On inverse elasticity methods for anisotropic hyperelastic materials

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Biomechanical studies of the cardiovascular system require patient-specific geometries. However, such geometries are typically generated from gated medical images, in which the vascular tissue is under pressure—that is, the imaged tissue is in a prestressed state. Therefore, identifying the zero-pressure geometry allows for a more accurate estimation of device performance and risk assessment.

Iterative methodologies based on solving a sequence of forward problems have been developed, in which the zero-pressure configuration (or reference configuration) is corrected based on the difference between the target geometry and the current deformed configuration. While these methods are straightforward to implement within the classical finite element framework, they may lead to excessive mesh distortion.

A direct methodology based on inverse elastostatics (IE), originally applied to isotropic hyperelastic compressible and quasi-incompressible materials, has been proposed. The theory has since been extended to anisotropic compressible hyperelastic materials. This lecture elaborates on the implementation of the IE framework for quasi-incompressible anisotropic hyperelastic materials, incorporating exact linearization of the governing equations to improve numerical efficiency. The accuracy and convergence properties of the implementation are demonstrated through several examples