Cascaded Convolutional Neural Network to Solve Phaseless Inversion

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The phaseless-data inverse scattering problems (PDISPs) are non-trivial due to their serious non-linearity and illposed nature. The conventional methods for PD-ISPs can be categorized into single-step methods and two-step methods, where the first ones directly reconstruct the image and the second ones retrieve the phase and amplitude of scattered fields then reconstruct the image as the traditional FD-ISPs [1,2]. The single-step methods directly reconstruct the constitutive parameters of the unknown scatterers by solving a non-linear model-based optimization and the objective function is defined as the residual between the measured modulus data and the computed modulus data. Due to lack of the phase information, this objective function has the higher order terms with respect to unknown contrast function compared to the one for the inverse scattering problems with full data (FD-ISPs). Consequently, the inverse scattering problems with phaseless data (PD-ISPs) have higher nonlinearity and are more difficult to be solve [3]. However, in the two-step inversion methods, phase retrieval in the first-step procedure plays a significant role in the inversion. And the inversion could be counter failure owing to the large errors in the first-step, which may result in irreversible data damage in the second-step.

In response to the above problems, a cascaded complex U-net (CCU-net) model is proposed to solve the PD-ISPs in the complex domain in this paper. The CCU-net cascades the PRNet and IRNet as a whole, the former is used to recover the phase and amplitude of the scattered field from the modulus square of the measured total field and the latter is to reconstruct the images. Here, we use the scattered field (both phase and amplitude are recovered) generated by PRNet directly as the input of the IRNet in the complex domain, the physical relationship between the complex scattered field data and the relative permittivity of the unknown target can be observed and learned well. Compared with the results obtained by the other methods, it is validated that the proposed CCU-net has the best performance in terms of the inversion accuracy and robustness. The real-time inversion of the PD-ISPs can be achieved well with one-step calculation by the cascaded network, which has great potential application in the industry application, such as non-destructive test, medical imaging, and super-resolution detection.

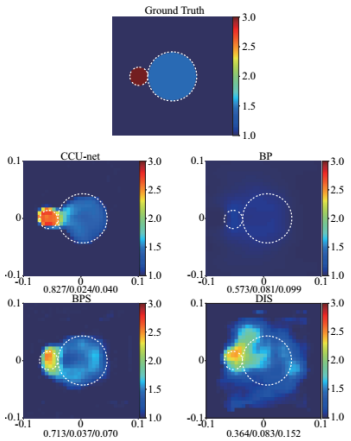

Figure 1. The reconstructed images by CCU-net, back propagation, back propagation with U-net, and direct inversion scheme with U-net at 4 GHz.

References

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