**Toward Real-Time Subsurface Reservoir Model Calibration by Deep Learning**

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**Abstract**: The characterization of reservoir permeability heterogeneity is essential to accurately infer fluid flow behavior in subsurface geological formations, such as hydrocarbon recovery, CCUS, and geothermal recovery. This task is often accomplished by integrating physics flow simulators with iterative history-matching methods, and such workflows are usually computationally expensive due to the iterative nature and the prohibitive cost of physics flow simulators.

In this talk, I will introduce two types of deep-learning methods to more efficiently estimate reservoir heterogeneity based on flow responses, such as well rates, pressure, or saturation. Inspired by the fast marching method, the first method is a direct data-inversion approach to estimate the permeability field based on transient pressure by the deep neural network. The approach requires no flow simulations during inference and we validated it in both homogeneous and heterogeneous permeability scenarios. To quantify the uncertainty in the reservoir, the second method is an ensemble multi-fidelity network to learn the nonlinear mapping from flow response to the model parameter, and an efficient forward solver is necessary if we need an iterative update during the multi-stage training. The inference results are comparable to the traditional ensemble method, in addition to a remarkable reduction in forward model evaluations. These approaches are computationally more efficient and flexible to incorporate a multitude of data sources. They are highly applicable for real-time model updates during closed-loop reservoir management.

**Headshot:**

