



International Association
for Identification

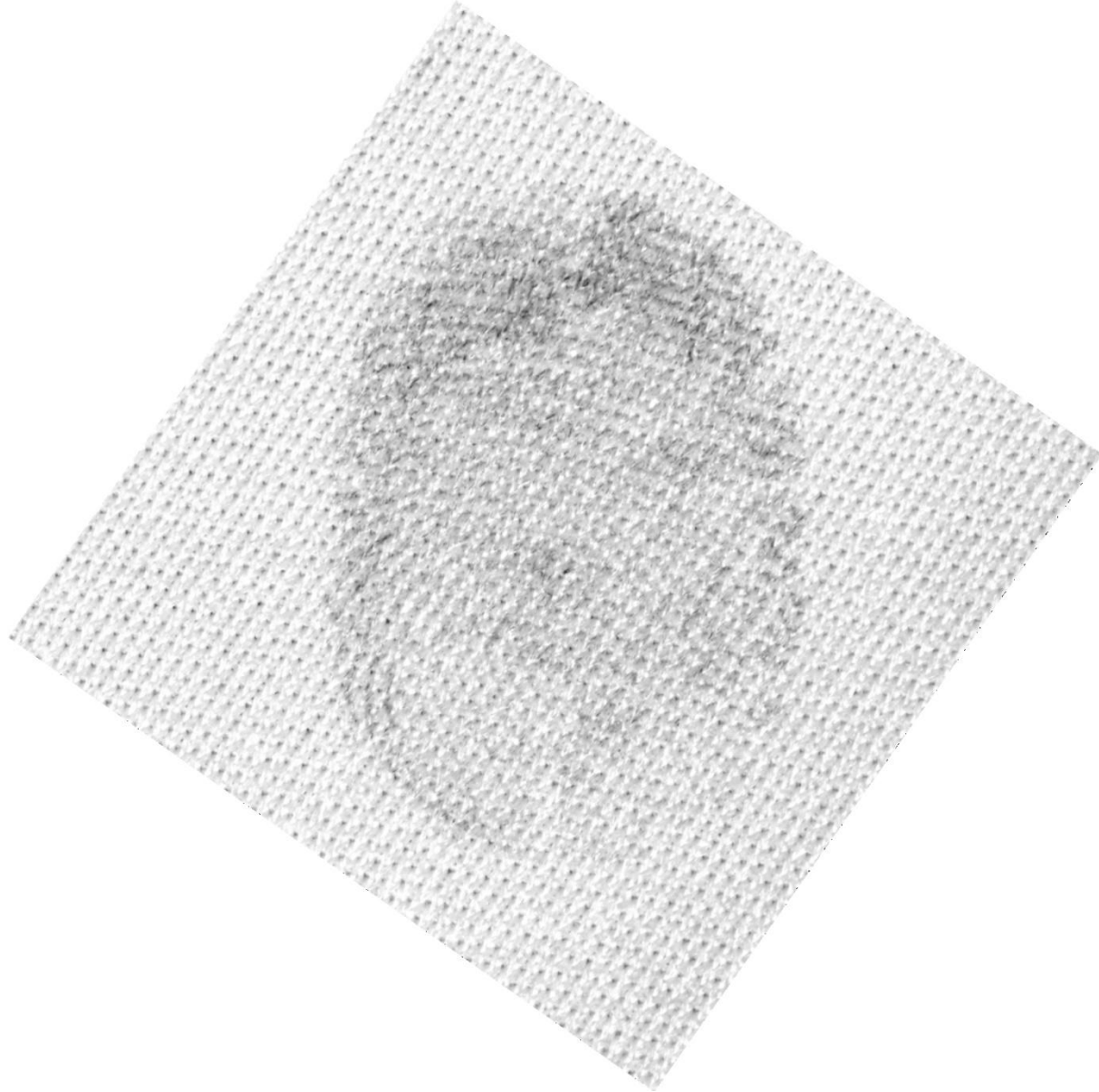
FFT for Friction Ridge Enhancement

Patricia LeFeuvre M.Eng., P.Eng. President

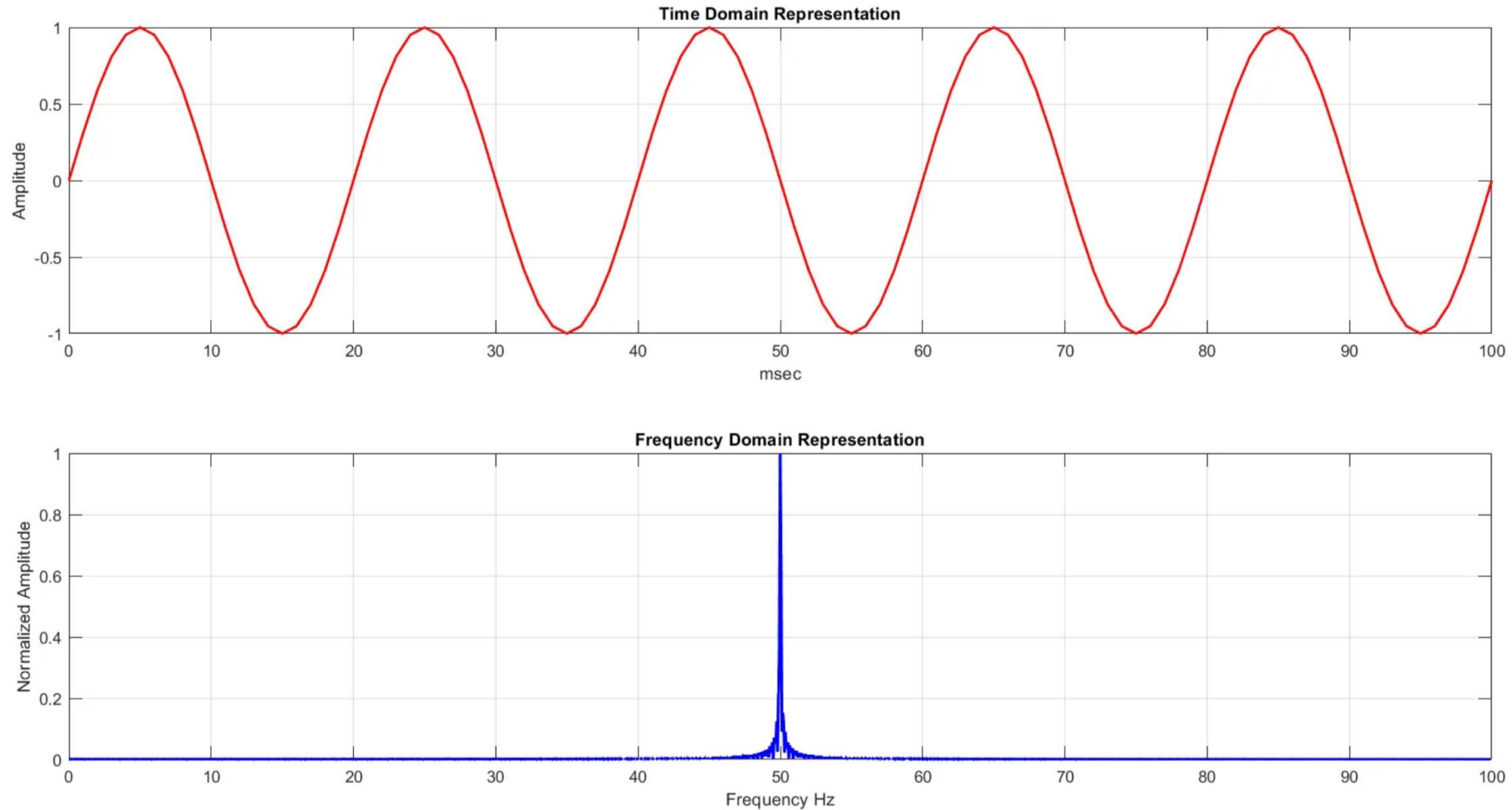
patricia.lefeuvre@csipix.com

