Multi-Dimensional Data Restoration from Subsampled EBSD Data

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Background incl. aims
Electron backscatter diffraction (EBSD) is a popular technique for the identification of sample morphology, providing information about the crystal orientation and grain boundaries present [1]. Although detector technology has significantly improved, analysis times can be long, on the order of hours, depending on sample type and size. Additionally, long dwell times are often needed to enable sufficient signal to be collected, making the technique unviable for beam sensitive samples.

Recently, compressive sensing techniques have been applied to electron microscopy, wherein low-dose and fast acquisition methods are enabled through the use of subsampling. To date, subsampling has been successfully applied in STEM and FIB-SEM [2-4].

EBSD datasets are 4-dimensional (4-D), meaning multiple applications of subsampling and reconstruction are possible. Demonstrated here is the application of probe subsampling in EBSD datasets. For reconstruction 2-D, 3-D and 4-D data volumes were investigated.

Methods
A low noise Ni-superalloy dataset consisting of 416 x 512 probe locations was used, with a mask applied to simulate 25% subsampling. The reconstruction methods investigated used 2-D, 3-D and 4-D data volumes to reconstruct the full dataset.

Probe location maps are formed by taking each pixel from the full set of EBSD patterns at a single probe location, forming an image similar to a pattern quality map. 2-D reconstruction consists of inpainting the probe positions on an image by image basis. In 3-D reconstruction the dataset is vectorised. In 4-D reconstruction the data is inpainted in the position it was acquired in.

Results

The results of inpainting the 2-D and 3-D data volumes are shown in Figure 1 (Reconstruction quality of 25% sampled EBSD datasets using 2-D or 3-D data volumes for inpainting).

For 2-D inpainting a minor decrease in hit rate is observed, dropping from 99.80% to 99.53%. The band contrast map is less defined at grain boundaries than in the fully sampled dataset and an overall smoother map being output with the surface texture being lost.

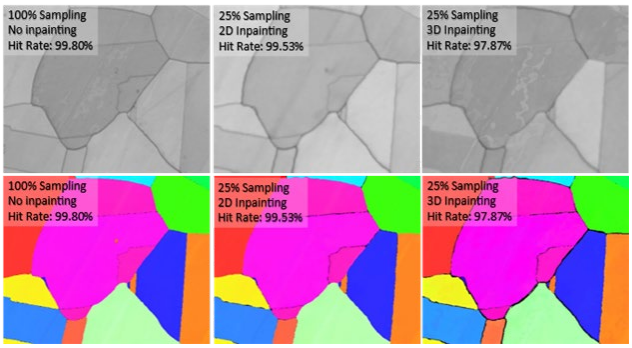
For 3-D inpainting the hit rate drops to 97.87%. This is evident in the IPF Z map, where significant zero solution pixels can be seen around the grain boundaries. By using a 3-D data volume for inpainting there is a greater overlap of EBSD patterns between grains which results in a less distinct EBSD pattern being inpainted. Despite this, the band contrast map is slightly sharper than the 2-D reconstruction, although some grain boundaries are no longer evident.

Although 4-D reconstruction shows promising results on a heavily cropped dataset (8x10 pixels), the memory currently required for this method limits its applicability. Due to this cropping, the datasets cannot be indexed in AZtec and hit rate is not recorded. Further work looking into optimising the datasets and inpainting parameters may help to improve this.

Conclusion

Pre-indexing reconstruction has been demonstrated. 2-D reconstruction is thus far the most effective method, with 3-D reconstruction through probe positions providing valid but slightly lower quality reconstructed patterns. Although the output quality of 4-D reconstruction is good it is currently unfeasible given the memory requirements.

Graphic:



Keywords:

EBSD, SEM, compressive sensing

Reference:

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