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HREM-Filters Pro/Lite
User's Guide

DigitalMicrograph Plugin
for
Image Filter Functions

Pro: Commercial Software
Lite: Free Software

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1. Introduction

HREM-Filters Pro/Lite is a plug-in for use in Gatan's DigitalMicrograph for Windows v.3.8 or later. However, we will recommend you to use the latest version.

This HREM-Filters Pro/Lite User's Guide is written to provide information on the basic functions of the HREM-Filters Pro/Lite software, a procedure for installation of the Plug-In, some general tips on operation. This Guide assumes the user is familiar with image manipulation using DigitalMicrograph as well as Windows operating system.

Note: HREM-Filters Lite is free software, so anyone can use this software without a license. However, HREM Research Inc. does not renounce a copyright of this software.

Technical Support

General enquiries on the HREM-Filters should be sent to:

HREM Research Inc.
Email: support@hremresearch.com
Web: www. hremresearch.com

Copyright Statements

2. Installation

This chapter describes hardware and software requirements to run the HREM-Filters Pro/Lite plug-in and an installation procedure of the plug-in.

2.1 Requirements

The HREM-Filters Pro/Lite plug-in runs under DigitalMicrograph environment, and the software and hardware requirements are similar to those for DigitalMicrograph itself.

2.1.1 Hardware requirement

The HREM-Filters Pro is commercial software and thus requires a license key (a USB dongle), while the HREM-Filters Lite is free software and thus requires no license key.

2.1.2 Software requirement

The following is a list of the software requirements necessary to run the HREM-Filters Pro/Lite plug-in:

- **DigitalMicrograph for Windows**.
- **USB Key Driver (only required for HREM-Filters Pro)**

2.2 Software Installation

The following modules should be installed. Please consult the ReadMe file for installation. The following modules should be placed in the folder “PlugIns” on the same level of the DigitalMicrograph.

- **HREM-Filters Pro or HREM-Filters Lite Plug-in (.gtk and .dll)**
- **HREM Mouse Tool Plug-in (Free-ware available at www.hremresearch.com)**
- **IPU Plug-in (only required for HREM-Filters Pro; Free-ware available at www.hremresearch.com)**
- **USB Key Driver (only required for HREM-Filters Pro)**

Note: The PlugIns folder should exist under a normal installation of the DigitalMicrograph.

Installing HREM-Filters Pro or HREM-Filters Lite Plug-in
HREM-Filters Pro or HREM-Filters Lite (.gtk and .dll) can be installed by drag-and-drop copy to the folder “PlugIns” on the same level of the DigitalMicrograph.

Installing HREM Mouse Tool Plug-in
This is a free plug-in. Please download the plug-in from the Scripts/Plugins page and install it according to the ReadMe file.

Installing IPU Plug-in
This is a free plug-in. Please download the plug-in from the Scripts/Plugins page and install it according to the ReadMe file. This plug-in is required by HREM-Filters Pro in order to extend Fourier transform capability. However, anyone can use the IPU Plug-in to calculate Fourier transform of an arbitrary sized image.

When the DigitalMicrograph is launched after placing the plug-ins the PlugIns folder, HREM-Filters Pro/Lite menu (Filters) commands will be appeared under “Filters” menu and the Mouse tool will be appeared as an addition to the standard tools.

Installing Key Driver
The user key driver should be installed by following the instructions given by the key driver installer (**only required for HREM-Filters Pro**). The key driver installer comes with HREM Filters Pro, or you can find it on our web site.

3. Getting Started…

Using the HREM-Filters Pro/Lite is very simple. All the operations are menu driven, and process the front *active* image. This chapter briefly explains each command.

3.0 Essentials

3.0.1 Noise model

The noise model is very important to extract a signal from a noisy image. Thus, HREM-Filters Pro supports two noise models: Amorphous noise and Random noise. Here, the amorphous noise means the noise from non-periodic substrate (amorphous material), while the random noise corresponds to white noise or statistical noise (Poisson noise).

The amorphous model will use a smoothed background in Fourier space, and be applicable for the most of the cases. However, the random model will be useful for an ADF STEM image or an elemental map, where the statistical noise is significant.

How amorphous noise model works

The background of the filter for the amorphous noise model is estimated as a lower-bound of the image spectrum. During the filter operation only the spectrum that is higher than the background is contribute the filtered image. Thus, the amorphous noise model will effectively extract a periodic structure.

However, non-periodic structures, such as a grain boundary or defect(s), will contribute to the image spectrum in the similar way that amorphous material contribute to the image background. Thus, such non-periodic structure will be washed out using the amorphous noise model.

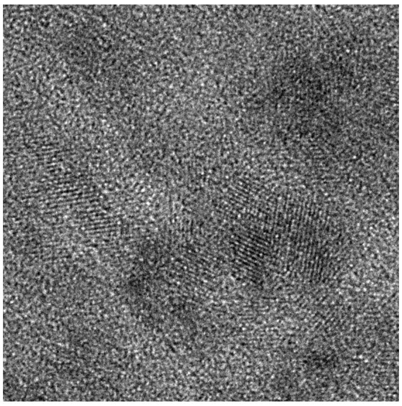
How random noise model works

The filter based on the random noise model adopts an iterative procedure, where the low-frequency information is protected by Gaussian low-pass filter, and the rest of information is passed to the Wiener/Difference filter. Then, the noise in higher frequency component will be progressively removed, while keeping the low frequency components as much as possible.

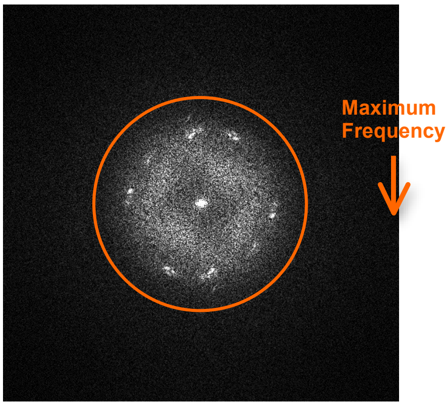
Therefore, the filter based on the random noise will keep non-periodic structures more than the filter based on the amorphous model.

3.0.2 Information Limit

The concept of Information Limit is important to filter-out the noise in keeping signal information in the image. Here, we assume that all the signal information exist only within the Information Limit as shown in the example below:

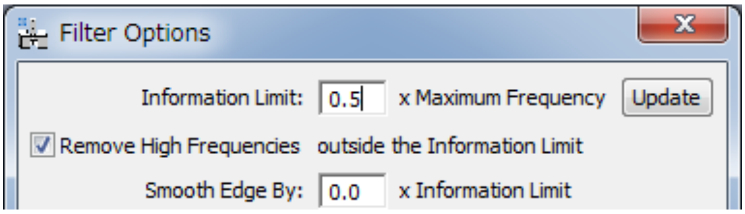


TiO2 nano-particles



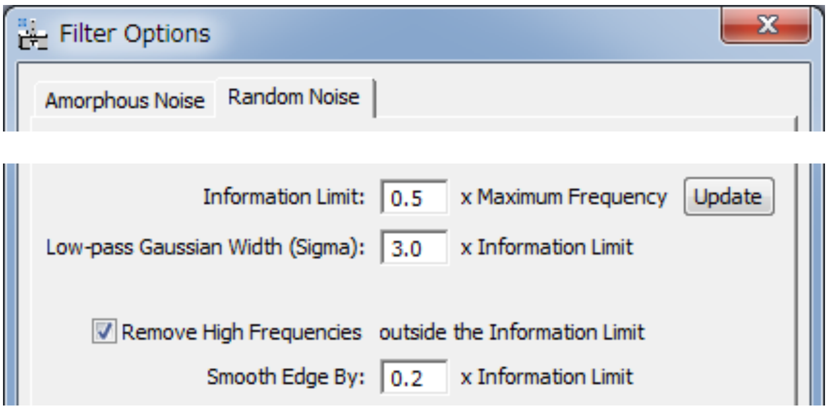
Fourier transform

We define the Information Limit in terms of the Maximum Frequency of the Fourier transform as shown below. If you want, you can remove high frequencies outside the Information Limit, which should correspond to noise.

