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# Deep Learning to predict Oil Volume Production in Pore-Scale Two-Phase Flow

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Deep neural networks have been explored in predicting single-phase flow properties within pore-scale porous media domains. However, their application to two-phase flow scenarios is limited in the literature.
The complexity of two-phase flow arises from fluid-fluid interactions, domain geometry, and the non-linear behavior at the fluid interface. Additionally, porous media domains are not homogeneous, which significantly alter flow outcomes with geometry change.
This study focuses on predicting oil volume production curves in two-phase flow within pore-scale porous media, incorporating the effect of varying fluid viscosities. The deep learning models developed to solve flow cases considering high capillary numbers, indicating dominant viscous forces over capillary forces. The inferred oil volume production curves could be applied to compute porous media properties, such as relative permeability curves.
To train the proposed Machine Learning models, we generate a synthetic porous media dataset using Voronoi diagram patterns, and solve the two-phase flow using the finite element method.
Two neural network architectures are explored: a Convolutional Neural Network (CNN) and a Deep Operator Network (DeepONet). The CNNs are the standard tool used when dealing with image-like data in the Machine Learning context. Moreover, previous works successfully applied CNNs to predict porous media properties, mainly in single-phase flow cases. The DeepONet is a Network structure designed to approximate complex relationships by combining separate inputs into a unified output. Therefore, it takes different non-correlated inputs that interfere on the answer separately and merges the separate functions in the end of the structure. The adoption of DeepONet concept improved the model metrics when compared to the standard CNNs.
Our results indicate that the DeepONet architecture outperforms the CNN, achieving a 45% lower mean squared error in predicting oil volume curves. Additionally, the proposed approach demonstrates robustness by generalizing to different viscosity ratios, enabling predictions of two-phase flow properties across diverse scenarios with varying oil viscosities.
The proposal is shown to be a robust solution to make quick assessment of oil-volume production in porous media, being this inference orders of magnitude quicker than the computation through Finite Element Method solution of the flow.

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Brazil

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## References

**Primary author:** CALDERANO, Pedro (PUC-Rio)

**Co-authors:** AYALA, Helon (PUCPR); CARVALHO, Marcio (PUC-Rio)

**Presenter:** CALDERANO, Pedro (PUC-Rio)

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