High Fidelity Geometric Modeling and Finite Element Mesh Generation from Volumetric Imaging Data with Applications in Computational Mechanics

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Abstract:

The development of finite element simulations in medicine, molecular biology and engineering has increased the need for high quality geometric model construction. Although there have been tremendous progresses in the area of surface reconstruction and 3D geometric modeling, it still remains a challenging process to generate desirable models in various application areas.

I will present details of meshing pipelines, especially algorithms to extract adaptive and quality 2D (triangular or quadrilateral) and 3D (tetrahedral or hexahedral) meshes of volumetric domains, conforming to boundaries defined as level sets of a scalar function on the domain. Guaranteed-quality all-quad/hex meshing, feature preservation, and automatic meshing for multi-material domains will be discussed. Besides piecewise linear element meshes, a skeleton-based sweeping method is developed to construct hexahedral solid NURBS for blood vessels from imaging data, then a wavelets-based scheme is used to simplify and fair the NURBS surface with continuity preservation, especially at the interface shared by multiple patches. The constructed solid NURBS have been successfully used in isogeometric analysis of blood flow. In this talk, I will additionally present two main applications of our meshing schemes: patient-specific geometric modeling from CT/MRI data, and implicit solvation models of biomolecular structures for multi-scale models for the Neuro-Muscular Junction synaptic system at both molecular and cellular scales.

About the speaker:

Prof. Zhang is an Assistant Professor in Mechanical Engineering at Carnegie Mellon University. She received her B.Eng. in Automotive Engineering (1996), and M.Eng. in Engineering Mechanics (1999), all from Tsinghua University, China, and M.Eng. in Aerospace Engineering and Engineering Mechanics (2002), and Ph.D. in Computational Engineering and Sciences (2005) from the University of Texas at Austin.

Prof. Zhang is the director of Computational Biomodeling Laboratory at Carnegie Mellon University. Her research interests include Computational Geometry, Mesh Generation, Computer Graphics, Visualization, Finite Element

Method, Isogeometric Analysis and their applications in Computational Biomedicine, Computational Biology and Engineering. Prof. Zhang has developed many novel meshing techniques for quality 2D and 3D finite element mesh generation, which have been used in a lot of applications at various scales. She has published over 50 papers in the international journals and conference proceedings.