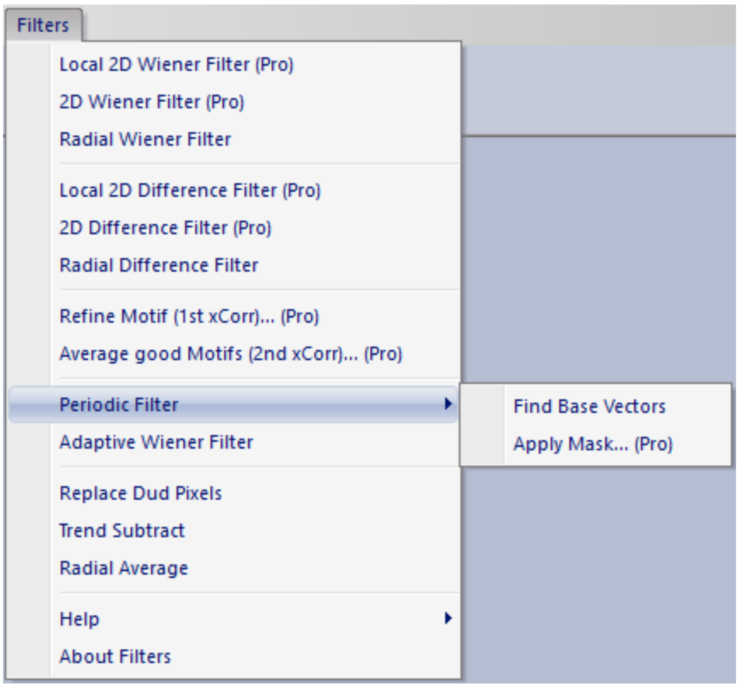


The default value of the Information Limit is 0.5. If the circle is too small or too large, you can adjust the radius of the circle by changing the value of the Information Limit. It is advisable to check the Information Limit by clicking “Update” button.

The Information Limit is indispensable for the Random Noise model, since the Low-pass Gaussian width is defined in terms of the Information Limit.



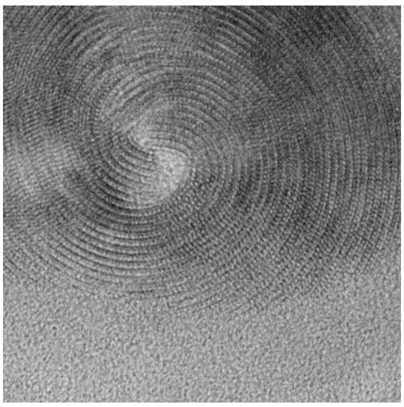
3.1 HREM-Filters



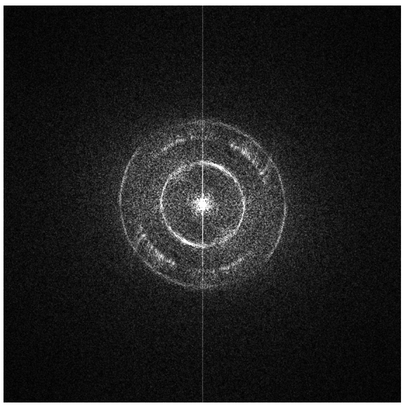
Filters Pro/Lite Menu.

Local 2D Wiener, 2D Wiener, Local 2D Difference and 2D Difference Filters and Apply Mask… are available only for HREM-Filters *Pro*. Other commands use the same routine for both *Pro* and *Lite* versions.

We will use the following image of crysotile, a clay minerals, taken by Prof. Kogure, Univ. of Tokyo. This is not an ideal crystal showing a simple translational symmetry, and thus clearly shows a power of Filters Pro.



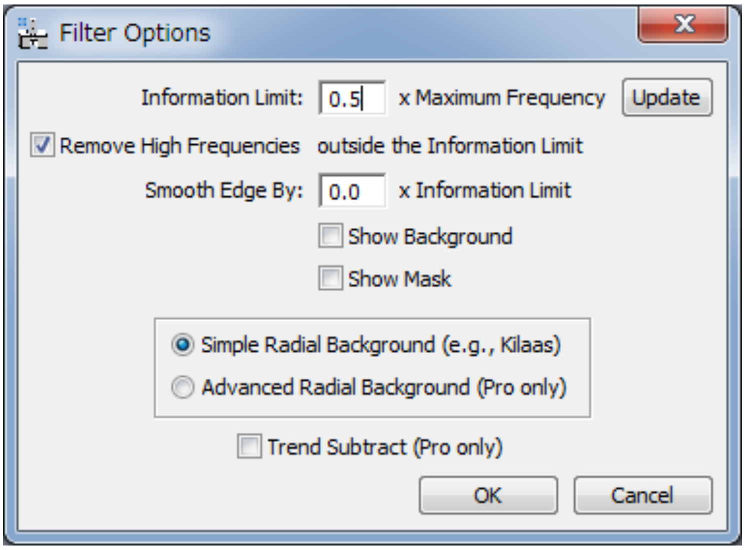
Original Image (crysotile)



Fourier transform

3.1.1 Radial Wiener/Difference Filter

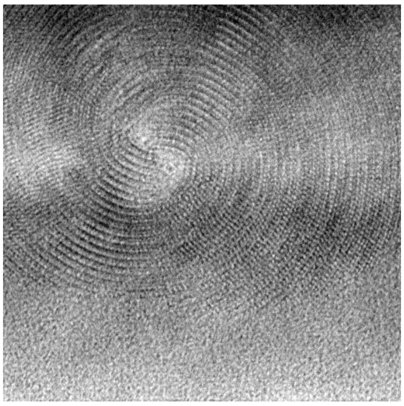
A background in Filter is estimated by radial average of Fourier transform of the whole area.



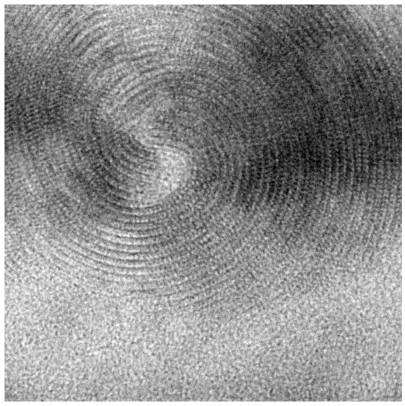
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.

Remove High Frequencies outside the Information Limit

Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Show Background:	If checked, the background of the Wiener filter will be displayed.
Show Mask:	If checked, the Wiener/Difference filter mask will be displayed.
Radial Background type:	The choice of the type of Radial Background. *Lite* can use *Simple Radial Background* obtained by rotational average of the intensity (e.g., Kilaas). *Advanced Radial Background* that is available for *Pro* only is a smooth version of the Simple Radial Background. Usually, this background is *far superior* to the Simple Radial Background.
Trend Subtract (Pro Only):	If checked, the trend of the original image is subtracted before Wiener filtering, and put back afterward.



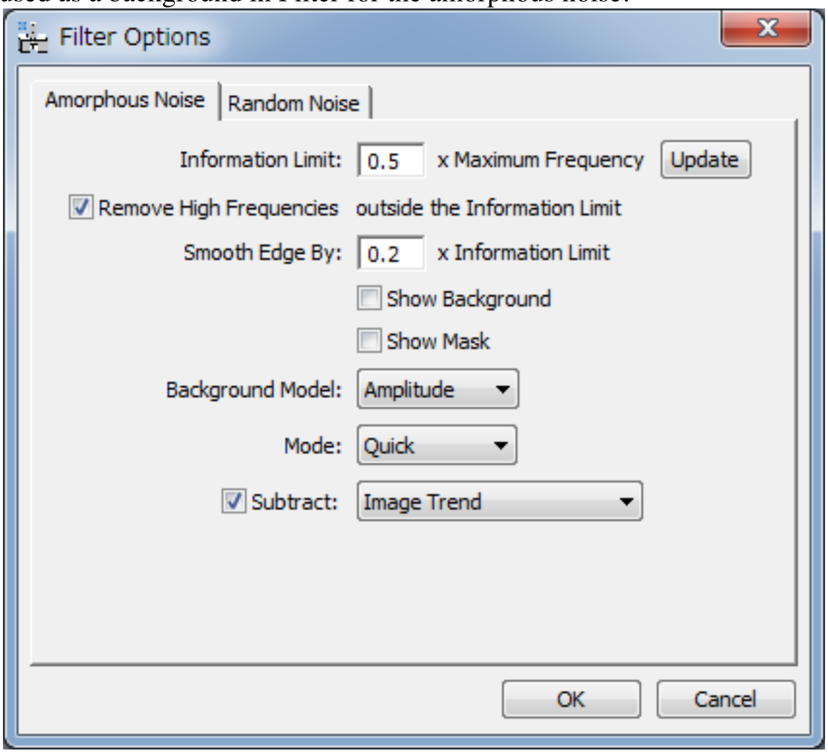
Radial Wiener filtered image



Residual of the original image

3.1.2 2D Wiener/Difference Filter (Pro Only)

A smoothed two-dimensional trend of Fourier transform of the whole area is used as a background in Filter for the amorphous noise.



