaviour of the proposed technique, including a study of the image resolution, the order of the FE interpolation and the number of voxels into each element on the accuracy of the solution. The results provide useful indications to define highly efficient FE models for each image.

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