Progressive learning to transfer between multi-physics systems

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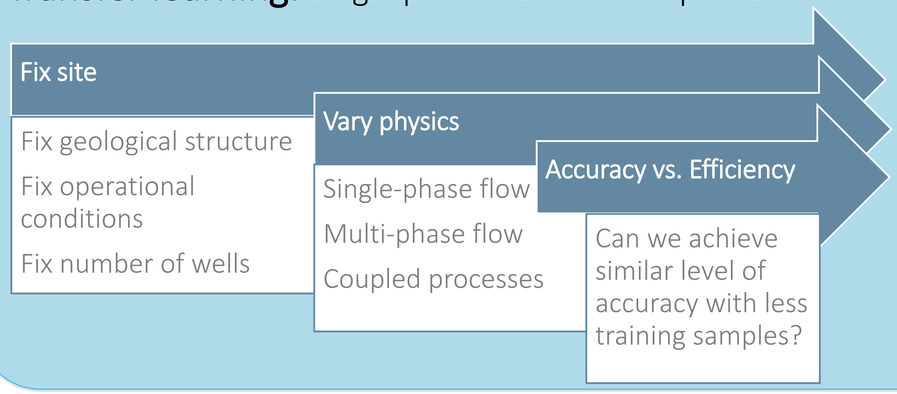
SMART
Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications

Objectives:

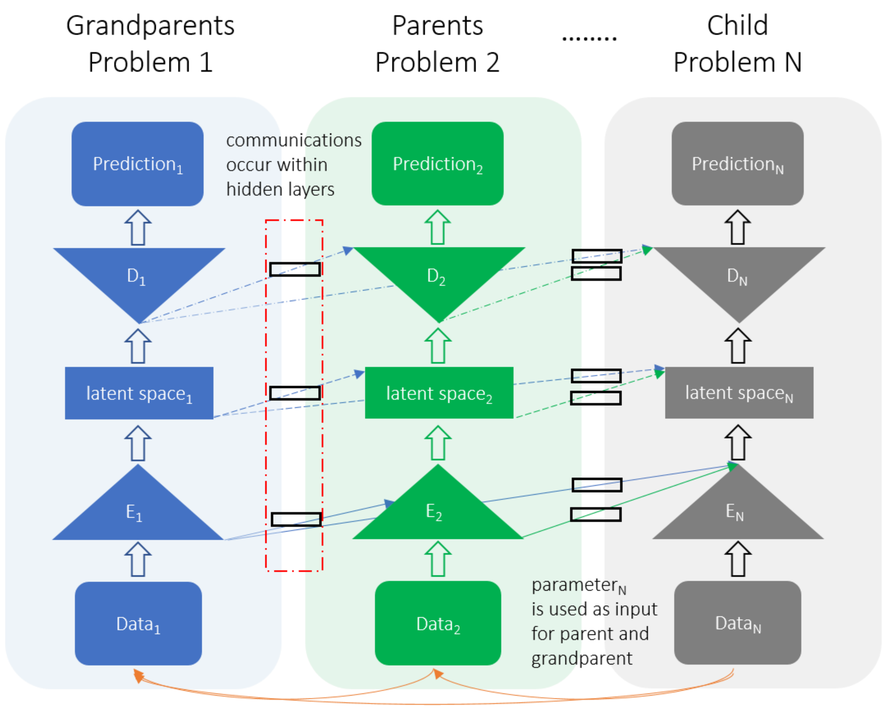
- Develop transfer learning to adapt trained models for new physical systems and reservoir models.
- Reduce training data requirements.
- Ensure flexibility for multiphysics problems.

Training: The model can be trained using subsets of the computational domain.