Information Limit: The Information Limit given by a fraction of the Maximum Frequency of the image.
By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.

Remove High Frequencies outside the Information Limit

Smooth Edge By: If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge)

Show Background: If checked, the background of the Wiener/Difference filter will be displayed.

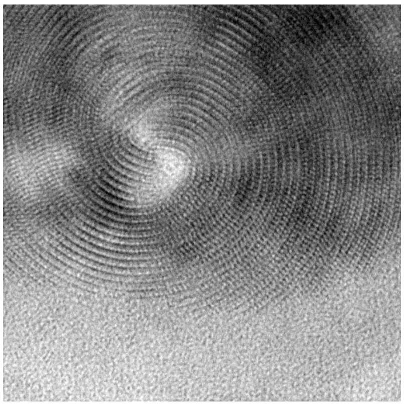
Show Mask: If checked, the Wiener filter mask will be displayed.

Background Model: The background of the filter will be estimated from the amplitude or the intensity.

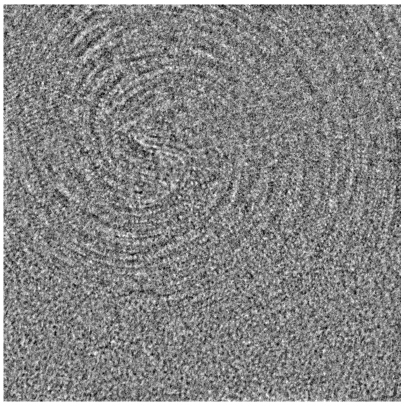
Mode: The choice of the 2D background estimation scheme from *Quick* and *Elaborate*.

Subtract: Image trend/Gaussian blurred image

If checked, the image trend or Gaussian blur of the original image is subtracted before Wiener/ Difference filtering, and put back afterward.



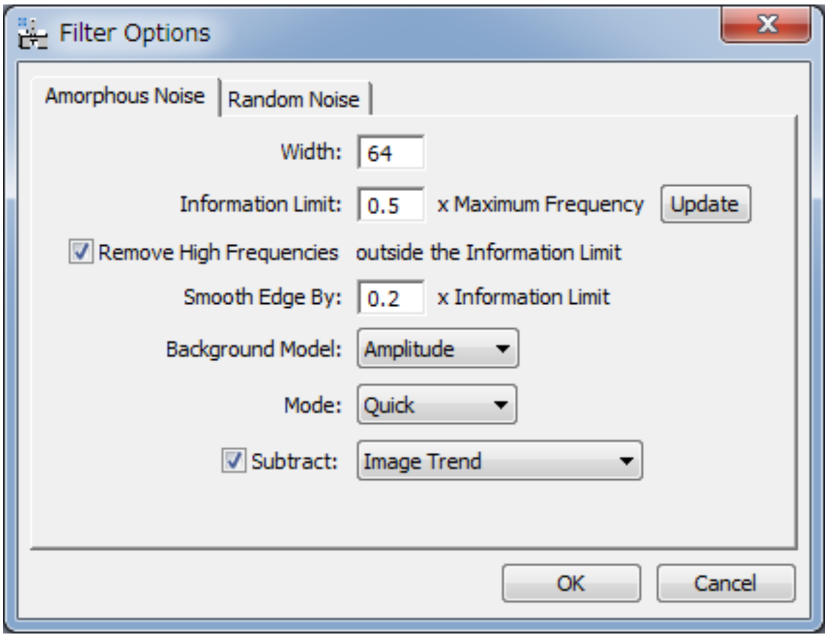
2D Wiener filtered image



Residual of the original image

3.1.3 Local 2D Wiener/Difference Filter (Pro Only)

A background in Filter is locally estimated by smoothed two-dimensional trends of Fourier transform of finite areas. The size of the area is controlled by the **Width** parameter below.



Width: Size of the local square area.

Information Limit: The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.

Remove High Frequencies outside the Information Limit

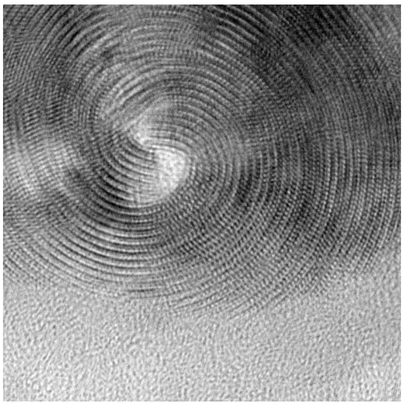
Smooth Edge By: If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).

Background Model: The background of the filter will be estimated from the amplitude or the intensity.

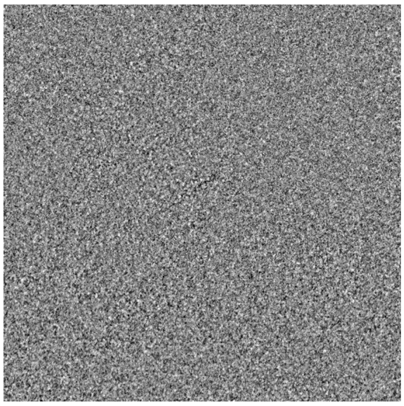
Mode: The choice of the 2D background estimation scheme from *Quick* and *Elaborate*.

Subtract: Image trend/Gaussian blurred image

If checked, the image trend or Gaussian blur of the original image is subtracted before Wiener/ Difference filtering, and put back afterward.



Local 2D Wiener filtered image



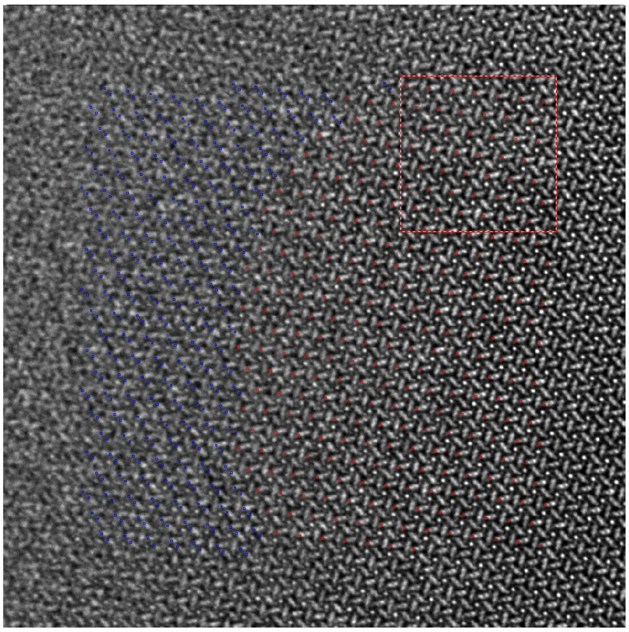
Residual of the original image

3.2 Motif Average

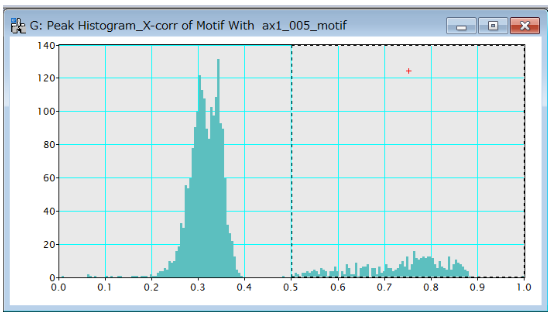
Motif averaging is a real space technique to obtain a noise-filtered image from an image of periodic structure. Here, we call a small region "motif," for which we search similar regions of the same size over the whole image. Then, we will take an average over the regions with high similarities. Usually, the similarity is measured by cross-correlation of the image and the motif.

