3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Nonlinear Electromagnetic Inversion of Damaged Experimental Data by a Receiver Approximation Machine Learning Method

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Electromagnetic inverse scattering is widely used in geophysical subsurface sensing, target detection and identification, nondestructive evaluation, and biomedical imaging. In practical applications, however, electromagnetic measurements often contain damaged data due to malfunctioning receivers, which will severely influence the inversion performance. Traditional deep learning based inverse scattering methods have not addressed such an important issue. Recently, a new receiver approximation machine learning (RAML) method has been proposed to repair the data from the damaged receivers for the two-dimensional (2-D) inverse scattering problem [1].

The RAML method is constructed on the basis of a two channel-artificial neural network (ANN) with two hidden layers. The inner parameters of RAML are optimized iteratively by the back-propagation (BP) algorithm according to the loss function in terms of mean squared error (MSE). The input of RAML is the complex-valued scattered field data from other receivers within a wavelength around the damaged receiver, where the complex-valued scattered field data is decomposed into real and imaginary parts and input to the corresponding two channels of RAML, respectively. The output of RAML is the approximated field data of the damaged receiver for the further inversion. In our previous research, the dual-module nonlinear mapping module (NMM)-image enhancing module (IEM) machine learning scheme has been proved its good performance for scatterers with high contrast and large electrical dimension in both synthetic and experimental datasets [2]. Thus, the repaired data obtained from RAML will be input to NMM-IEM to obtain the final inversion result.

Compared with the synthetic data, the experimental data are more challenging for the inversion, thus, the experimental data including both transverse electric (TE) and transverse magnetic (TM) modes provided by Institute Fresnel are employed to evaluate the effectiveness of the proposed RAML method [3]. Two experiments are designed to verify the performance of the RAML: for the first experiment, ten random receivers (4.15% of the 241 receivers) are damaged in each test case to verify the performance of the proposed model. In the second experiment, the most complex model from the first experiment with 120 damaged receivers (about 50% of the 241 receivers) is used to test the extreme ability of RAML. It could be seen that, even in this extreme situation, RAML can still maintain good inversion performance.

References

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