An efficient preconditioner for the coupled contact mechanics and fluid flow in fracture network

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For many subsurface application, such as geothermal energy production and CO_2 sequestration, a major role is played by the coupled simulation of frictional contact mechanics and fluid flow in fractured porous medium. In addition, large domains with high resolution representations of the geological structures and their heterogeneous properties are usually required to achieve the desired accuracy. These aspects naturally reflect on the growing demand for better performance of sophisticated and computationally expensive models. In this talk, the focus is on the linear solver, that is the most time consuming component of a simulation, and in particular on the design of a scalable and efficient preconditioning framework for the coupled contact mechanics and fluid flow problem. The model relies on the explicit discretization of the fractures, with the Lagrange multipliers method used to impose the contact constraints. Low order finite elements are used for the mechanics, while a cell-centered finite volume scheme has been adopted for the fluid flow. The arising system of equations has been properly stabilized to satisfy the inf-sup condition.

We design a scalable preconditioning framework for the 3x3 block matrix exploiting the natural unknown subdivision and a state-of-the-art aggregation-based multigrid solver. Two different approaches have been derived with the identification of theoretical bounds for the eigenvalue distributions of the preconditioned matrices. The two methods are tested on real world cases to prove the algorithmic scalability, the influence of the relative weight of fracture-based unknowns and the performance on a real-world problem.

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