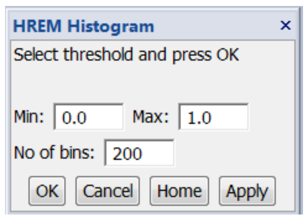
3.2.1 Refine Motif (First cross-correlation)

At first assign the original motif using a Rectangle ROI as shown below:



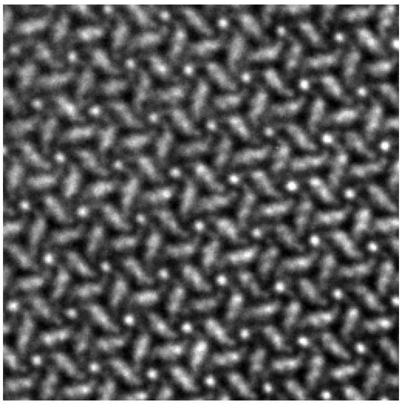
Next, launch the "Refine Motif" command. Then, the histogram of cross-correlation of the whole image and the motif will appear.



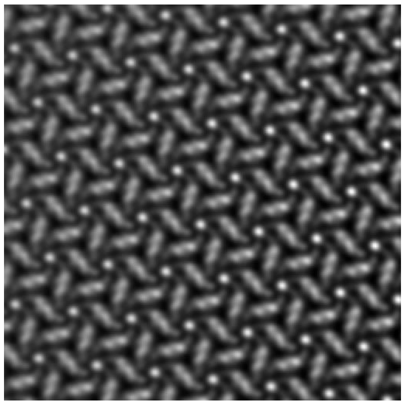


You can change the minimum and maximum values, and the number of bins to be displayed in the HREM Histogram palette. The found peaks are displayed in blue, and the peaks above the threshold in red. The peak threshold can be changed by adjusting the left range of the range ROI.

When you satisfy the thresold setiting, press "OK" in the HREM Histogram palette. Then, the original motif and the refined motif averaged over the selected patches will be displayed as shown below:



Original motie



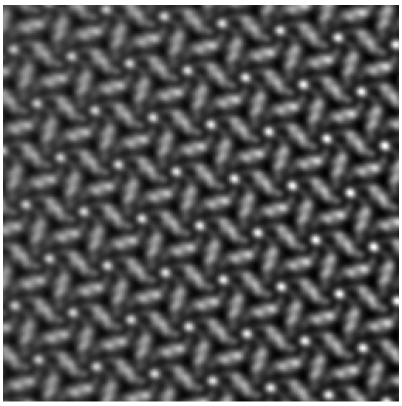
Refined motif

3.2.2 Average good Motifs (Second cross-correlation)

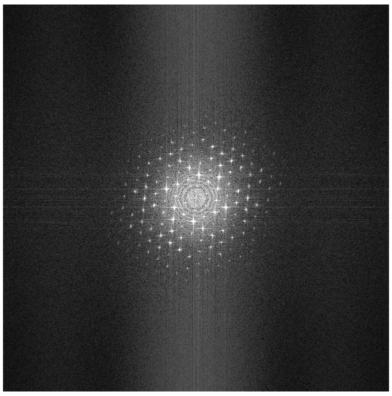
This is the second step of “Motif Averaging,” where the cross-correlation of the whole image with the refined motif is calculated, and an averaged image over the good motifs will be finally obtained.

To obtain the averaged image, launch “Average good Motifs” command when the “Refine Motif” is a front image. Then, the similar histogram and HREM Histogram pallet will appear. Adjust the threshold by watching the peak color, blue or red, over the whole image. If needed, you can change the minimum and maximum values, and the number of bins in the HREM Histogram palette.

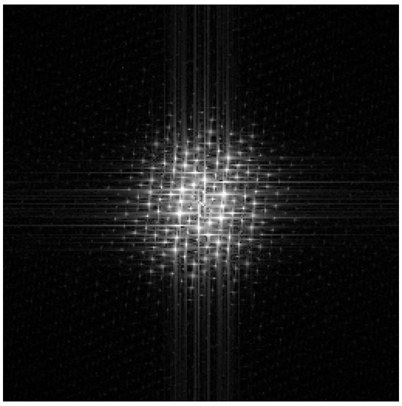
When you satisfy the thresold setiting, press “OK” in the HREM Histogram palette. Then, the averaged image over the good motifs will be displayed as shown below:



The Fourier transforms below shows obtained from the whole original image and the averaged image over the good motifs, respectively. Here, you can see the averaged motif keeps all the periodic information of the original image, and further shows a bit finer details, which cannot be detected by eyes.



FT of the whole image



FT of the motif averaged image

3.3 Other Filters

3.3.1 Periodic Filter

DigitalMicrograph has a set of mask tools for Fourier filtering. However, it is not easy to set up a set of base vectors using a Periodic Mask tool for a Periodic Filter. The commands under this menu will work the Periodic Mask tool of DigitalMicrograph.

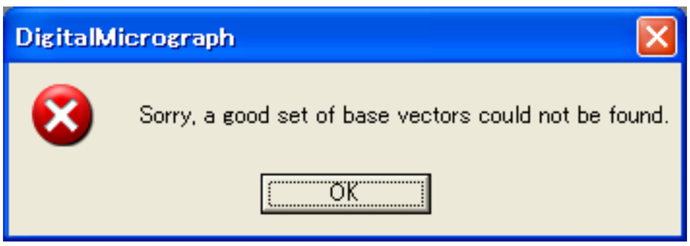
How to use “Periodic Filter”:

1. Specify any lattice points on the base vector directions by using the Periodic Mask tool.
2. Choose “Find Base Vectors” command when the masked image is at the front.
3. Adjust a mask size using the Periodic Mask tool.
4. Apply a mask using “Apply Mask…” command under the Process menu or Periodic Filter menu.

3.3.1.1 Find Base Vectors (Using Periodic Mask tool)

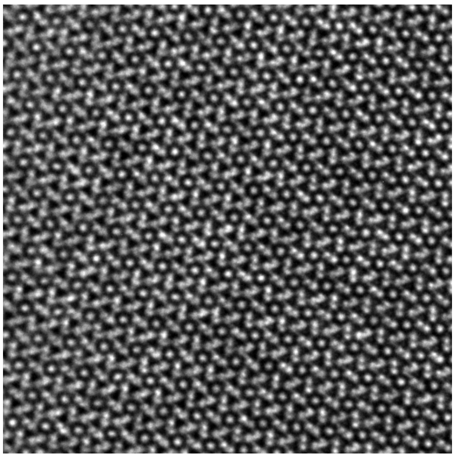
This command will find a precise base vectors for a Periodic Filter.

1. Put the arrowheads of the Periodic Mask tool ay any lattice points on the *directions* of two base vectors.
2. (Optional) Put a Point ROI on one spot. The spots on the lines passing thought the Point ROI will help to find the base vectors.
3. Choose this command when the masked image is at the front, then true base vectors along the specified direction will be estimated precisely based on a least-square technique. Please note that user has to specify a set of correct directions to cover all the lattice points.
4. Make sure the base vectors are correct. If the command fails to find the correct base vectors, you will get a following message:

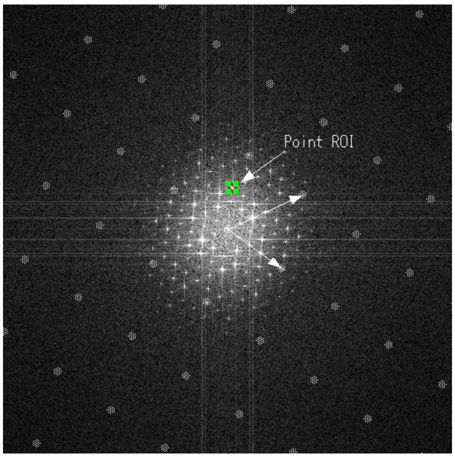
   

   Then, you may want to try other set of lattice points using the Periodic Mask tool. Before trying another lattice points, you may also want to try with the Option (Step 2) using the same lattice points.
5. Adjust a mask size using the Periodic Mask tool.