info@csipix.com

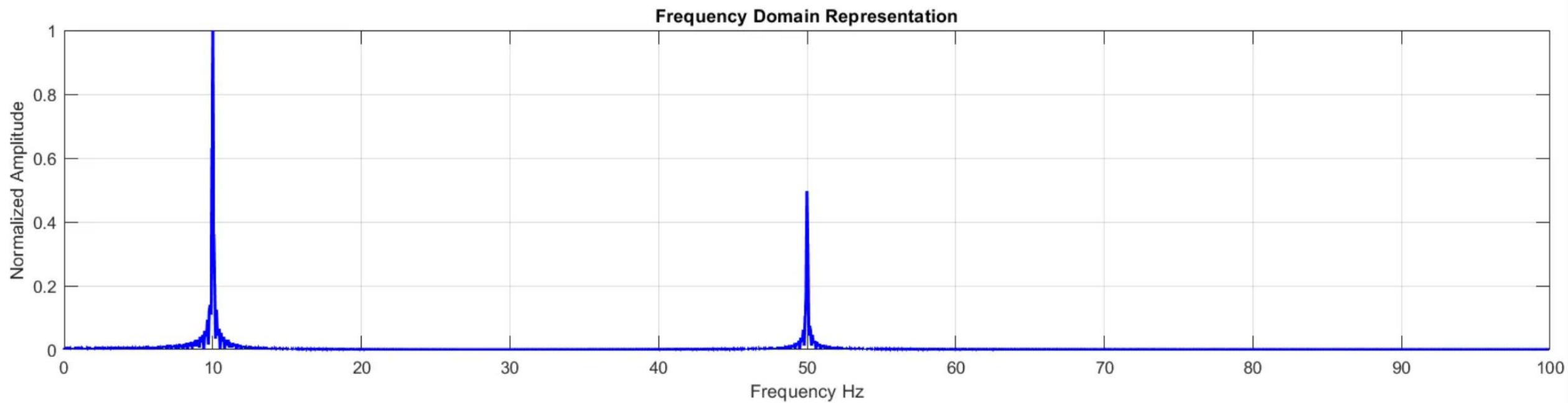
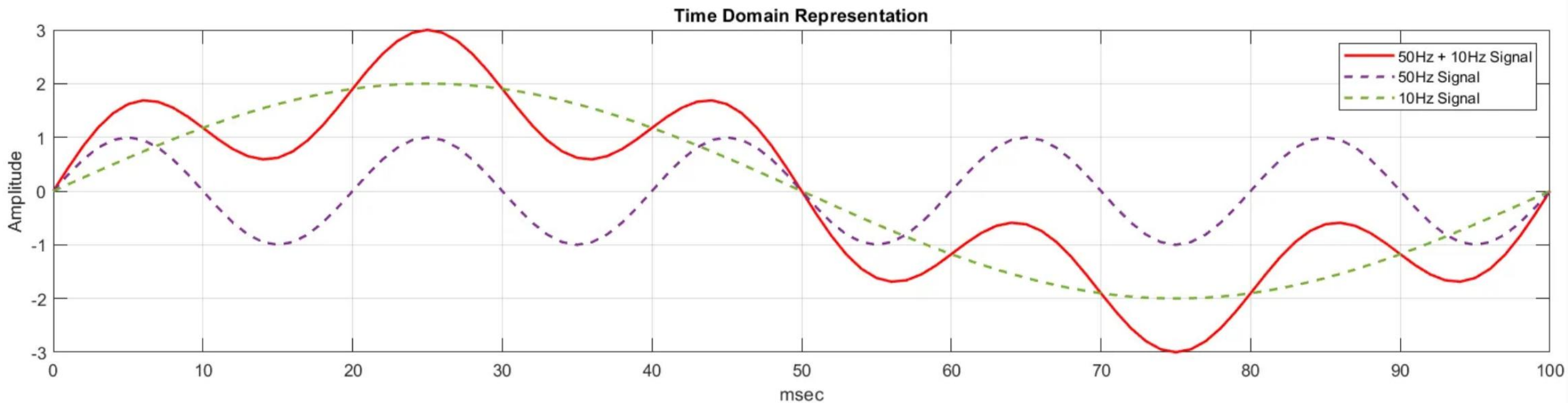
FFT Applications for Friction Ridges

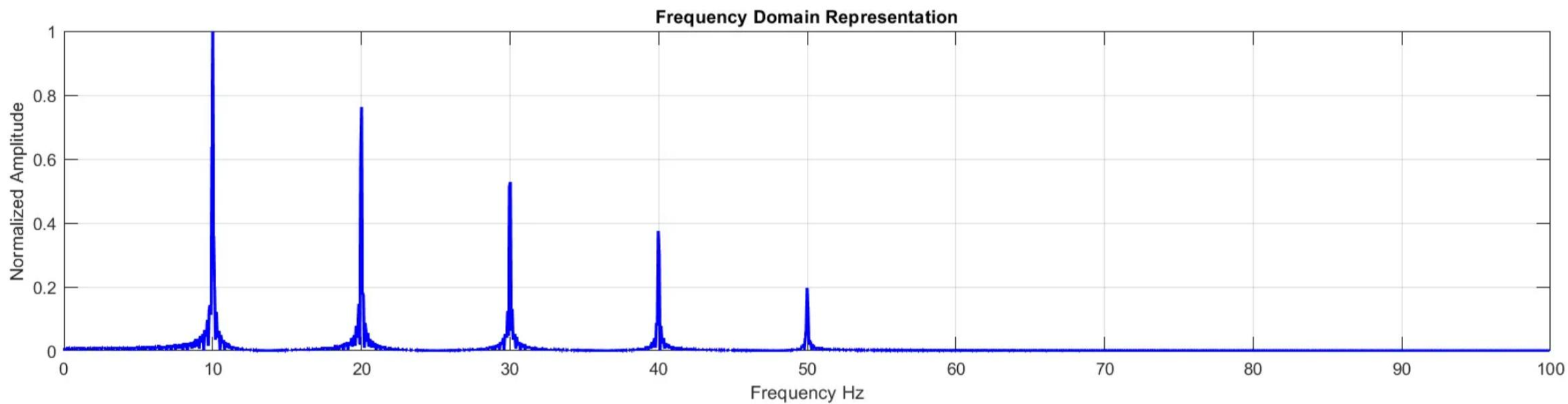
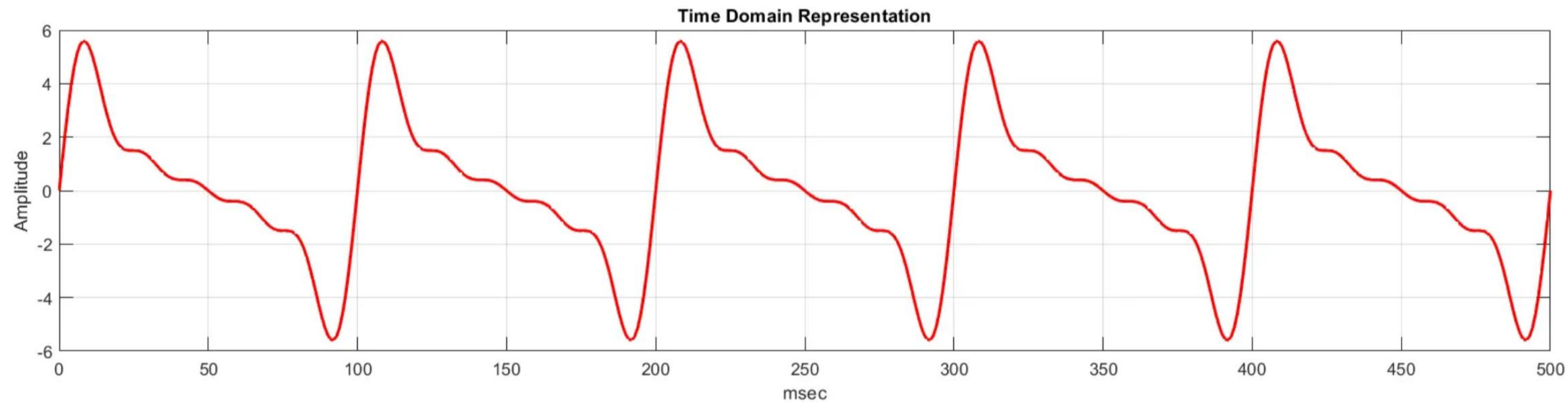


