1. Introduction

The EFTEM Spectrum Imaging package allows you to collect spectrum images one plane at a time from a microscope equipped with an imaging filter. This quick reference summarizes the capabilities of version 1.0 of the software.

2. Acquisition

When you have tuned your imaging filter and have a sample in place you can acquire an EFTEM spectrum image.

To collect a spectrum image

1. Choose Setup on the EFTEMSI menu.

   Enter the CCD binning, integration time and energy range to sample. The energy range can be specified either by entering starting and finishing energies or by entering a starting energy, the number of planes, and a step size. The data can be acquired from high energy-loss to low energy-loss if desired by specifying a negative step size and a finishing energy numerically less than the starting energy.

2. Choose Acquire on the EFTEMSI menu.

   Two images appear. The leftmost is the spectrum image, the rightmost is the current plane being acquired. Acquisition will continue until all planes have been collected at which point the “current plane” will disappear and a beep will sound.

3. Artifact Correction

The EFTEM spectrum image will most likely suffer from x-ray hits and a drift of the sample during the acquisition. The x-ray hits will appear as occasional extreme values in the image planes of the spectrum image. If the sample drifted during the experiment then the image planes will not line up with each other and spectra drawn from the spectrum image will contain artifacts. The software can help you to reduce or eliminate these problems.

3.1. Removing x-rays

To remove x-rays hits from a spectrum image

1. Choose Remove x-rays from the Artifact correction submenu.

   The software will check each image plane of the spectrum image for spikes that lie more than 10 standard deviations above the the local median.

   The number of standard deviations required before a pixel is considered to be anomalous, and the maximum number of x-rays to remove can be set by the user. To override the default values choose the Remove x-rays menu item while pressing the Alt/Option key. Enter new values in the dialog and click OK.
3.2. Spatial Drift Correction

Thermal effects in the microscope cause the sample to drift under the electron beam. Since the acquisition of a spectrum image can take a considerable period of time, this drift can cause the planes of the spectrum image to be offset from on another. The offset of the last plane from the first could amount to tens of pixels depending on the magnification, exposure time and specimen.

The EFTEM Spectrum Imaging software allows you to measure this drift and re-align the energy planes after acquisition. The first step is to measure the spatial drift. Then you may have to edit the drifts if it there is a clearly erroneous estimate. Finally you re-align the image planes using the measured drifts.

**To measure the spatial drift**

1. **Choose** Measure spatial drift **from the Artifact correction submenu.**
   You will be prompted for the reference plane to use in the correction process.

2. **Enter your preferred reference plane and hit OK.**
   The drift measurement begins. Each plane is compared to the reference plane to determine its \(x\) and \(y\) offset. This data is entered in the drift map (the leftmost plot) where you will see two lines develop. The solid-filled line is the \(x\) drift, the other line is that for \(y\). The rightmost plot shows the cross-correlation between each plane and the reference plane.

If there is an entry in the drift map that differs considerably from its neighbors then it is likely to be incorrect. This may happen if the sample has extreme contrast changes from one plane to the next in the energy range of the experiment. In this case you should edit the drift map to remove the anomalous entry before applying it to the original spectrum image.

**To edit an anomalous drift value**

1. **Select the offending channel on the drift map using the pointer tool.**
   If there are more than one incorrect adjacent channels then select them all.

2. **Choose** Interpolate over anomaly **from the Artifact correction submenu.**
   The selected entries will be re-calculated based on a linear interpolation between their two neighboring channels.

If the drift map contains several entries that are anomalous then you may want to re-calculate the map based on a sub-region of the spectrum image. You can make a rectangular selection on the spectrum image and choose Measure spatial drift to determine the drift based on just this region. The region sides must be a power of two in size (press the Alt/Opt key as you make the selection).

Alternatively, you may want to just smooth the drift map using one of the two median filters provided by the software. This can be highly effective if there are one or two anomalous drifts that are not adjacent in the drift map.
To filter the drift map

1. Choose Light/Heavy median filter from the Artifact correction submenu. The drift map will be smoothed as required.

To apply the measured drift map to the spectrum image

2. Choose Remove measured drift from the Artifact correction submenu. You will be prompted to choose the correct spectrum image and drift map. Each plane of the spectrum image will be offset by the measured drift and placed in a new spectrum image. This new spectrum image will not be the same size as the original. It will be trimmed to the size of the common sub-area of all image planes in the old spectrum image.

4. General Utilities

The EFTEM Spectrum Imaging package includes some utilities or working with spectrum image data. On the Volume manipulation menu are a number of items that allow you to delete or extract data from a spectrum image, or insert data into a spectrum image. On the Miscellaneous menu the View planes as movie item allows you to scan through the data at a constant rate. This can provide a useful quick overview of the data.

4.1. Volume Manipulation

The volume manipulation routines are all similar so we will demonstrate just two here.

To extract a sub-volume from a spectrum image

1. Choose Extract volume from the Volume manipulation submenu. You are prompted to enter the $x$, $y$, and $z$ ranges of data to extract from the frontmost spectrum image.

2. Enter a set of inclusive limits and hit OK. A new spectrum image appears containing the extracted sub-volume.

To insert a new first plane into a spectrum image

1. Choose Insert plane before from the Volume manipulation submenu. Select an image to insert on the popup menu in the dialog.

2. Hit OK. Enter the number of the plane before which to insert the new image. Enter 0 to insert a new first plane.

3. Hit OK. A new spectrum image is created having one more plane than the original. The first plane is the image you selected.
4.2. Viewing planes as a movie

If you want a quick overview of the data then you can use the slice tool or you can have the data played one plane at a time as if it were a movie.

To view the spectrum image planes as a movie

1. **Choose** View planes as movie from the Miscellaneous submenu.
   
   You are prompted to enter the delay between each plane.

2. **Hit OK.**
   
   The planes will be displayed one by one with a delay between each. You can pause the sequence by pressing the Control key at any time. If a selection exists on the spectrum image then its contents will be used to set the contrast limits for that plane. In this way you can easily focus your attention on a sub-region of the spectrum image.