Computational reconstruction of heterogenous material behavior from simple contact probing

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Abstract

This work presents a general nonlinear computational framework for the inverse reconstruction of advanced heterogenous constitutive models using contact-generated deformation data. Key ingredient of the framework is an independent discretization of deformation and material fields [1]. The former is based on high-order isogeometric finite elements, as they offer high accuracy and smoothness, which is particularly advantageous for contact simulations [2]. The latter is based on low-order Lagrange elements, as they are advantageous to capture material discontinuities. A reconstruction algorithm is then formulated based on a least square error objective that compares the finite element results based on the two discretizations with given experimental data. Local optimization based on the trust-region approach is used. Analytical sensitivities are incorporated to accelerate the inverse analysis. Implicit contact algorithms are used to model large-deformation contact [3]. The performance of the proposed reconstruction framework is illustrated by several numerical examples using synthetic experimental results that are generated from high-resolution simulations with the subsequent addition of up to 4% noise. The results show that with a sufficient number of experimental measurements, design variables and analysis elements, the algorithm is capable to reconstruct material distributions with high precision even in the presence of material discontinuities and large noise.

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[2] C.J. Corbett and R.A. Sauer (2014), "NURBS-enriched contact finite elements", *Comput. Methods Appl. Mech. Engrg.*, **275**:55-75

[3] R.A. Sauer and L. De Lorenzis (2013), "A computational contact formulation based on surface potentials", *Comput. Methods Appl. Mech. Engrg.*, **253**:369-395

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