1 Dimensional Fast Fourier Transform (FFT)



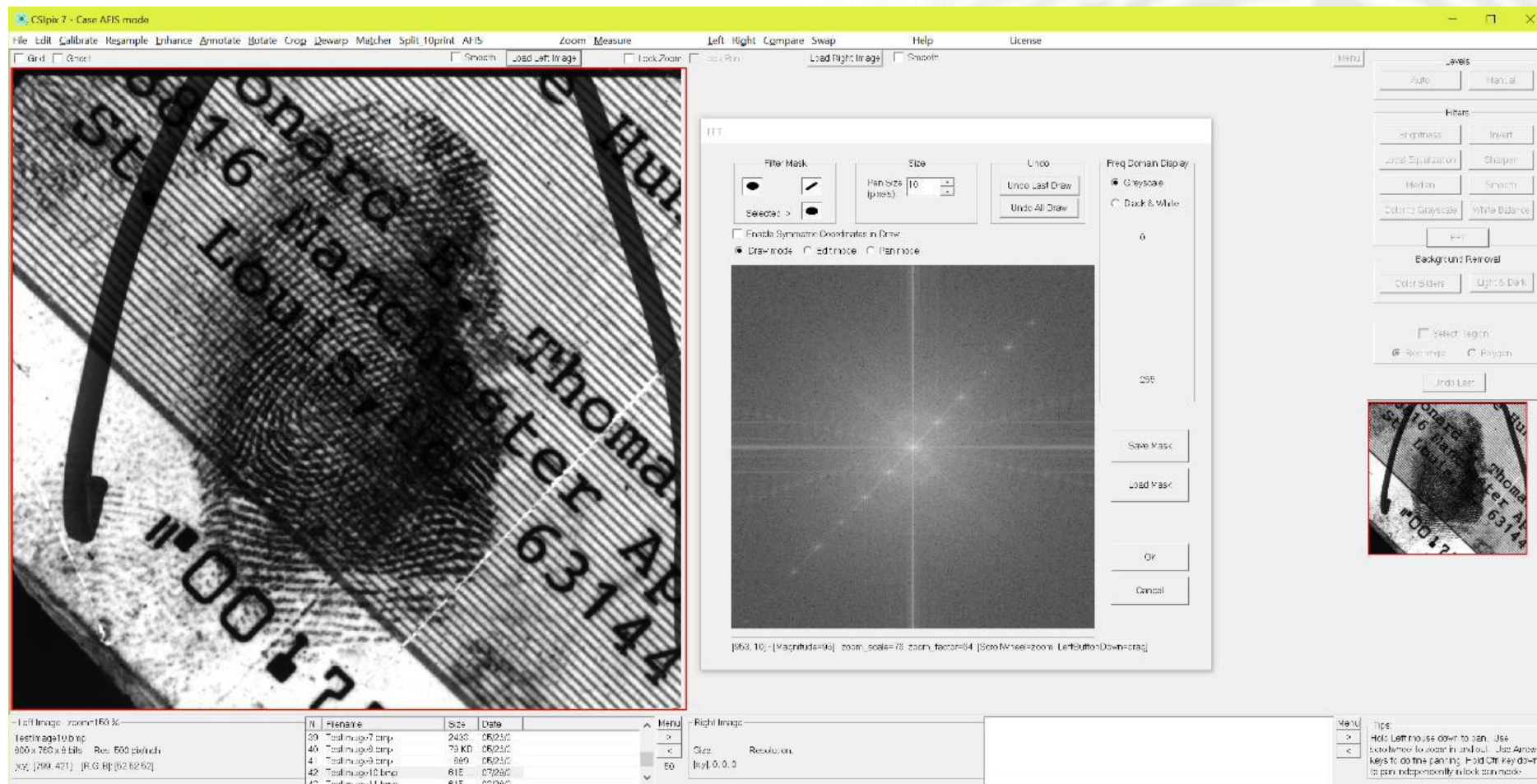
<https://aniket-kamat.medium.com/demystifying-the-fourier-transform-a995bdb6d73a>





2-D FFT

When you click on the 'FFT' button in the Enhance interface you will see the Frequency Spectrum (FS) representation of the image in the FFT interface.



FFT

The data displayed in the FFT interface represents the Left (or Right) spatial image in the Fourier or frequency spectrum (FS).

Q1 and Q3 are mirrored

Q2 and Q4 are mirrored

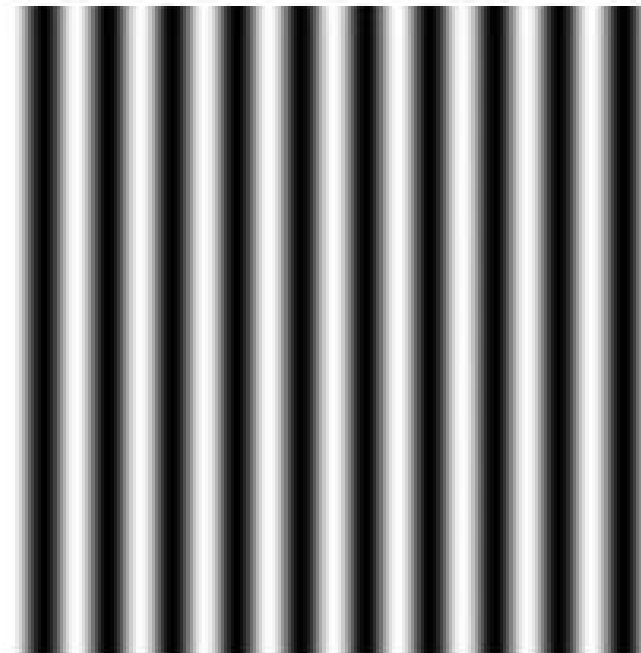
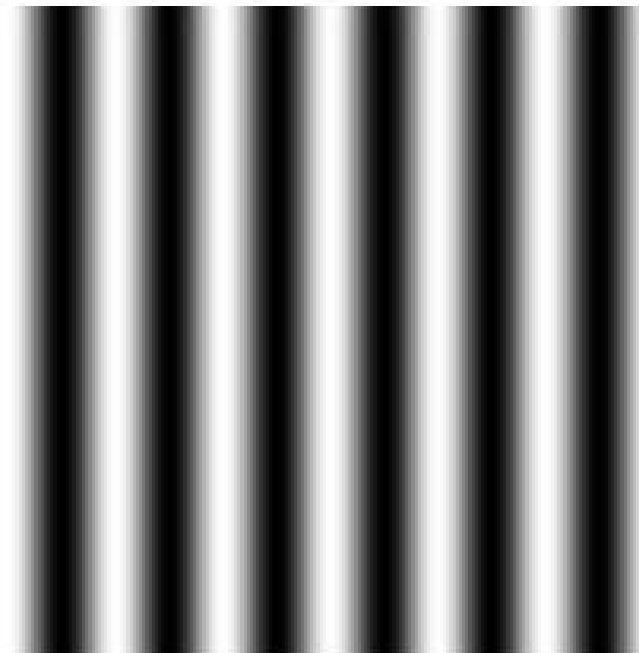
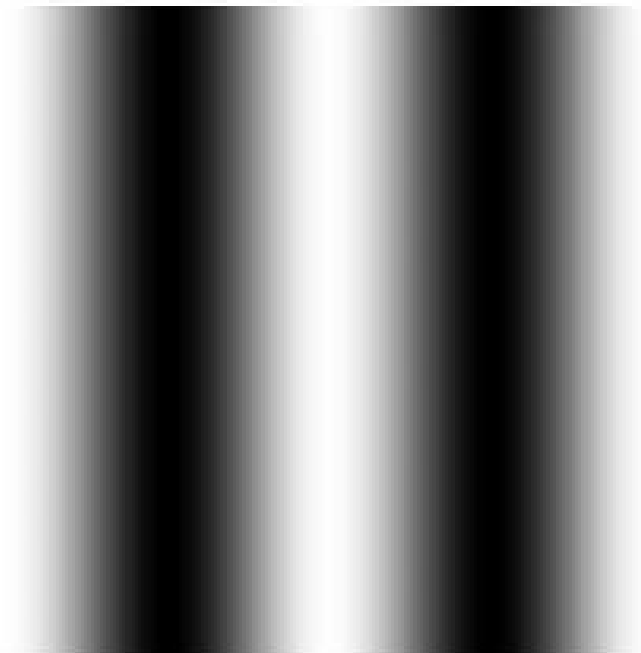


The center of the FS represents image average grey level - low frequency.