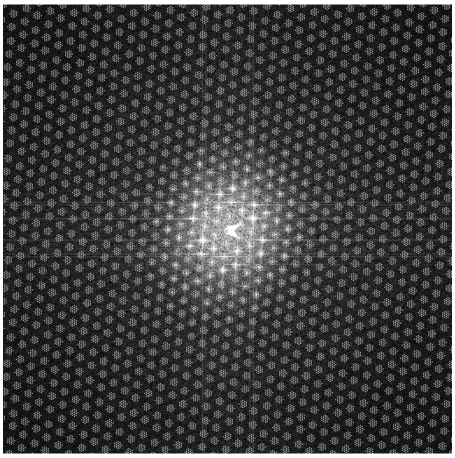
When an image size is large, Filters Lite will take some time to get a result compared with Filters Pro.



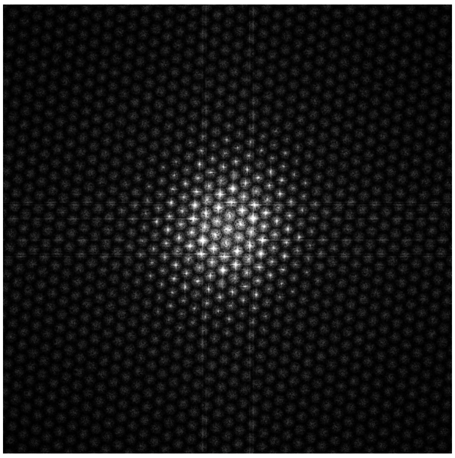
Original image (512x512) (Si3N4: Courtesy of C. Kisielowski)



Two lattice points on the base vector directions selected by using the Periodic Mask tool. Note an optional Point ROI.

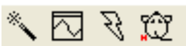


Base vectors and lattice positions estimated by using this command.



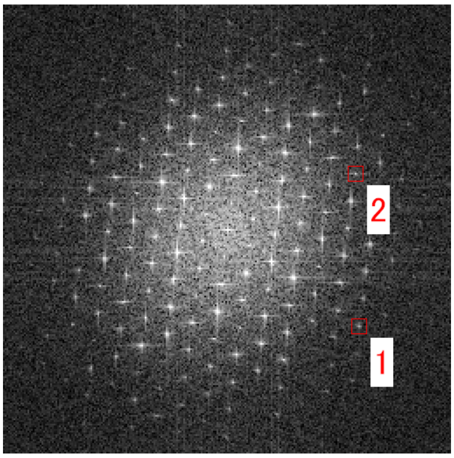
Mask applied by using the Apply Mask command of the Process menu.

3.3.1.2 Find Base Vectors (Using Mouse tool)

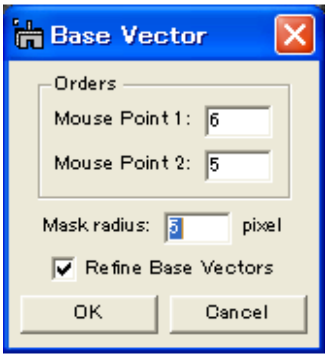


This command will find a precise base vectors for Periodic Filtering using the Mouse tool.

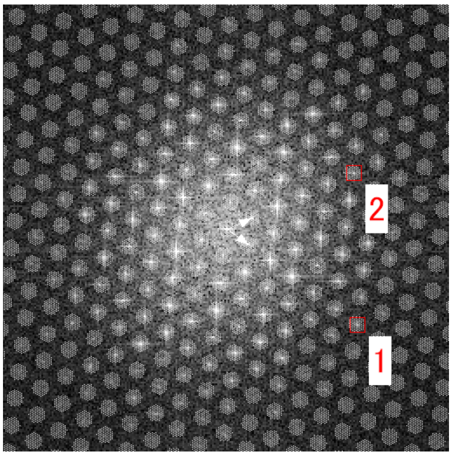
1. Select any lattice points on two base vector directions by using the Mouse tool.



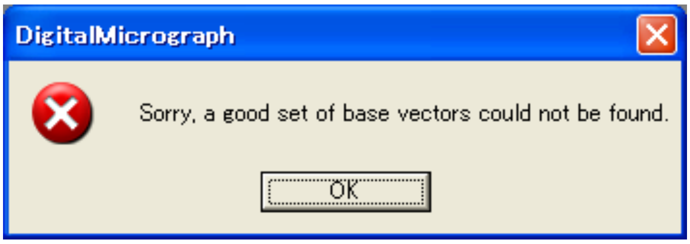
2. Choose this command when the masked image is at the front, then the following dialog will appear:



Here, you have to specify the order of the reflections specified by the Mouse tool. You can here specify the mask radius. If you check “Refine Base Vectors,” then true base vectors along the specified direction will be estimated precisely based on a least-square technique. Please note that user has to specify a set of correct directions to cover all the lattice points.



3. Make sure the base vectors are correct. If the command fails to find the correct base vectors,



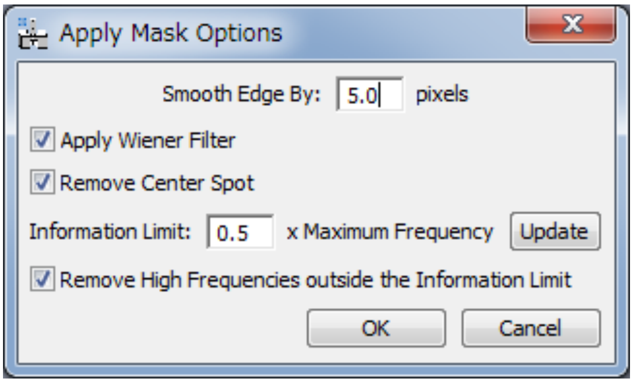
Then, you may want to try other set of lattice points using the Mouse tool.

4. Adjust a mask size using the Periodic Mask tool.

When an image size is large, Filters Lite will take some time to get a result compared with Filters Pro.

3.3.1.3 Apply Mask…(Pro Only)

This is an extended version of the command "Apply Mask…" under the Process menu of DigitalMicrograph. There are several options that will reduce random noise from the final filtered image.



Apply Wiener Filter: Amplitude of the spot is modified by a Wiener estimate

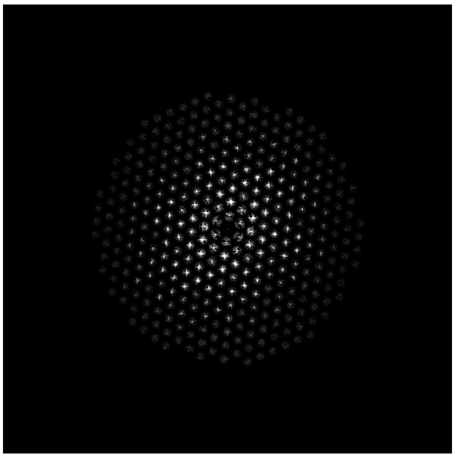
$$F \Rightarrow \frac{|F|^2 - |F_b|^2}{|F_b|^2} F$$

where F_b is average amplitude around each spot.

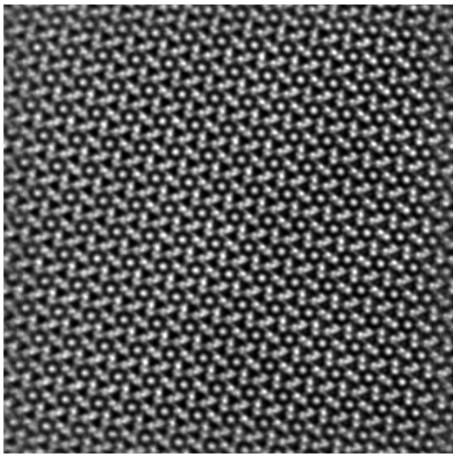
Remove Center Spot: Amplitude around the center spot is set to zero except the origin single point.

Information Limit: The Information Limit given by a fraction of the Maximum Frequency of the image.
By clicking this button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.

Remove High Frequencies outside the Information Limit
If checked, high frequencies outside the Information Limit will be removed.



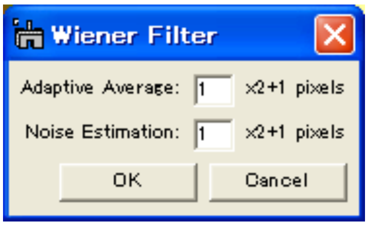
Mask applied by using the extended Apply Mask command.



