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Optimal material distribution for an unsaturated flow problem

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Abstract

The Richards equation is a transient nonlinear partial differential equation, which describes the motion of a fluid within an unsaturated porous medium. We model the absorption of fluid where swelling is not considered.

We present a topology optimization problem where we distribute materials with different porosity, permeability and fluid absorption properties. The objective is to maximize the total amount of fluid within a given region, while keeping the fluid content in specific regions low. The distribution of two and three different materials is considered.

The topology optimization approach follows the ersatz material approach. The function gradients are obtained by the adjoint method which requires the solution of a transient linearized variant of the state problem.

The numeric solution of Richards eqaution is based on the open source package OpenFOAM, which implements the finite-volume method. We sketch the necessary extensions to efficiently evaluate the function gradients for problems with thousands of design variables.