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Mixed Pressure-Velocity Physics-Informed Neural Networks for Flow Modeling in Heterogeneous Porous Media

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Abstract

The standard formulation of Physics-Informed Neural Networks (PINNs) often encounters convergence issues when simulating fluid flow in highly heterogeneous porous media. To overcome these challenges, this work adopts the mixed formulation of the governing equations, which separates mass continuity from Darcy's law. This separation eliminates the need to compute spatial derivatives of discontinuous hydraulic conductivity, thereby improving both stability and accuracy.

Building on this mixed formulation approach, several neural network architectures were explored to further improve performance. Numerical experiments revealed that the highest accuracy was achieved by assigning separate neural networks to pressure and each component of the velocity field, resulting in three distinct networks for 2D problems. This approach effectively captures the intricate behavior of fluid flow in heterogeneous porous media.