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# Weak-signal extraction enabled by deep-neural-network denoising of diffraction data

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Removal or cancellation of noise has wide-spread applications for imaging and acoustics. In every-day-life applications - such as image restoration - denoising may even include generative aspects, which are unfaithful to the ground truth. For scientific use, however, denoising must reproduce the ground truth accurately. Denoising scientific data is further challenged by unknown noise profiles. In fact, such data will often include noise from multiple distinct sources, which significantly reduces the applicability of simulation-based approaches.

We show how scientific data can be denoised via a deep convolutional neural network such that weak signals appear with quantitative accuracy. In particular, we study X-ray diffraction and resonant X-ray scattering data recorded on crystalline materials. We demonstrate that weak signals stemming from charge ordering, insignificant in the noisy data, become visible and accurate in the denoised data. This success is enabled by supervised training of a deep neural network with pairs of measured low- and high-noise data. We additionally show that using artificial noise does not yield such quantitatively accurate results. Our approach thus illustrates a practical strategy for noise filtering that can be applied to challenging acquisition problems.

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