Noise reduction in FFTs through machine learning algorithms for the study of Ge-based quantum computing devices

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Ge quantum devices have become increasingly relevant and widely studied in recent years due to their applications in quantum computation. One of the most effective techniques for characterizing these materials and studying their physical properties is High Angle Annular Dark Field imaging in a Scanning Transmission Electron Microscope (HAADF-STEM). This technique allows researchers to study the crystallography of the material and determine its composition and the presence of defects.

A commonly used methodology for studying these materials involves calculating the Fast Fourier Transform (FFT) spectrum from various regions of interest in the device. These spectra provide information about the crystal phase and orientation of the region. By applying a mask to different frequencies, researchers can visualize the different crystallographic planes and possible defects in the material. However, FFT spectra often have noise that can impede the study of these materials.

To address this issue, in this work, we used a Convolutional Neural Network (CNN) to denoise FFT spectra. The CNN was trained on over 5000 simulated spectra from various materials, typically used in quantum devices, and in different orientations. Denoising the FFTs facilitated a more thorough study of these spectra, allowing us to conduct a comprehensive study of these Ge devices. Furthermore, this CNN model may become a key and common step in the analytical workflow towards cleaner microscopy data analysing quantum devices and beyond.

Figures

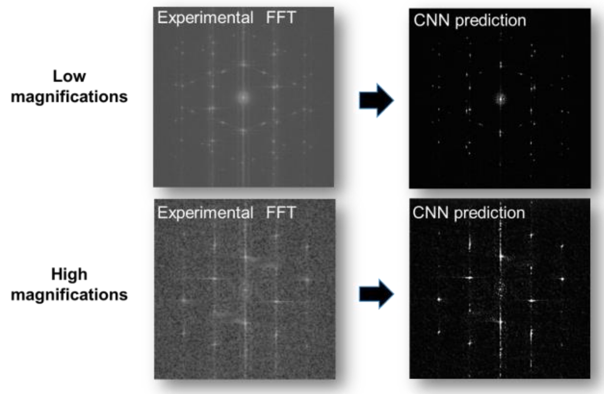

Figure 1: CNN results of the FFT denoising applied to low and high magnification spectra.