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IDENTIFICATION OF MATERIAL PARAMETERS OF SOFT TISSUE: TOWARDS INTEGRATIVE INVERSE ANALYSIS BASED ON IMAGE SIMILIARITY

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Advances in computational methods steadily increase the applicability and practical relevance of computational models. With respect to clinical application, patient specific computational models become increasingly powerful tools to predict outcome and development of diseases or to allow for better planing and development of (surgical) interventions, see e.g. [1]. Such models incorporate complex 3-dimensional geometries, finite deformation kinematics and nonlinear constitutive properties. Despite these sophisticated means, material parameters are often based on population averaged mean values and are furthermore assumed to be of spatial homogeneity. Especially for soft living human tissue the latter assumption does not generally hold. Incorporation of spatially accurate representations of material parameters is therefore of high importance to further advance computational methods toward application in a clinical setting.

Although not being directly measurable in-vivo, material parameters can be accurately estimated by means of inverse analysis procedures, which often rely on non-invasively available information. In the case of cardiovascular applications, this information is conveniently obtained from medical imaging techniques, such as CT, MRT or Ultrasound. Since usually inverse algorithms for parameter identification utilize some measure of displacement or strain as reference solution, image processing techniques are utilized to extract the desired information from image data. This often includes image registration, which itself constitutes an inverse problem. To render the image registration well-posed, regularization techniques are introduced, which commonly are not specifically tailored to the subsequent parameter identification and thus the regularization of the registration can result in a subsequent deterioration of the final best fit material parameters.

As a remedy, we propose a new embedded registration and inverse analysis approach inspired by [2,3,4,5], where results are not disturbed by artificial regularization effects during the image registration step. Instead of splitting the material parameter identification process into two stages, namely image registration and the subsequent inverse computation (sequential registration based approach), we directly utilize an image based measure of similarity in the objective function to be minimized directly by the inverse algorithm (integrative image based approach). In contrast to [2], we propose to apply a surface based measure of image similarity [5] and to control regularity of the solution directly in the objective function.

Formulation of the proposed integrative image based inverse analysis will be given and examples will be provided, that demonstrate behavior of and compare the newly proposed method to the classical two-staged sequential registration based approach.

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