PARAMETER ESTIMATION IN CARDIAC FLUID–STRUCTURE INTERACTION FROM SOLID AND FLUID DATA

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Abstract. Parameter estimation in the heart has been carried out so far using measurement in the myocardium, typically using displacement surrogates obtained from magnetic resonance imaging (MRI) [1, 2]. Nevertheless, blood flow velocity measurements are routinely acquired in the clinical practice and can be directly compared with the computed flow velocities of fluid–solid interaction (FSI) models. To the best of the authors' knowledge, inverse problems in cardiac mechanics using "velocity images" of the blood flow have remained unexplored, especially since fully coupled 3D FSI models are challenging mathematically, algorithmically and computationally.

We propose a parameter estimation approach involving sequential data assimliation of a coupled fluid–solid model using both measurements of the solid and the fluid mechanics. The forward solver consists of a one-way coupling of the solid mechanics to the fluid mechanics, using for the fluid an unconditionally stable fractional-step method in ALE form [3], while the nonlinear solid mechanics is defined by a compressible hyperelastic material law. The reduced-order Unscented Kalman Filter [4] is used for the efficient solution of the inverse problem.

First results are presented of estimated constitutive and boundary condition parameters of the solid for an idealized, synthetic myocardium model. Our findings show that combining measurements of the solid displacements and the fluid velocity significantly improves the estimation of parameters of the solid model in comparison to solid- or fluid-only measurements.

Keywords: inverse problems, cardiac mechanics, blood flows, fluid-structure interaction

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