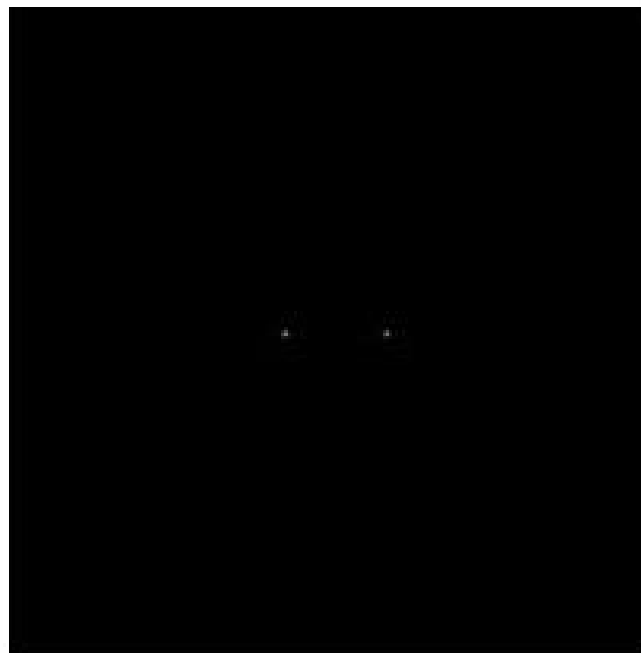
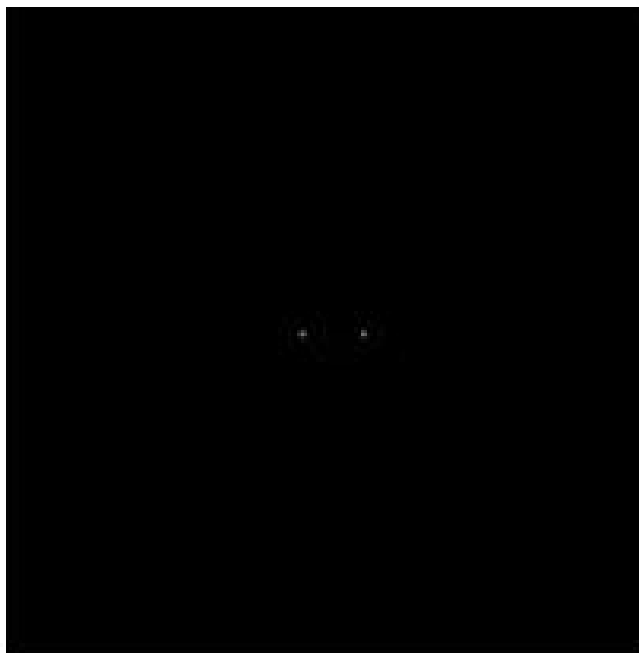
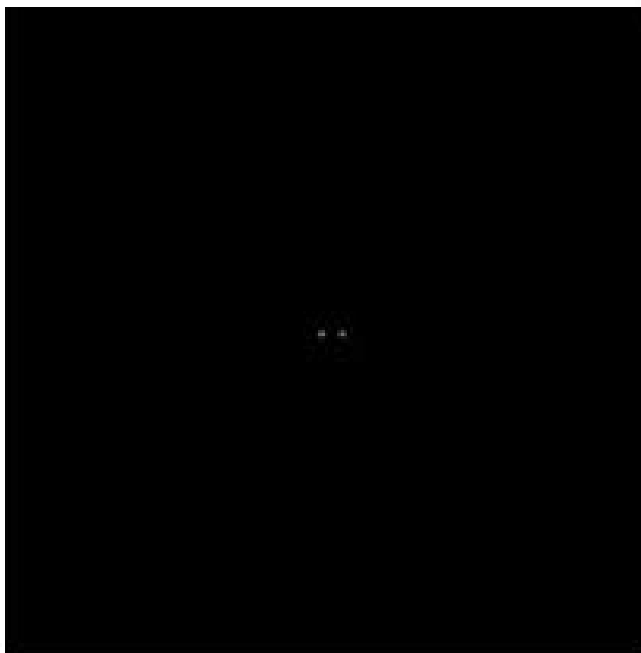
The further away from the center, the higher the frequencies represented

FFT

Images

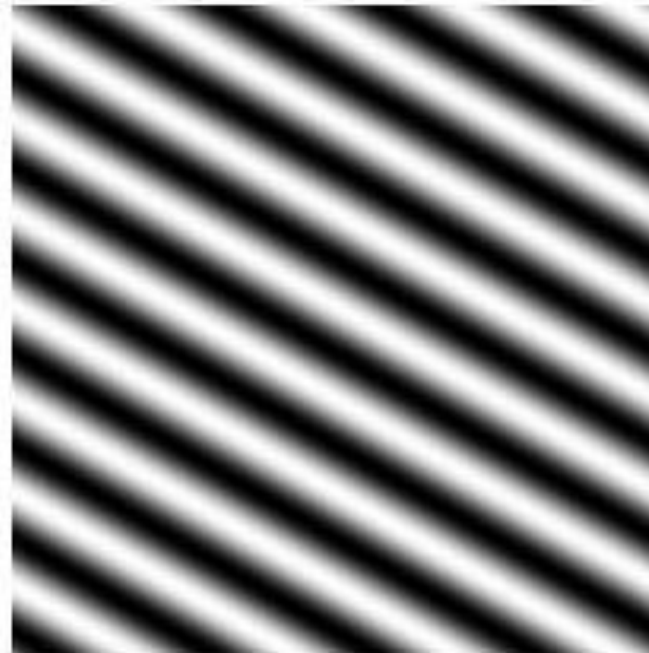
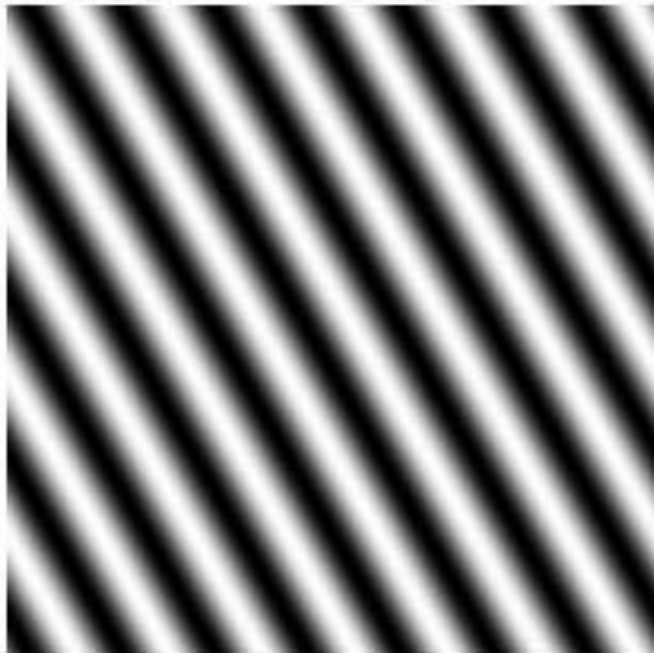


Corresponding
Fourier Spectra

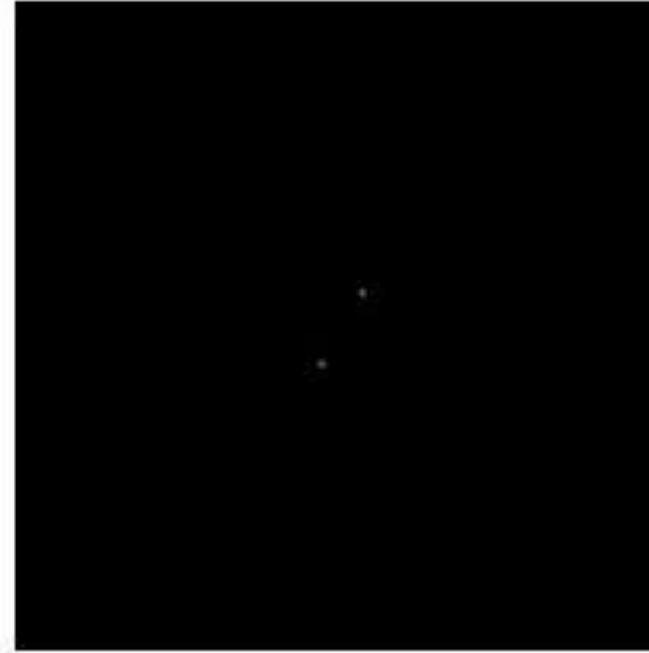
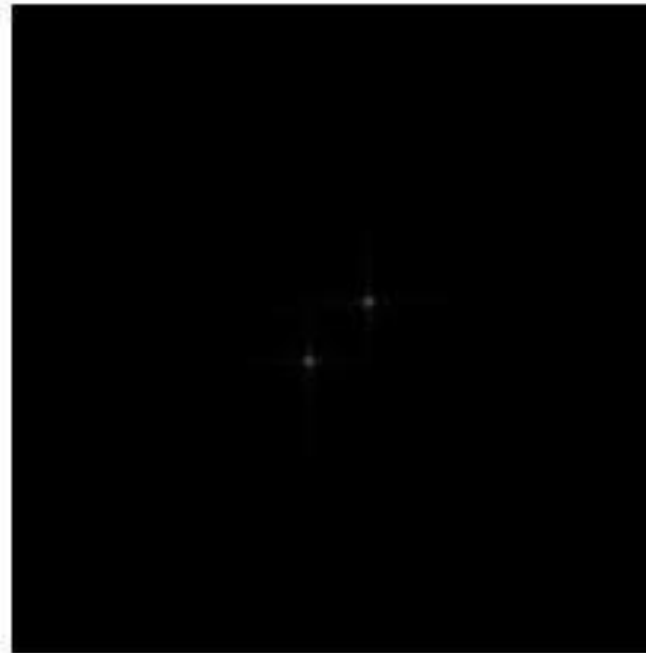
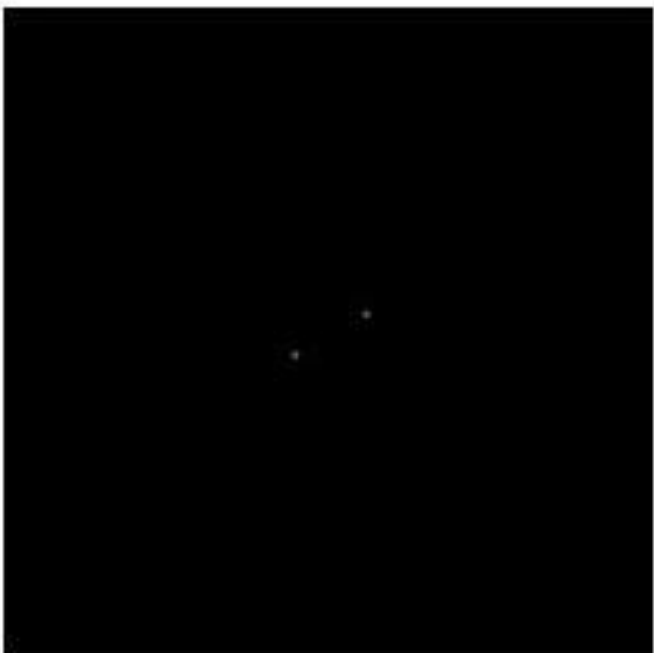


