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Phase retrieval by a conditional Wavelet Flow: applications to near-field X-ray holography

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Phase retrieval is an ill-posed inverse problem with several applications in the fields of medical imaging and materials science. Conventional phase retrieval algorithms either simplify the problem by assuming certain object properties and optical propagation regimes or tuning a large number of free parameters. While the latter most often leads to good solutions for a wider application range, it is still a time-consuming process, even for experienced users. One way to circumvent this is by introducing a self-optimizing machine learning-based algorithm. Basing this on invertible networks such as normalising flows ensures good inversion, efficient sampling, and fast probability density estimation for large images and generally, complex-valued distributions. Here, complex wavefield datasets are trained and tested on a normalising flows-based machine learning model for phase retrieval called conditional Wavelet Flow (cWF) and benchmarked against other conventional algorithms and baseline models. The cWF algorithm adds a conditioning network on top of the Wavelet Flow algorithm that is able to model the conditional data distribution of high resolution images of up to 1024 x 1024 pixels, which was not possible in other flow-based models. Additionally, cWF takes advantage of the parallelized training of different image resolutions, allowing for more efficient and fast training of large datasets. The trained algorithm is then applied to X-ray holography data wherein fast and high-quality image reconstruction is made possible.

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