Filtered image.

3.3.2 Adaptive Wiener Filter

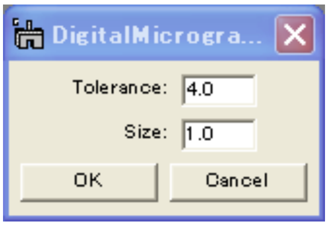
This command applies a linear filter (local average) to an image *adaptively* according to the local image variance. The sizes of a local average and local variance can be controlled by “Adaptive Average” and “Noise Estimation”, respectively. If the variance is large, the filter performs less smoothing, while the variance is small, the filter performs more smoothing.
The adaptive filter is more selective than a simple local average filter, preserving edges and other high-frequency parts of an image.



3.4 HREM-Filters Utilities

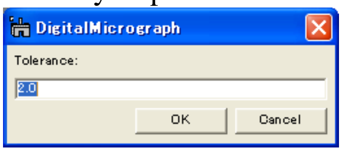
3.4.1 Replace Dud Pixels

This command will remove dud image points due to bad pixels of a CCD camera or due to uncontrollable x-ray or cosmic ray. The values of the dud pixels will be replaced by a local mean. This is an automatic version of **Zapper** tool of DigitalMicrograph's standard tools.



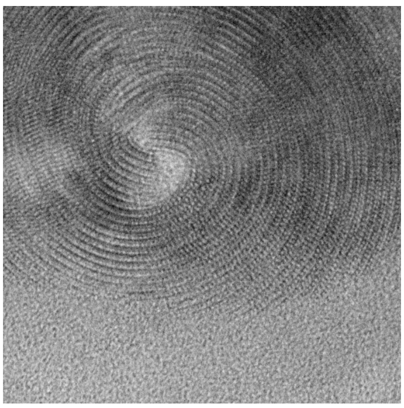
The size of a cluster of dud points can be controlled by the **Size** parameter. The **Tolerance** controls a degree of singularity in terms of a local standard deviation.   This will work ideally for small isolated clusters.

For a long connected dud image pixels, an area that includes the dud pixels may be indicated by a **ROI** tool manually. Then, the dud pixels will be replaced by a local mean, when a pixel differs from the local mean by a specified **tolerance** times the variance of the area.

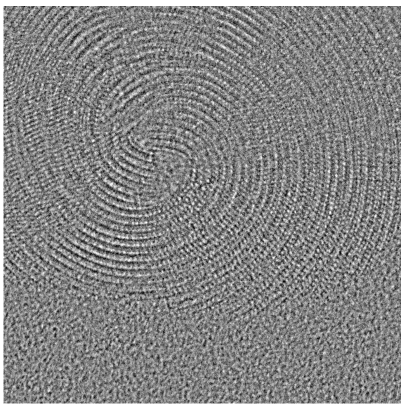


3.4.2 Trend Subtract

This command will remove a smoothed trend of an image, and makes a structural detail to be recognized more clearly. When an image size is large, Filters Lite will take some time to get a result compared with Filters Pro.



Original Image (crysotile)

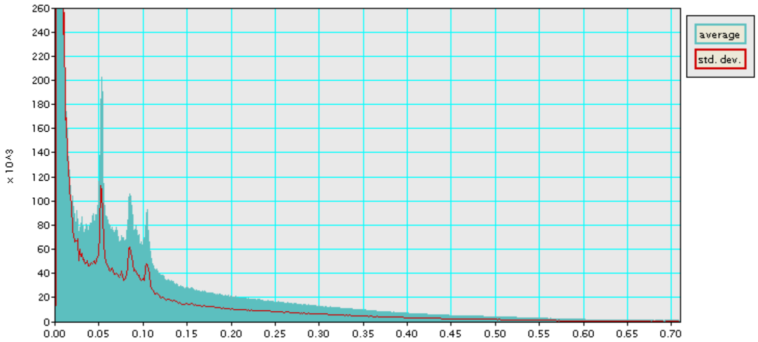


Trend Subtracted imag

3.4.3 Radial Average

This command will calculate an average profile over the pixels on the same radial distance from its image center. If the image is complex number such as a Fourier transform of an image, a modulus will be averaged.

This command will also calculate a standard deviation profile, although the profile is hidden by default. You can see the standard deviation profile by choosing “Show std. dev.” on a context menu that will appear by clicking a right mouse button on the “std. dev.” legend.



Radial average profile (Standard deviation profile is set to “show.”)

4. Filter Description

4.1 Fourier Transform

An observed signal F_o in Fourier transform may be written as a sum of a true signal F_c due to a crystal part and a background F_b due to a non-crystal part: $F_o = F_c + F_b$. If we assume the true signal and the background are mutually independent, then we may be able to write $|F_o|^2 \approx |F_c|^2 + |F_b|^2$.

4.2 Wiener Filter

The Wiener filter seeks a solution that minimizes the summed square difference between the true signal F_c and its estimate $\hat{F}_c$ resulting

$$\hat{F}_c = \frac{|F_c|^2}{|F_c|^2 + |F_b|^2} F_o \approx \frac{|F_o|^2 - |\hat{F}_b|^2}{|F_o|^2} F_o = \frac{|F_o|^2 - |\hat{F}_b|^2}{|F_o|} e^{i\phi_o},$$

where ϕ_o is the phase of the observed signal F_o and $\hat{F}_b$ the estimate of the background. Here, we assume F_c and F_b are independent.

If $|F_o| - |\hat{F}_b| \le 0$, $\hat{F}_c$ is set to zero.

4.3 Difference Filter

The Difference filter (the background subtraction filter) is simply given by

$$\hat{F}_c = \left(|F_o| - |\hat{F}_b|\right) e^{i\phi_o},$$

where ϕ_o is the phase of the observed signal F_o and $\hat{F}_b$ the estimate of the background. If $|F_o| - |\hat{F}_b| \le 0$, $\hat{F}_c$ is set to zero.

Reference: R. Kilaas, *J. Microscopy* 190 (1997) 45-51.

4.4 Background Estimation

In order to use either filter we have to estimate a background contribution $\hat{F}_b$. A radial average background has been commonly used. Here, we propose new backgrounds.

1. Radial Background
Normally, the background is estimated as a radial average of the Fourier transform of the whole image assuming that the contribution from amorphous (non-periodic) materials varies slowly.

Reference: L.D. Marks, Ultramicroscopy 62 (1996) 43-52; R. Kilaas, *J. Microscopy* 190 (1997) 45-51.

2. Two-Dimensional Background
A radial background will not work, when structure information appears at the same distance from the origin in Fourier space. Thus, we developed a novel approach based on P-spline fitting to estimate a smoothed two-dimensional background in Fourier space.

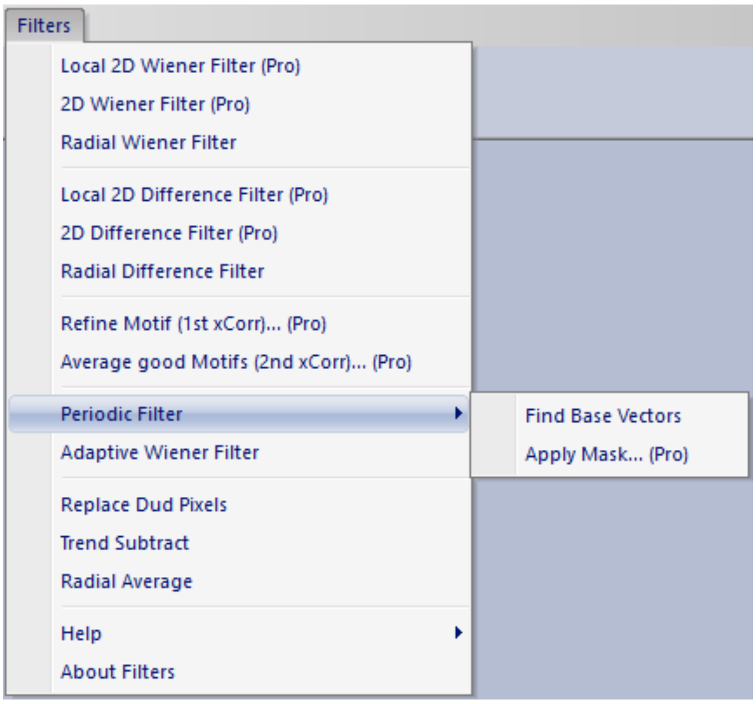
Reference: P.H.C. Eilers et al., *Computational Statistics and Data Analysis* 50 (2006) 61-76.

