HIGH ORDER SPACE-TIME FINITE ELEMENT SCHEMES FOR THE DYNAMICS OF VISCOELASTIC SOFT TISSUE

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Abstract

As plaque builds up in a coronary artery, blood flow past the stenosed region becomes turbulent and creates abnormal variations in wall shear stresses in the wake. These shears drive low amplitude acoustic shear waves at around 1 kHz through the soft tissue in the thorax which appear at the chest wall and can be measured non-invasively by placing sensors on the skin. This acoustic surface signature (bruit) has thus the potential to provide a cheap non-invasive means of diagnosing Coronary Artery Disease [Banks and Pinter, Multiscale Model. Simul. 3, 2005, 395-412]. An efficient and accurate solver with the ability to resolve these low energy surface fluxes will be an essential ingredient.

With this as our motivation we will describe the development and formulation of a high order solver for a space-time elasto- and visco-dynamic problem formed by merging Hookes law with the Zener and Kelvin-Voigt models for viscoelasticity. We employ a spectral finite element method to discretize in space and a high order discontinuous Galerkin finite element discretization in time using normalized Legendre polynomials of arbitrary degree, r, say. This choice allows the linear system to be decoupled by following Werder et al.'s technique [Comp. Meth. Appl. Mech. Engrg. 190, 2001, 6685-6708] and results in a set of (r+1) complex symmetric systems for each time slab. We illustrate the effect of the decoupling with respect to accuracy and computation time.