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Nonlinear Electromagnetic Inverse Scattering Using DeepNIS

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Nonlinear electromagnetic (EM) inverse scattering is a quantitative and super-resolution imaging technique, in which the more realistic interactions between the internal structure of scene and EM wavefield has been taken into account the imaging procedure, in contrast to conventional tomography. However, it poses important challenges arising from its intrinsic strong nonlinearity, ill-posedness and expensive computation costs. In this work, we build the connection between the CNN and the unfold iterative solution to nonlinear electromagnetic inverse scattering, and then establish a novel CNN, termed as DeepNIS, for the nonlinear electromagnetic inverse scattering. The DeepNIS is a non-iterative solution to the nonlinear electromagnetic inverse scattering. A central issue to the DeepNIS-based solution is the convolution operation, which can be implemented in parallel. The non-iterative and parallelizable natures of the DeepNIS imaging mechanism make it very suitable for dealing with large-scale inverse scattering problems. We showed that the DeepNIS has the overwhelming advantage over conventional inverse scattering methods in terms of the image quality and computational time. Our experimental results demonstrate that the proposed DeepNIS are capable of learning the inverse mapping between the raw intensity image and object directly from the experimental data. The results also suggest that the neural network can "learn" the governing equations of the system, including its forward operator and possible deviations from underlying idealizations and assumptions. Nonetheless, we still remark that one can explore more advanced CNN architectures to get more impressive inverse scattering results. To summarize, the DeepNIS could remarkably break the limitation of the conventional inverse scattering strategies, and can be used for treating the nonlinear electromagnetic inverse scattering with large-scale and high-contrast objects.

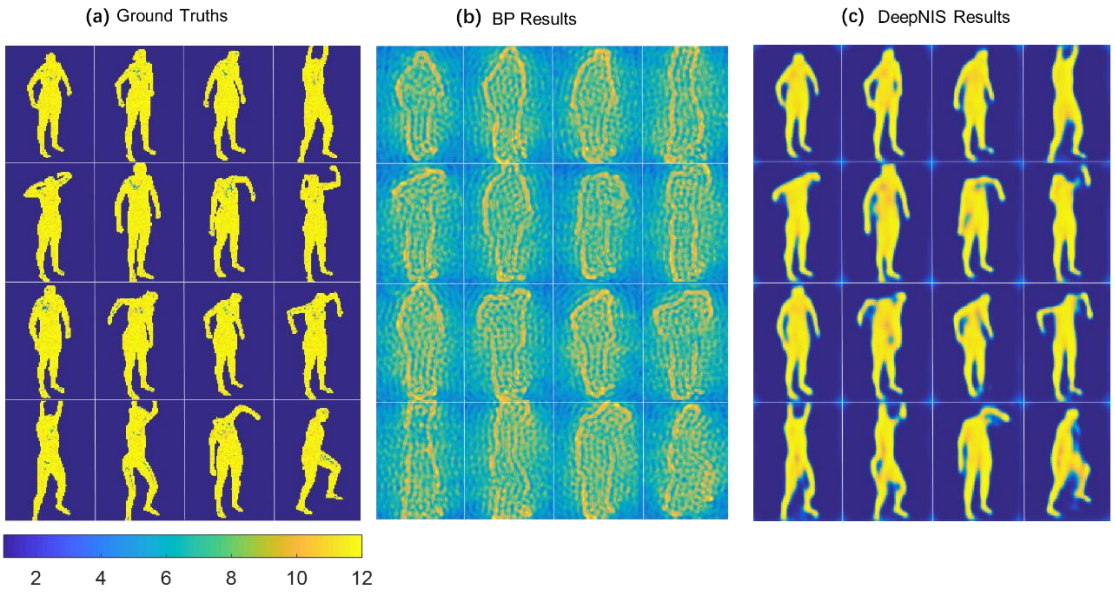

Figure 1. Results of electromagnetic inverse scattering of 16 human bodies. (left)16 ground truths, (middle) the BP results used as the inputs for the DeepNIS, and (right) the DeepNIS results. Here, the human bodies have been set to be lossless with the relative permittivity 12.