FFT

Images

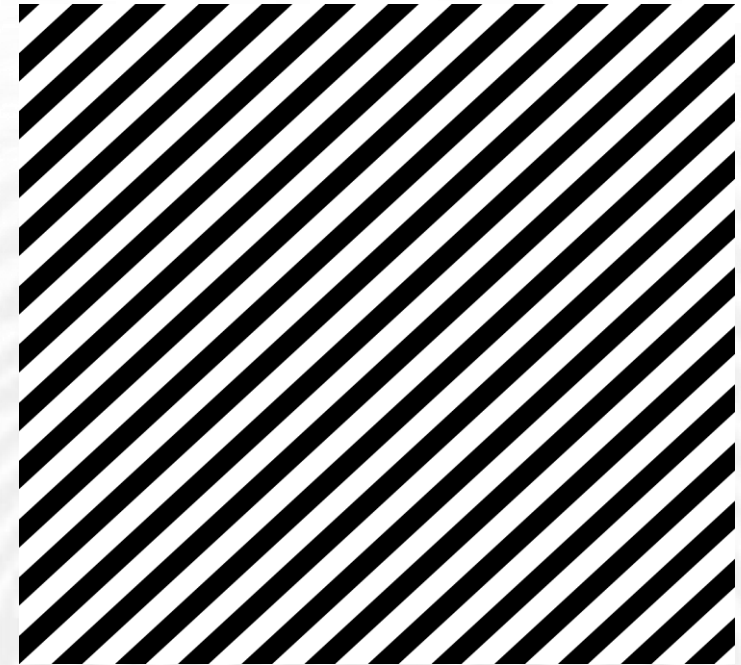
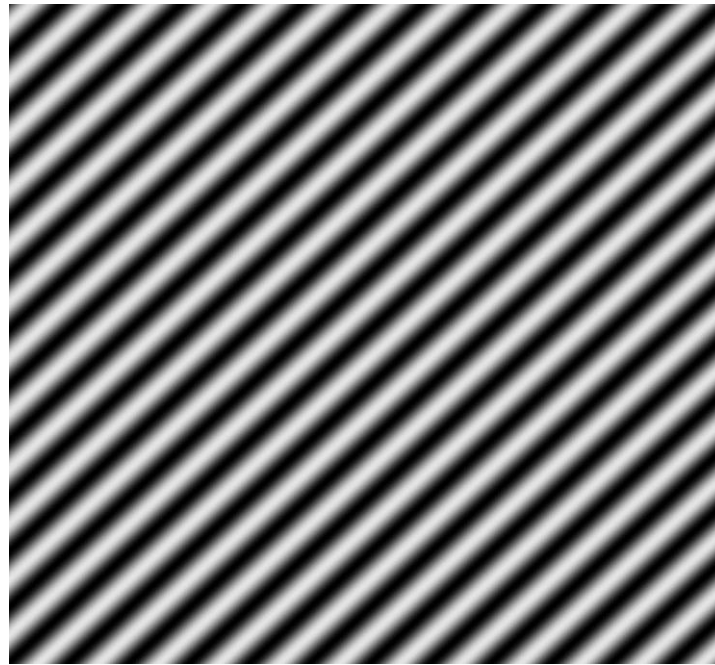


Corresponding
Fourier Spectra

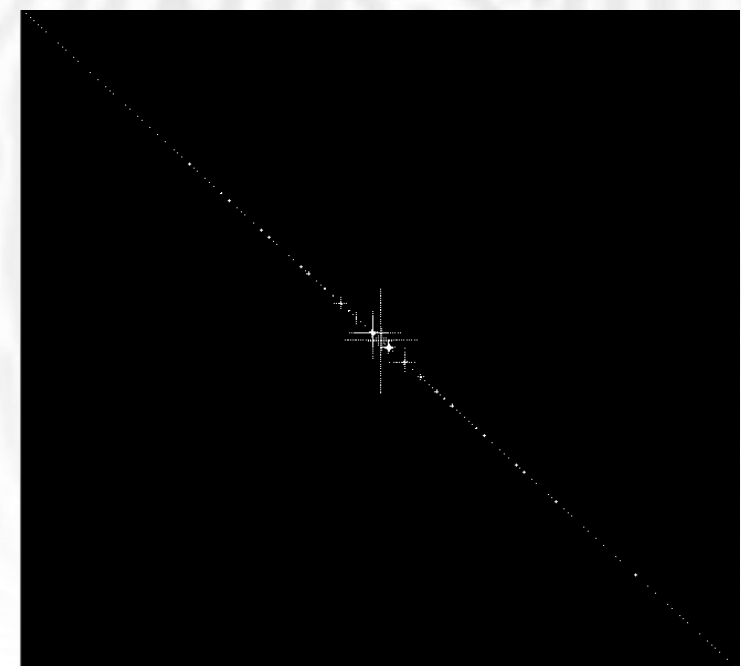
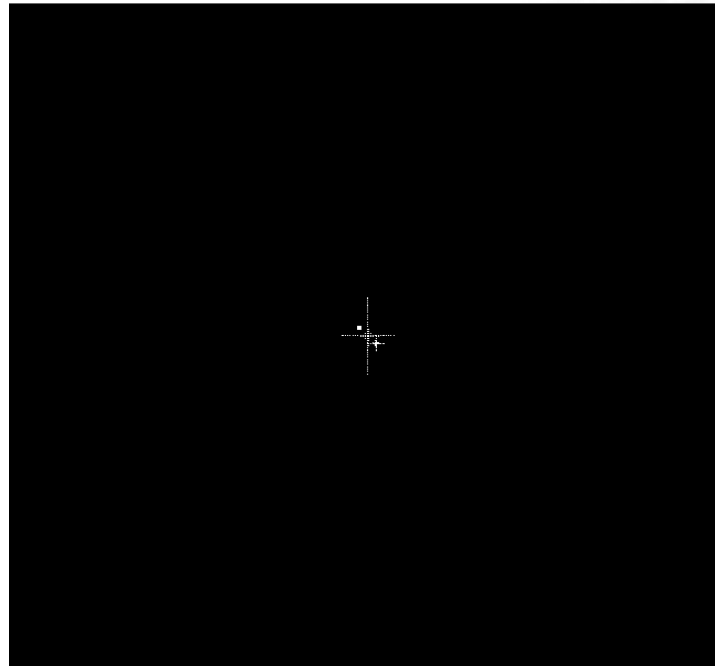


