Hybrid Newton method for the acceleration of well events handling in the numerical simulation of CO_2 Storage

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Numerical simulations are crucial for solving multi-phase flow equations in CO2 injection sites. However, simulating fluid flow in porous media is highly demanding computationally, often requiring several hours on an HPC cluster for a single injection scenario in a large CO2 reservoir. Well events, like opening and closure, pose significant challenges due to their sudden impact on the system, necessitating a drastic reduction in time step size to solve resulting nonlinear equations accurately. Yet, these events tend to exhibit spatial and temporal similarities, determined by factors such as injection conditions, reservoir state, boundary conditions, and porous media parameters.

This thesis work aims to employ recent advancements in physics-informed deep learning to mitigate the impact of well events in numerical simulations of multiphase flow in porous media. In practice, we suggest a hybrid method that complement the conventional nonlinear solver with a machine-learning model while maintaining numerical reliability. Our approach involves customizing the hybrid Newton methodology, which predicts a global initialization for Newton's method closer to the solution. We employ the Fourier Neural Operator machine-learning model for this prediction task.