Transfer learning: Single phase flow to multiphase flow to coupled processes

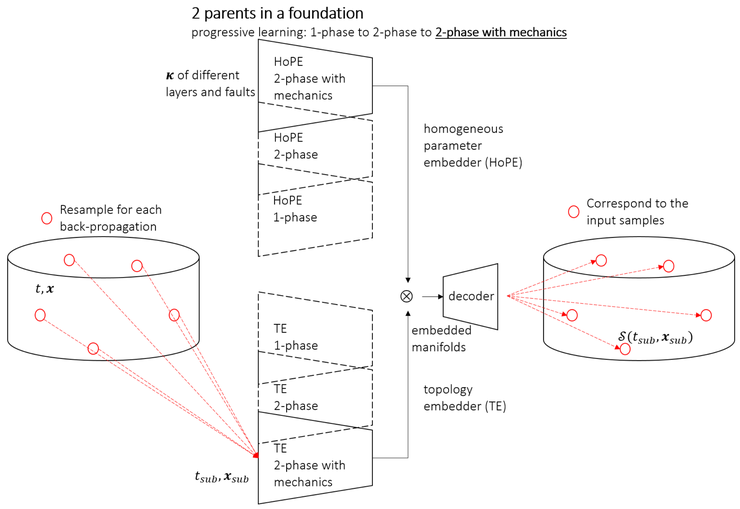


Parent: pressure model
Current: saturation model



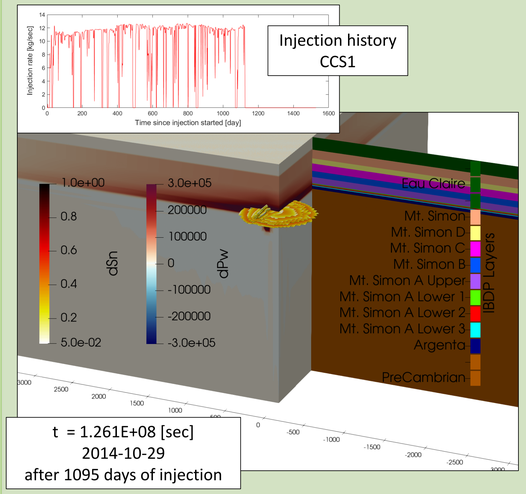
- Schematic of multi-level progressive transfer learning.
- N-1 pre-trained ML models for N-1 different problems can accelerate training and improve accuracy for a new ML model addressing a new problem.

Progressive Improved Neural Operator (p-INO)



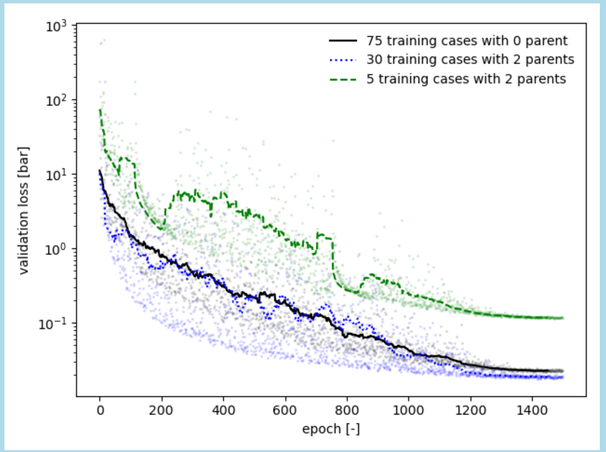
We apply our progressive learning framework to our improved neural operator (INO). Each INO represents each physics.

Forward Modeling

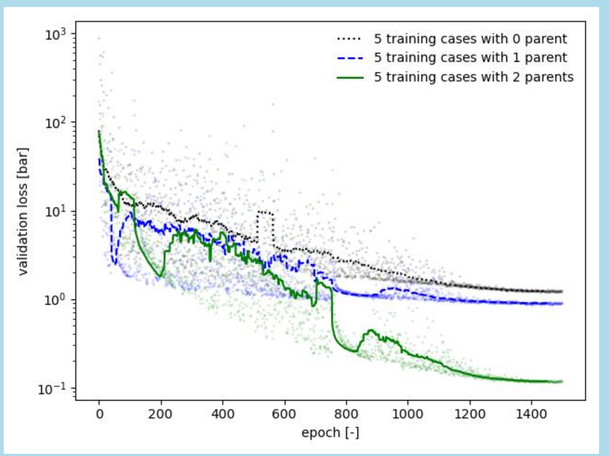


The FEM numerical model domain, representing a 1/4 of the entire area under study, is structured with several stratified layers and includes a vertical fault.

Transfer learning from 1-phase to 2-phase with mechanics



Using less than half of training samples, the model can achieve almost the same level of accuracy



Adding more prior knowledge (parents) can enhance model's accuracy when the training set is fixed

ML model training:
Training time: 1300 mins for TL and 900 without TL using single Quadro RTX 8000
Number of parameters: 2.22 M (TL, 30Mb) and 1.1 M (no TL, 13Mb)

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