FFT

Images

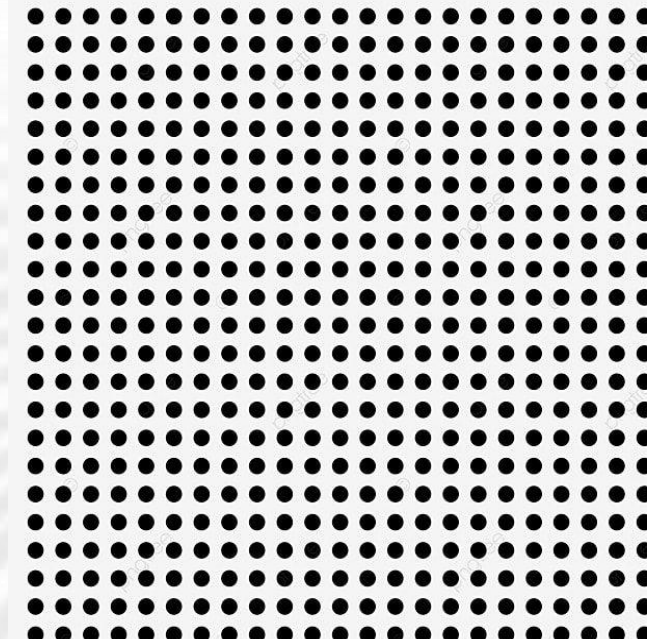
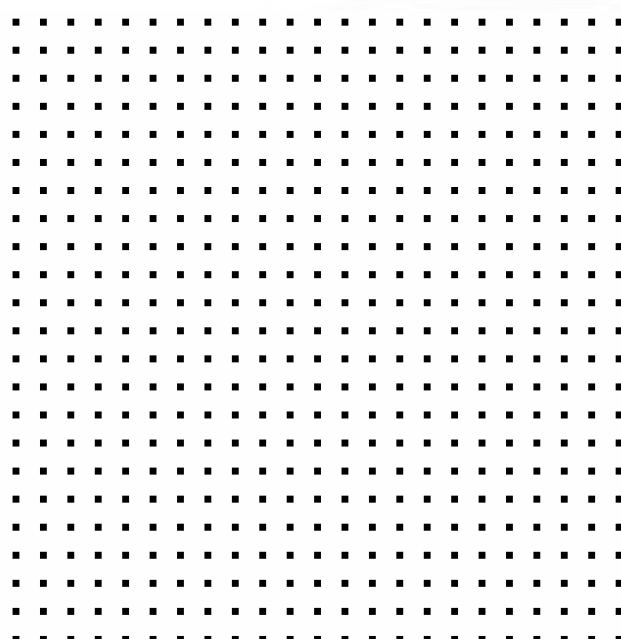
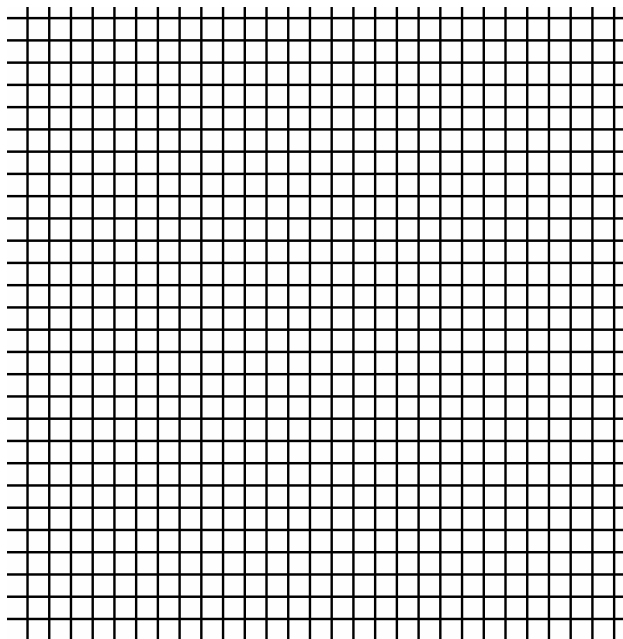


Corresponding
Spectra

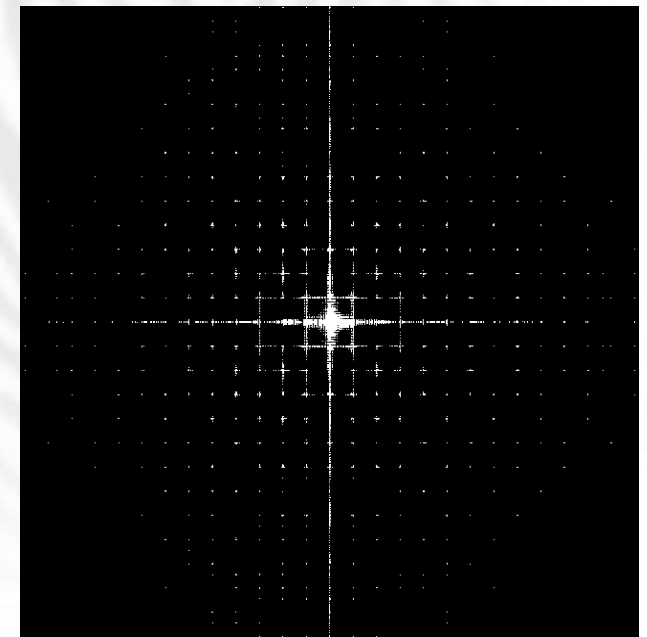
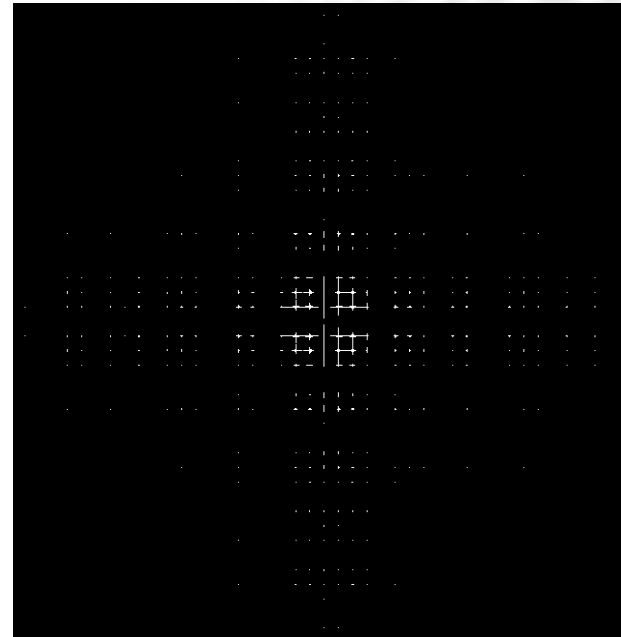
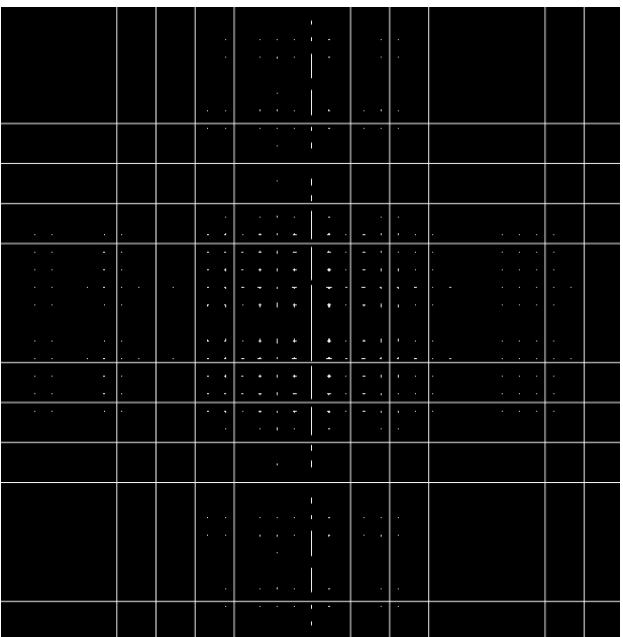


FFT

Images

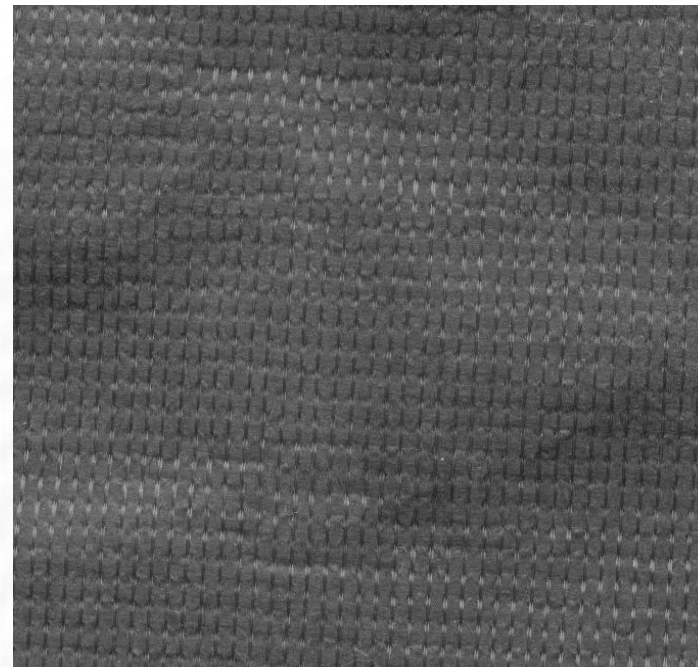
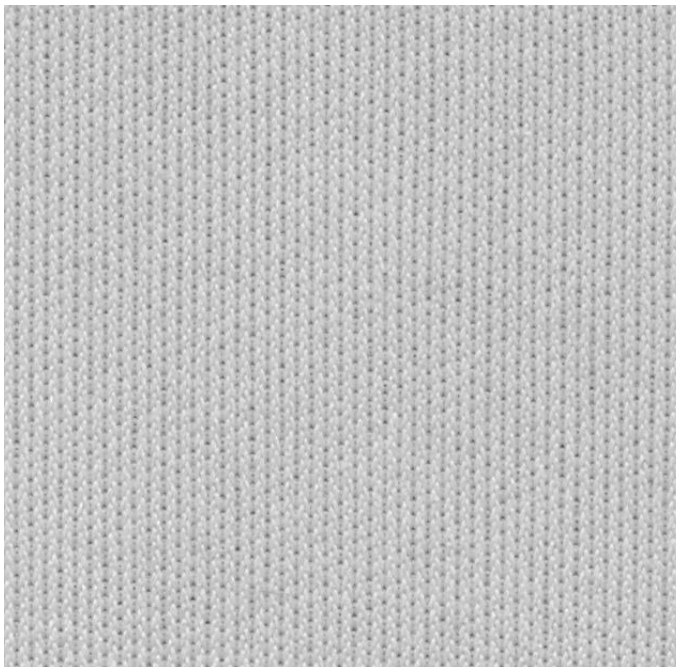


