Processing very large pixelated STEM datasets: challenges and solutions

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Recent advances in electron counting devices have enabled the development of fast pixelated electron detectors, which are able to acquire two dimensional images at over 1000 frames per second (fps). Coupled with a large improvement in the signal-to-noise ratio over conventional scintillator-CCD devices, these new detectors allow for rapid acquisition of transmission electron microscopy (TEM) data with a greater potential to minimize the electron dose. One application of particular interest is pixelated scanning TEM (STEM), where a diffraction pattern (Fig. 1a) is acquired for each point of a STEM scan, resulting in a 4-D dataset with two spatial dimensions and two reciprocal space dimensions. While this enables many new and exciting experiments, it also introduces several challenges. Two of these are: i) very large datasets, typically in excess of 8 GB; and ii) online sample interpretation requires real-time data processing and the high data bandwidth (easily exceeding 160 MB/s) makes live imaging difficult.

This presentation will outline solutions to these issues, covering both the general concepts and specific software implementations developed at the University of Glasgow for working with pixelated detectors:

- Live and near-live imaging even at 1000 fps (Fig. 1b);
- Use of 1-bit detector mode for ADF and DPC imaging (Fig. 1c), allowing for acquisition at 5000 fps (200 us);
- Imaging of magnetisation using Differential Phase Contrast (DPC) STEM;
- Radial integration of intensity to produce line plots for quantitative analysis and further use, e.g. for ADF or Laue zone imaging;
- Post processing relying on the lazy loading implementation in HyperSpy, which allows for out-of-core processing of datasets much larger than the available computer memory. This is enabled by storing the data in the HDF5 file format which, through data chunking, allows for efficient loading of small portions of the data;
- The open source software packages fpd and fpd_data_processing, developed at University of Glasgow for doing the aforementioned processing.

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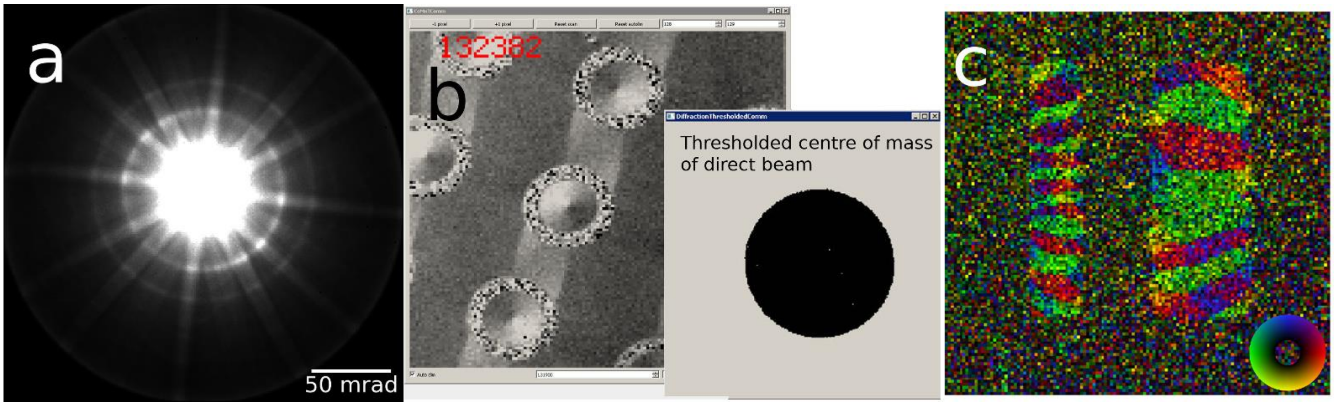

Fig. 1: a) STEM diffraction pattern of a perovskite oxide. b) Live DPC imaging of ferromagnetic domains using the fpd_live_imaging software package. c) DPC imaging of ferromagnetic domains using 1-bit detector depth, allowing for 80 us frame time.