3. Local Two-Dimensional Background
When an orientation of periodic structure is different locally, the background estimated for the whole image is not adequate. Thus, a set of two-dimensional backgrounds in Fourier space is estimated by dividing an image into local small areas.

4. Periodic Mask Background
A periodic mask is frequently applied to a Fourier transform of a lattice image. We may be able to modify a simple periodic filter to a Wiener type filter, where a background is estimated for each diffraction spot from a surrounding area of each mask.

Quick Reference Guide

The HREM-Filters Main Menu



The commands in the HREM-Filters menu are described below.

Command	Description
Local 2D Wiener Filter	Calculates a Wiener filtered image using 2D local backgrounds
2D Wiener Filter	Calculates a Wiener filtered image using a 2D background
Radial Wiener Filter	Calculates a Wiener filtered image using a radial background
Local 2D Difference Filter	Calculates a Difference filtered image using 2D local backgrounds
2D Difference Filter	Calculates a Difference filtered image using a 2D background
Radial Difference Filter	Calculates a Difference filtered image using a radial background
Refine Motif	Calculates a cross-correlation of the whole image with the given motif, and give a refined motif for the next command.

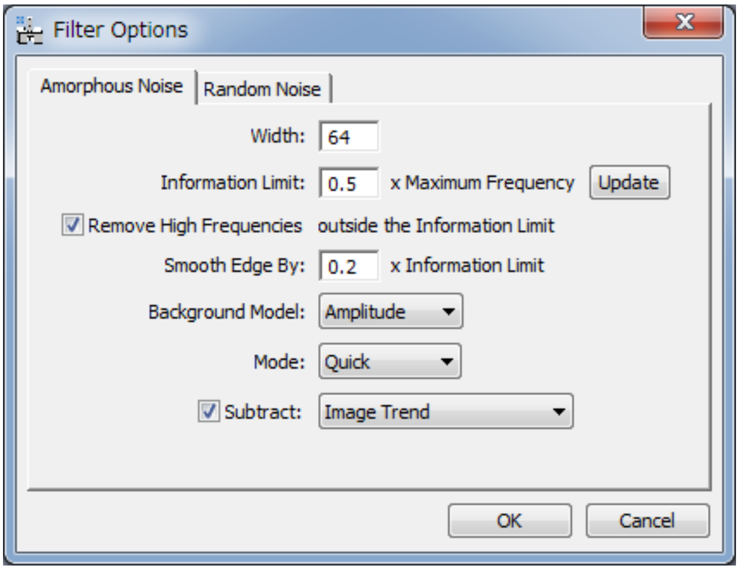
Average good Motifs	Calculates a cross-correlation of the whole image with the refined motif, and give an averaged image over he good motifs (image patches).
Periodic Filter (see sub menus)	Commands to assist/extend Periodic Filter Find Base Vectors Apply Mask
Adaptive Wiener Filter	Performs a linear filter (local average) adaptively according to the local image variance.
Replace Dud Pixels	Replaces dud pixels with a local average automatically according to the local image variance.
Trend Subtract	Subtracts an image trend (global background)
Radial Average	Calculates a radial average and std. deviation of a Fourier transform

Local 2D Wiener/Difference Filter Menu

Filter Options Dialog

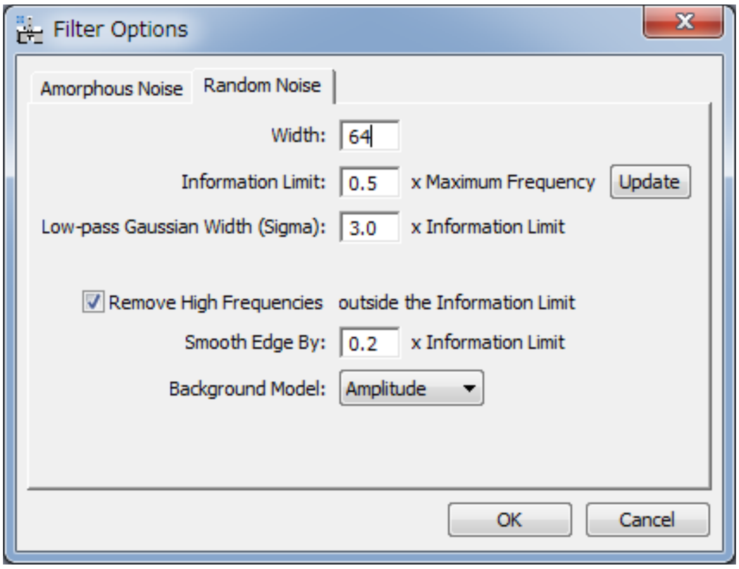
There are two noise model: Amorphous noise and Random noise.

Amorphous Noise Tab



Component	**Description**
Width:	Size of the local square area.
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Remove High Frequencies outside the Information Limit	
Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Background Model:	The background of the filter will be estimated from the amplitude or the intensity.
Mode:	The choice of the 2D background estimation scheme from *Quick* and *Elaborate*.
Subtract: Image trend/Gaussian blurred image	
	If checked, the image trend or Gaussian blur of the original image is subtracted before Wiener/ Difference filtering, and put back afterward.

Random Noise Tab



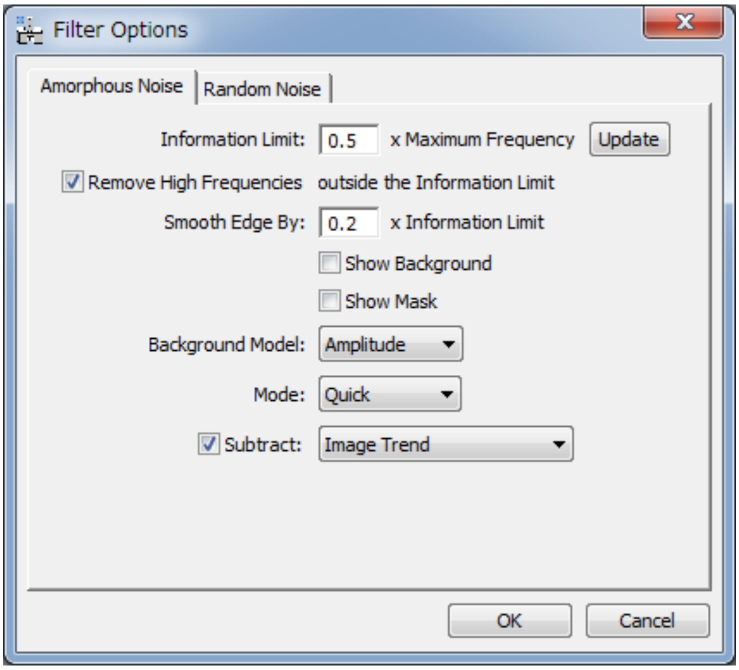
Component	Description
Width:	Size of the local area that is square.
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Low-pass Gaussian width (sigma) :	
	Low-pass Gaussian width is defined in terms of Information limit. A Large Low-pass width requires a longer iterations.
Remove High Frequencies outside the Information Limit	
Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Background Model:	The background of the filter will be estimated from the amplitude or the intensity.

2D Wiener/Difference Filter Menu

Filter Options Dialog

There are two noise model: Amorphous noise and Random noise.