Corresponding
Spectra

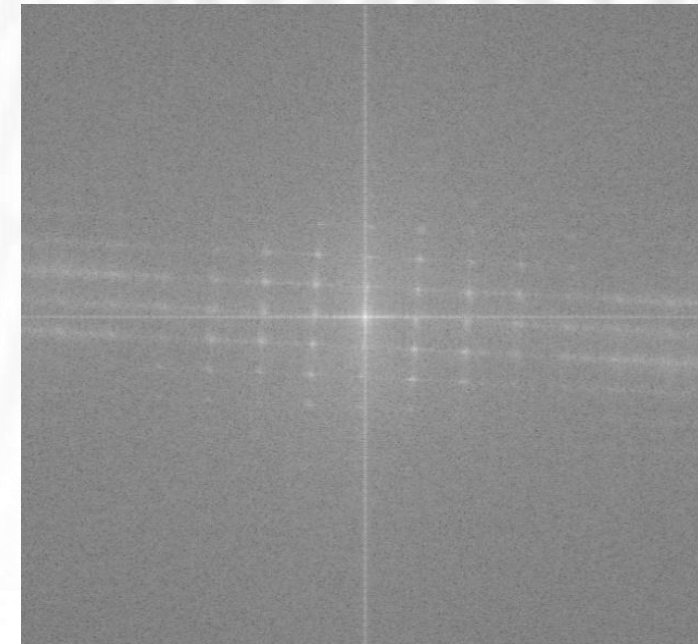
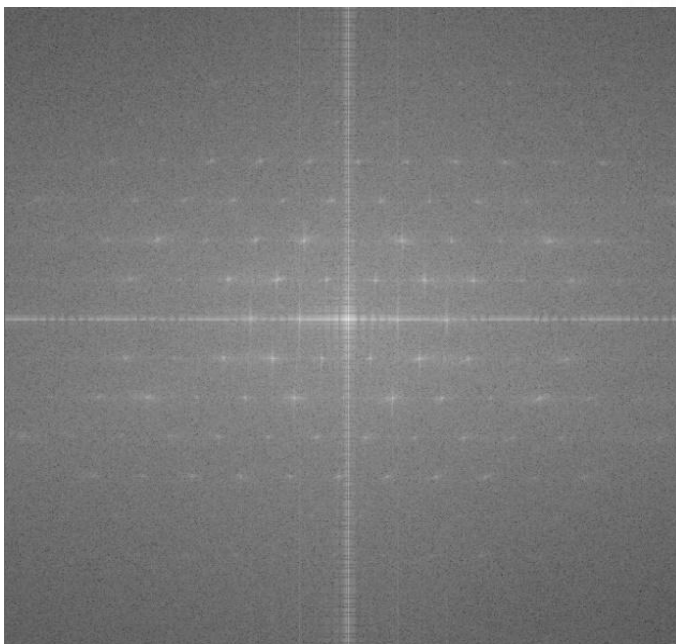


FFT

Fabric Images



Corresponding
Spectra

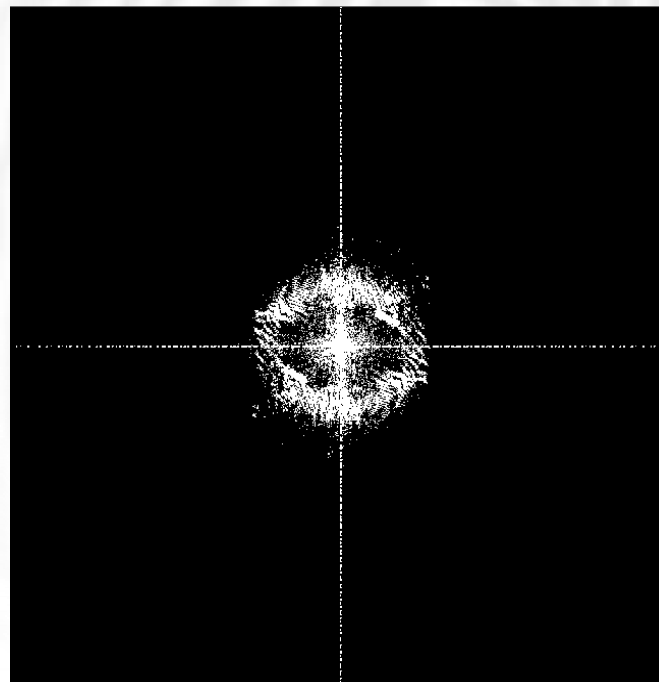
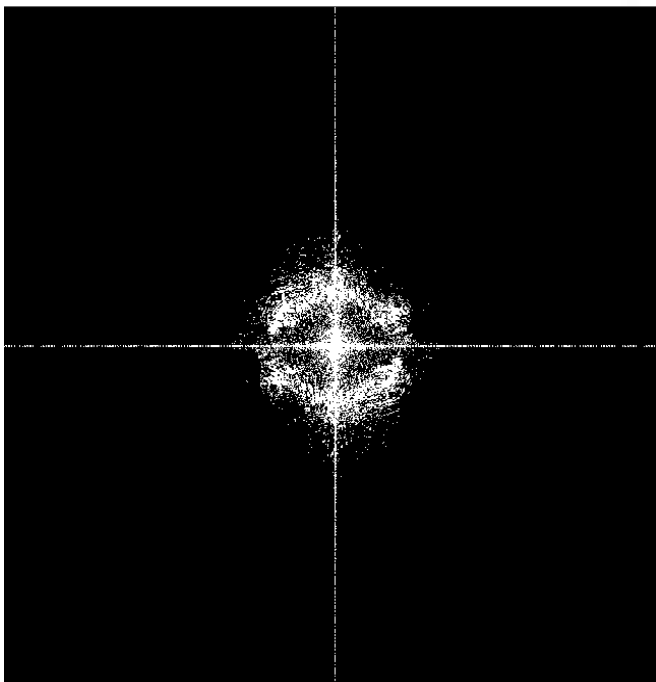


FFT

Images



Corresponding
Spectra



FFT

Images



300 PPI

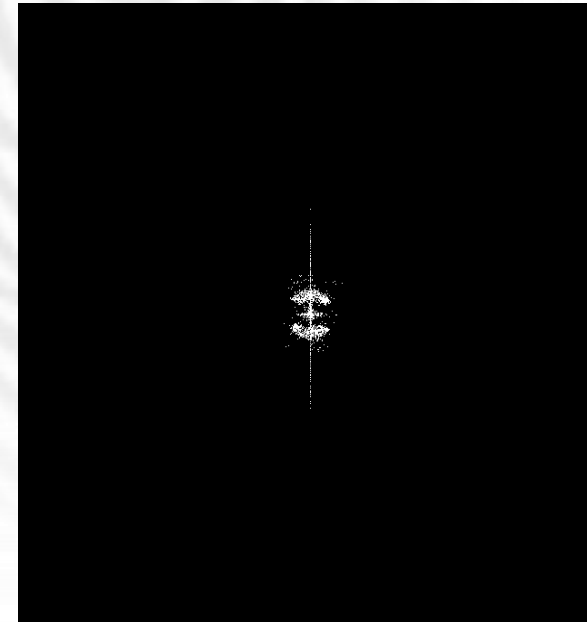
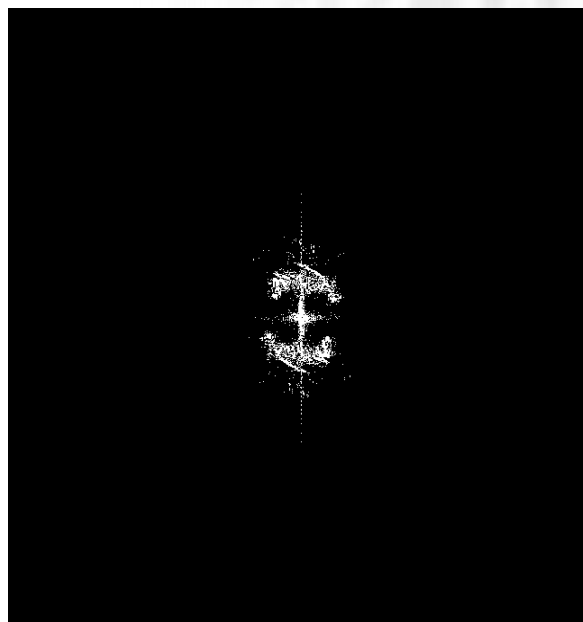
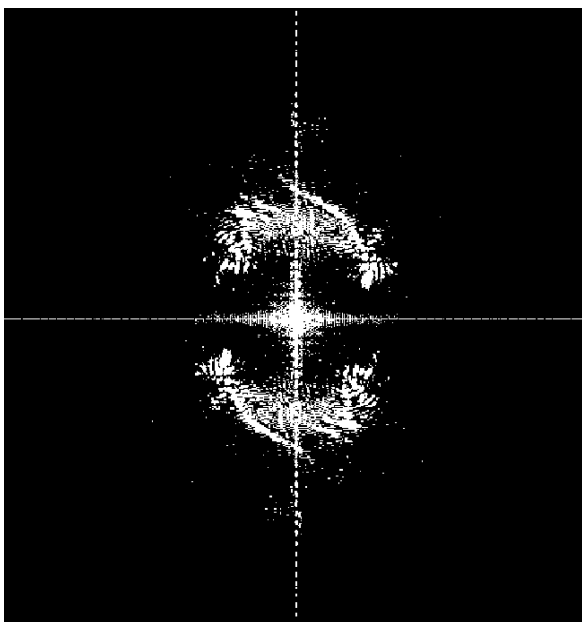


