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Using the transfer learning approach in neural network solution of inverse problems of exploration geophysics

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Inverse problems (IP) of exploration geophysics (EG), which consist in reconstructing the spatial distribution of the properties of the medium in the Earth's thickness from the geophysical fields measured on its surface, are characterized by ill-posedness, which complicates their solution, both by traditional methods and by machine learning methods, including neural networks(NN). A general approach to reducing the ill-posedness of IPs is to use additional information, such as a priori knowledge about the system under consideration. When using NN to solve EG IP, *a priori* knowledge about the system can be taken into account at the stage of creating the training dataset in the form of assumptions about the structure of the geological section, and its implementation involves the use of narrow parameterization schemes that describe a certain class of geological sections. In our previous studies [1], we have shown that indirect introduction of a priori information through the use of a narrower parameterization scheme shows a better result of NN solution of the EG IP compared to use of a more universal parameterization scheme.

However, generating a training dataset involves solving a direct problem for each pattern included in it, and it is therefore computationally expensive. Since each parameterization scheme requires creating new training data and training a new set of neural networks, using narrow parameterization schemes also incurs high computational costs. Therefore, to reduce computational costs, in this study it is proposed to use an approach based on transfer learning. In this case, models are pre-trained on data from a more general parameterization scheme and then fine-tuned on data from a more specific parameterization scheme. This will allow us to use less training data and to spend less time to train a neural network compared to training neural networks in the traditional way.

In this study, we investigate the applicability of transfer learning approach to EG IP of gravimetry, magnetometry and magnetotellric sounding, and we evaluate the computational cost savings when using it.

[1] I. Isaev, I. Obornev, E. Obornev, E. Rodionov, M. Shimelevich, and S. Dolenko, Stud. Comput. Intell. 1120 (2023) 455. DOI: 10.1007/978-3-031-44865-2_48