**Title:** High-Order Mesh Generation and Warping for Biomedical Simulations

**Speaker:** Dr. Suzanne Shontz, University of Kansas

**Abstract:** There are numerous challenges in generating high-quality meshes of cardiac anatomies due to the complex geometry of the heart, its curvature, and its motion. More generally, computational modeling of anatomical models bounded by curved surfaces can benefit from the use of high-order curved meshes. Using such meshes ensures that the curvature is captured correctly in the corresponding mesh. In addition, for a fixed level of accuracy, pairing a high-order mesh with a high-order PDE solver requires fewer mesh elements hence making the mesh generation and PDE solve much less computationally expensive. The use of high-order meshes in dynamic simulations helps prevent instabilities.

In this talk, we first present our advancing front-based high-order tetrahedral mesh generation method for finite element meshes. While most existing high-order mesh generation methods employ a computer-aided design (CAD) model to represent the boundary surface, our method requires only the element vertices and connectivities. Thus, it can employ a high-order surface mesh which was generated from medical image segmentation masks or a CAD model. Our method then directly generates a high-order volume mesh and applies mesh optimization to utilize the higher degrees of freedom and further improve the mesh quality.

Second, we present our high-order mesh warping algorithm for tetrahedral meshes, which allows us to perform time-dependent deformations present in biomedical applications. Our method is based on a finite element formulation for hyperelastic materials. We employ the two-parameter incompressible Mooney-Rivlin model with appropriate material properties to represent the continuum model. We use Newton iteration to solve the nonlinear elasticity equations obtained from the Mooney-Rivlin model and equilibrium conditions; the solution to the nonlinear elasticity equations then yields the deformed mesh.

Finally, we use our methods to generate several second-order tetrahedral meshes of anatomical models obtained from medical images and CAD models and apply several time-dependent deformations. We conclude with a vision for research in mesh generation for biomedical simulation.

This talk represents joint work with Fariba Mohammadi, University of Michigan, and Cristian Linte, Rochester Institute of Technology.