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Early Stopping of Untrained Convolutional Neural Networks

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In recent years, new regularization methods based on (deep) neural networks have shown very promising empirical performance for the numerical solution of ill-posed problems, such as in medical imaging and imaging science. Due to the nonlinearity of neural networks, these methods often lack satisfactory theoretical justification. In this work, we rigorously discuss the convergence of a successful unsupervised approach that utilizes untrained convolutional neural networks to represent solutions to linear ill-posed problems. Untrained neural networks have particular appeal for many applications because they do not require paired training data. The regularization property of the approach relies solely on the architecture of the neural network instead. Due to the vast over-parameterization of the employed neural network, suitable early stopping is essential for the success of the method. We establish that the classical discrepancy principle is an adequate method for early stopping of two-layer untrained convolutional neural networks learned by gradient descent, and furthermore, it yields an approximation with minimax optimal convergence rates.

Primary author: JAHN, Tim (TU Berlin)

Presenter: JAHN, Tim (TU Berlin)