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Optimization of the porous material described by the Biot model

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Gradient-based shape optimization of microstructures generating locally periodic porous materials saturated by viscous fluid is discussed. The porous medium is described as the Biot continuum [2] obtained via the homogenization method, see e.g. [3]. The effective material properties are given by the drained skeleton elasticity, the Biot stress coupling, the Biot compressibility coefficients and the hydraulic permeability of the Darcy flow model. Coming from a linearization of the macroscopic Lagrangian function local non-linear optimization problems are derived which exhibit a free material optimization type characteristic. Sensitivity analysis using the domain method of the design velocity approach is presented for all homogenized material coefficients. For the shape optimization the design of the microstructure is parametrized by control points of a B-spline tensor product volume which embeds the whole representative volume element. In conclusion numerical examples motivated by material design are given, where the objective of the optimization is to maximize stiffness while permitting sufficient permeability and vice versa. For the 2-scale problem, numerical studies are presented at a location of interest of the macroscopic domain. Results for different Lagrange multipliers are discussed reflecting different importance of the objective and the opposed constraint.

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