CRTC's BCC-Based Image-To-Mesh (I2M) Conversion Method*

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This is a progress report of a 10 year-long effort in lattice-based, single-tissue [1], multi-tissue [2], and adaptive [3] mesh generator (CBC3D) that converts 3-dimensional segmented image data (e.g. MRI, CT, micro-CT) into good quality tessellations, for physics-based simulations [4,5]. The current state of the software generates tetrahedral or mixed FE meshes (tetrahedral, pentahedral, and hexahedral) of good quality with high geometric and topologic fidelity, and smooth surfaces. A single-tissue version of this software is open-source and available through ITK and 3D Slicer.

Methods: This is a two-step procedure. The first step creates high quality adaptive Body-Centered Cubic (BCC) initial mesh. The second step deforms the BCC mesh to corresponding physical image boundaries taking into account element quality and geometric/topologic fidelity. The mesh is refined according to local feature size of labels in the segmented image, and the resolution of each tissue is automatically adjusted based on user-defined fidelity parameter in (0,1].

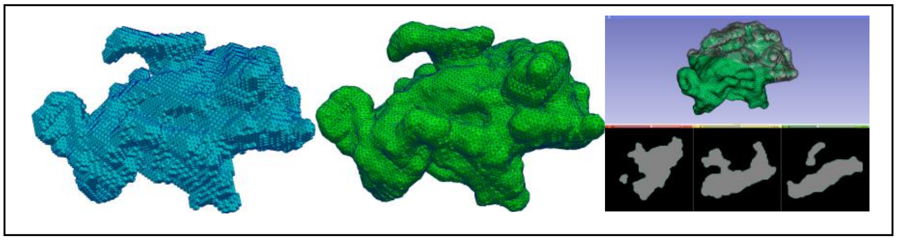

Figure 1: BCC mesh generation and refinement (left), mesh smoothing (middle), and fidelity of I2M conversion (right) of a nidus MRI [3]. Right image depicts the superimposed smoothed mesh (green) on the segmented 3D image (gray) --the intersection of the mesh boundary and an image slice is shown in axial, sagittal, and coronal plane (bottom-right).

Results: The last ten years we used CBC3D method on isotropic/anisotropic segmented volumetric image data that cover a spectrum of different applications. Figure 1 depicts a mesh of a nidus segmentation [3], and a visual assessment of the achieved I2M conformity on 3D Slicer. Figure 2 depicts examples of large tetrahedral/mixed meshes of complex geometries. In all cases a quantitative assessment is based on metrics like the dihedral angles [0˚,180˚] and the scaled Jacobian [0,1]. Both figures depict I2M conversions with varying degree of complexity and challenges for element quality, gradation, and geometric & topologic fidelity. There are many challenges ahead: (1) use of Structured Adaptive Mesh refinement to improve mesh gradation and (2) parallel implementation to make it real-time.

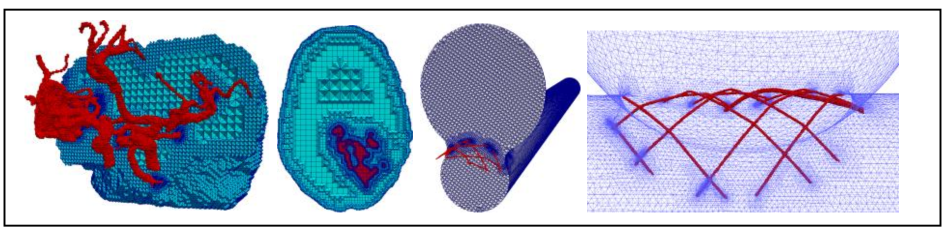

Figure 2: From left to right: Brain-AVM [3] mesh (7.8M tets, min dihedral angle: 6.95˚); Brain-nidus mixed mesh (1.4M tets, 300K pents, 145K hexs, min dihedral angle: 30˚, min scaled Jacobian: 1.0); Pipeline LVIS stent [5] (9.1M tets, min dihedral angle: 5.56˚); stent detail.

References:

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