Ongoing Approaches for utilizing Neural Networks in DC Resistivity Inversion

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Abstract

As part of an investigation into applications of Neural Networks for EM problems, different approaches have been tested for DC resistivity modeling and inversion.

The first approach consists of using Convolutional Neural Networks (CNN) for DC resistivity inversion. For this purpose, dipole-dipole pseudosections were simulated using the in-house FEMALY toolbox and used as input data for a CNN, which was trained to output underground resistivity. Training results showed qualitatively good match with the ground truth. However, the predictions are characterized by lack of extrapolation to unseen types of data (e.g. homogeneous half-spaces) and coarse grid enforced by the approach.

The second approach laid in the use of Physics Informed Neural Networks (PINN). In this approach, the relevant partial differential equation is included as a regularization term in the loss function, leading to a network whose outputs are guided by physics. Derivatives for the PDE term are obtained via automatic differentiation, removing the need for discretization. This also necessitated a move to solving the forward problem. While this approach has the benefits of being mesh-free and incorporating physics into the training process, in practice it failed at even elementary modeling cases, particularly involving resistivity anomalies.

A third approach aimed at combining the previous two, by creating a physics-informed Convolutional Neural Network. This was achieved by replacing the previous loss approaches by a convolution with a Laplace-operator Kernel. This approach produces results that look promising qualitatively for homogeneous half-spaces, however full Dirichlet boundary conditions are required and resistivity anomalies can again not be easily incorporated.

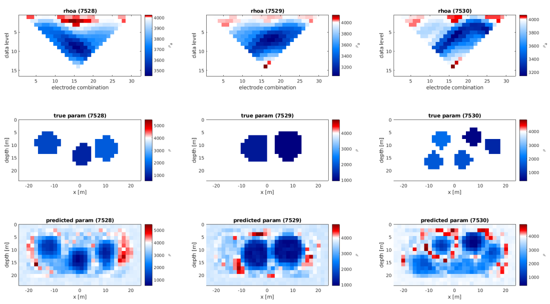

Figure 1: Input pseudosection, ground truth and CNN prediction for 3 subsurface resistivity distributions.

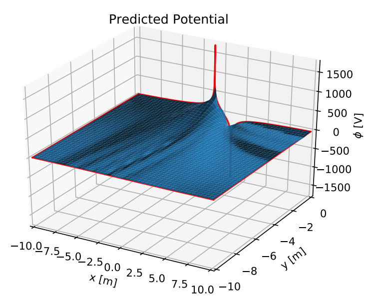

Figure 2: PINN prediction for electrical potential in a homogeneous half-space with 2 current electrodes