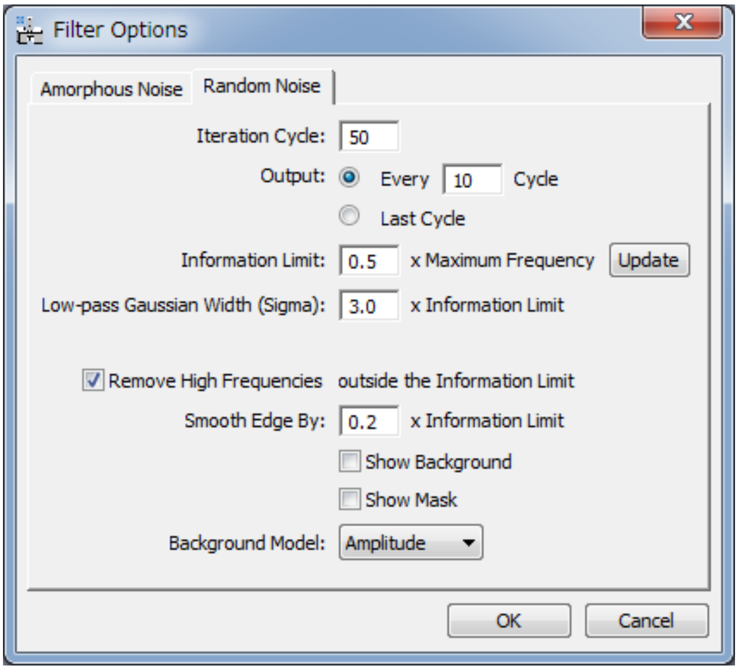
Amorphous Noise Tab



Component	**Description**
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Remove High Frequencies outside the Information Limit	
Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Show Background:	If checked, the background of the Wiener/Difference filter will be displayed.
Show Mask:	If checked, the Wiener/Difference filter mask will be displayed.
Background Model:	The background of the filter will be estimated from the amplitude or the intensity.
Mode:	The choice of the 2D background estimation scheme from *Quick* and *Elaborate*.
Subtract: Image trend/Gaussian blurred image	
	If checked, the image trend or Gaussian blur of the

	original image is subtracted before Wiener/ Difference filtering, and put back afterward.

Random Noise Tab



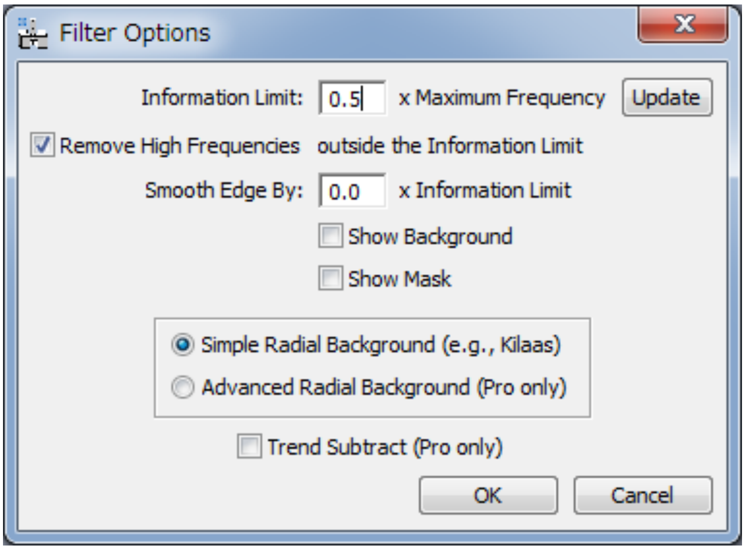
Component	**Description**
Iteration Cycles:	The number of iterations. If you want, you can continue processing from the previous result using this command.
Output Cycle: Each xx Cycles Last Cycle	Specifies the cycle(s) at which you want to save the result(s).
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Low-pass Gaussian width (sigma) :	
	Low-pass Gaussian width is defined in terms of Information limit. A Large Low-pass width requires a longer iterations.
Remove High Frequencies outside the Information Limit	
Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Show Background:	If checked, the background of the Wiener/Difference filter will be displayed.
Show Mask:	If checked, the Wiener filter mask will be displayed.

Background Model:	The background of the filter will be estimated from the amplitude or the intensity.

Radial Wiener/Difference Filter Menu

Filter Options Dialog

Dialog



Option	**Description**
Information Limit:	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking the Update button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Remove High Frequencies outside the Information Limit	
Smooth Edge By:	If checked, high frequencies outside the Information Limit will be smoothly attenuated from one to zero between (Information Limit)*(1- Smooth Edge) and (Information Limit)*(1+ Smooth Edge).
Show Background:	If checked, the background of the Wiener/Difference filter will be displayed.
Show Mask:	If checked, the Wiener/Difference filter mask will be displayed.
Radial Background type	The choice of the type of Radial Background. *Simple Radial Background*: simple rotational average of the intensity (e.g., Kilaas). *Advanced Radial Background* (*Pro* only): smoothed version of the Simple Radial Background. Usually, this background is *far better* than the Simple Radial Background.
Trend Subtract (Pro Only):	If checked, the trend of the original image is subtracted before Wiener/Difference filtering, and put back afterward.

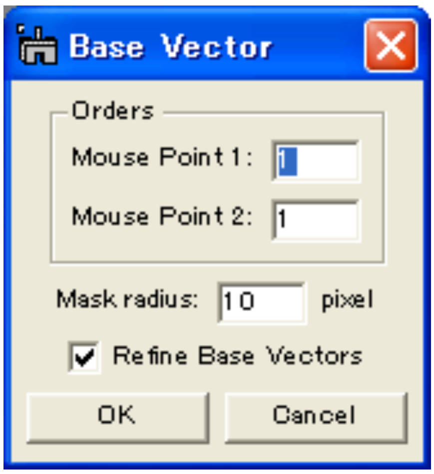
Periodic Filter Menu

Option	Description
Find Base Vectors	Assists to find a precise base vectors for a Periodic Filter using the Periodic Mask tool, or using the mouse tool.
Apply Mask…	Apply a periodic mask with Wiener filter and/or low-pass filter. This command is available for *Pro* only.

Find Base Vectors – Base Vectors Dialog

When two mouse points are placed on the two spots along the two base vectors, the dialog below will appear.

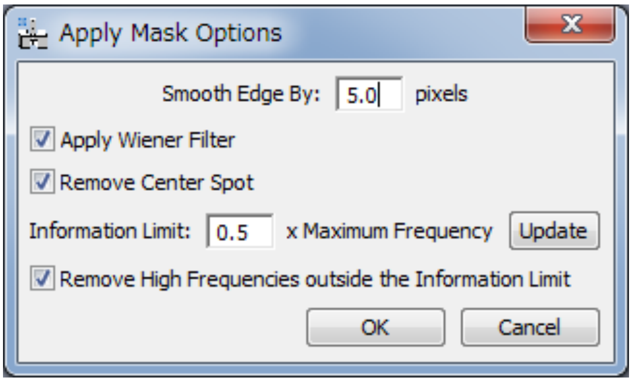
Dialog



Option	Description
Mouse Point 1	The order (index) of the mouse point #1 for the base vector 1.
Mouse Point 2	The order (index) of the mouse point #2 for the base vector 2.
Mask Radius	The mask radius for each spot in pixels.
Refine Base Vectors	The base vector can be refined with a least-square fitting by checking this box. Use this capability except you intentionally want to use the mouse points without the least-square refinement.

Apply Mask Menu - Apply Mask Options Dialog

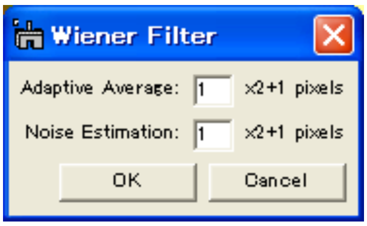
Dialog



Option	Description
Smooth Edge By	The width of smoothing of each spot (same as DM - Process/Apply Mask command).
Apply Wiener Filter	If checked, Wiener filter is applied to each spot by estimating the background for the spot.
Remove Center Spot	If checked, the whole mask area of the center spot will be removed (filtered out)
Information Limit: Update	The Information Limit given by a fraction of the Maximum Frequency of the image. By clicking this button, you can verify the Information Limit on the power spectrum. When you change the value of the information limit, click the button again to check the size of the circle.
Remove High Frequencies outside the Information Limit	
	If checked, high frequencies outside the Information Limit will be removed.

Adaptive Wiener Filter

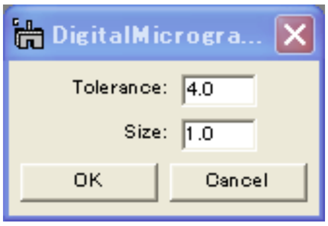
Dialog



Option	Description
Adaptive Average	Defines an area of local average
Noise Estimation	Defines an area for local variance estimation

Replace Dud Pixels

Dialog



Option	Description
Tolerance	Controls a degree of singularity in terms of a local standard deviation
Size	The size of a cluster of dud points.