A selective smoothed finite element method for extremely large deformation of anisotropic incompressible bio-tissues

C. Jiang[1], Z.Q. Zhang[2], G.R. Liu[3], *X. Han[1]

[1] State Key Laboratory of Advanced Technology of Design and Manufacturing for Vehicle Body, Hunan University, P.R. China, 410082.
[2] Institute of High Performance Computing, A*STAR, Singapore, 138632
[3] Department of Aerospace Engineering and Engineering Mechanics, University of Cincinnati, 2851 Woodside Dr, Cincinnati, OH 45221, USA.

*Corresponding author: hanxu@hnu.edu.cn

A dynamic selective smoothed FEM technique is proposed for extremely large deformation of anisotropic incompressible bio-tissues, using the simplest 4-node tetrahedron elements. The Face-based Smoothed FEM (FS-FEM) is used for the deviatoric part of deformation and the Node-based Smoothed FEM (NS-FEM) is used for the volumetric part, for outstanding accuracy, stability and computational efficiency. The NS-FEM offers an "overly-soft" feature (in contrast to the standard FEM "overly-stiff" model), which can be used to effectively mitigate the volumetric locking. Numerical examples are presented to examine the performance of the Selective S-FEM method, including soft tissues of isotropic materials, transversely isotropic materials and anisotropic arterial layered materials. The present method is found having good accuracy and performance. The examples also demonstrate that the proposed explicit dynamic selective S-FEM is very robust and possesses remarkable capabilities of handling element distortion, which is very useful for soft materials including bio-tissues.

Keywords: Finite Element Method, Smoothed Finite Element Method, Gradient Smoothing, Incompressibility, Anisotropy, Tetrahedral, Large Deformation, Explicit time integration