750 PPI



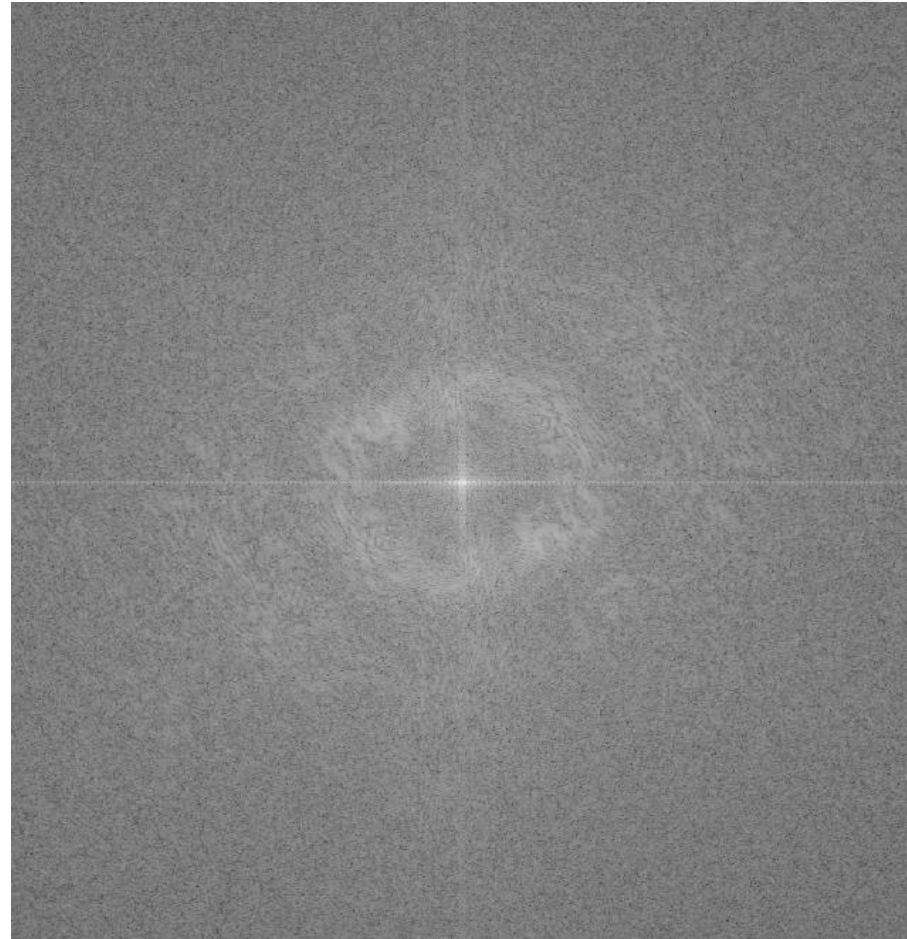
1500 PPI

Corresponding
Spectra



FFT

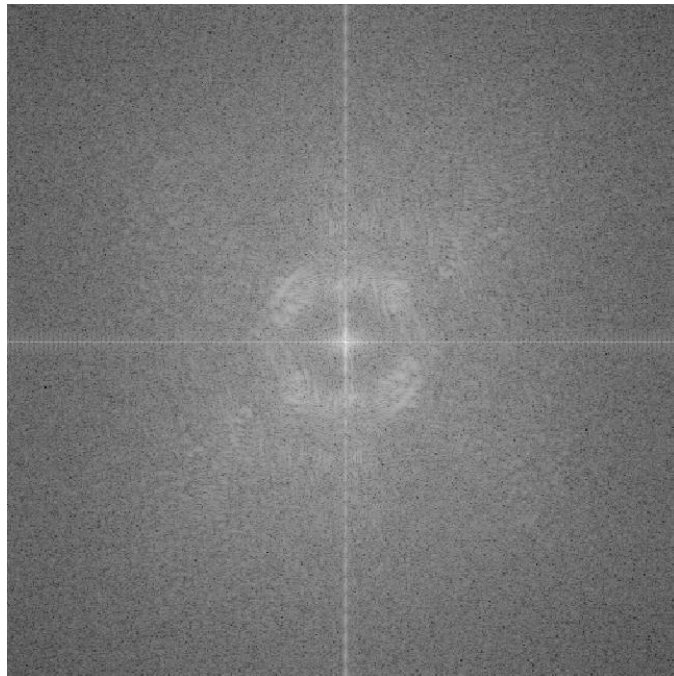
Black and white (not grayscale) images of fingerprints have sharp edges therefore they can have **ringing** in the Fourier Spectrum



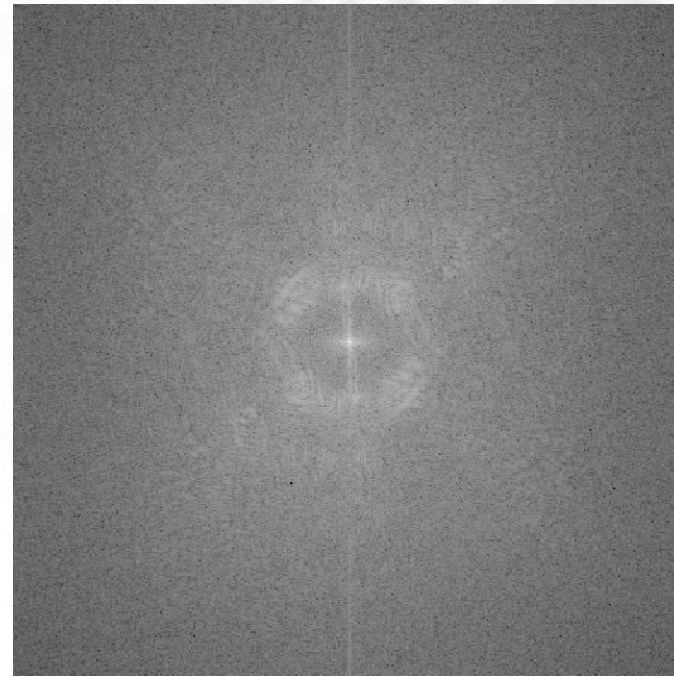
FFT – Vertical and Horizontal Lines in the Spectrum

The vertical and horizontal lines that intersect the middle of the spectrum are usually artifacts of the image padding we have to do to generate the spectrum. They are less prominent if the image does not require padding (512 x 512, 1024 x 1024 or 2048 x 2048 size images do not need padding). **There is usually no need to mask these lines.**

FD for 370 x 474 Pixel Image



FD for 512 x 512 Pixel Image



FFT for Pattern Removal

CSipix 7 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Rotate Crop Unwarp Matcher Split 10print AFIS Zoom Measure Left Right Compare Swap Help License

☐ Grid ☐ Ghost ☐ Smooth Load Left Image ☐ Lock Zoom Load Right Image ☐ Smooth

Left Image: zoom=150 %

TestImage10.bmp
800 x 768 x 8 bits Res: 500 pixels
xy: [799, 421] [R,G,B]: [62,62,62]

N	Filename	Size	Date
39	TestImage7.bmp	2435	05/23/02
40	TestImage8.bmp	79 KB	05/23/02
41	TestImage9.bmp	889	05/23/02
42	TestImage10.bmp	615	07/28/02
43	TestImage11.bmp	815	07/28/02

Right Image: Size Resolution: [xy]: 0, 0, 0

FFT

Filter Mask: ☐ Selected: ☐

Size: Pen Size (pixels): 10

Undo: Undo Last Draw Undo All Draw

☐ Enable Symmetric Coordinates in Draw

☒ Draw mode ☐ Edit mode ☐ Pen mode

Freq Domain Display: ☒ Greyscale ☐ Back & White

0

255

Save Mask Load Mask

OK Cancel

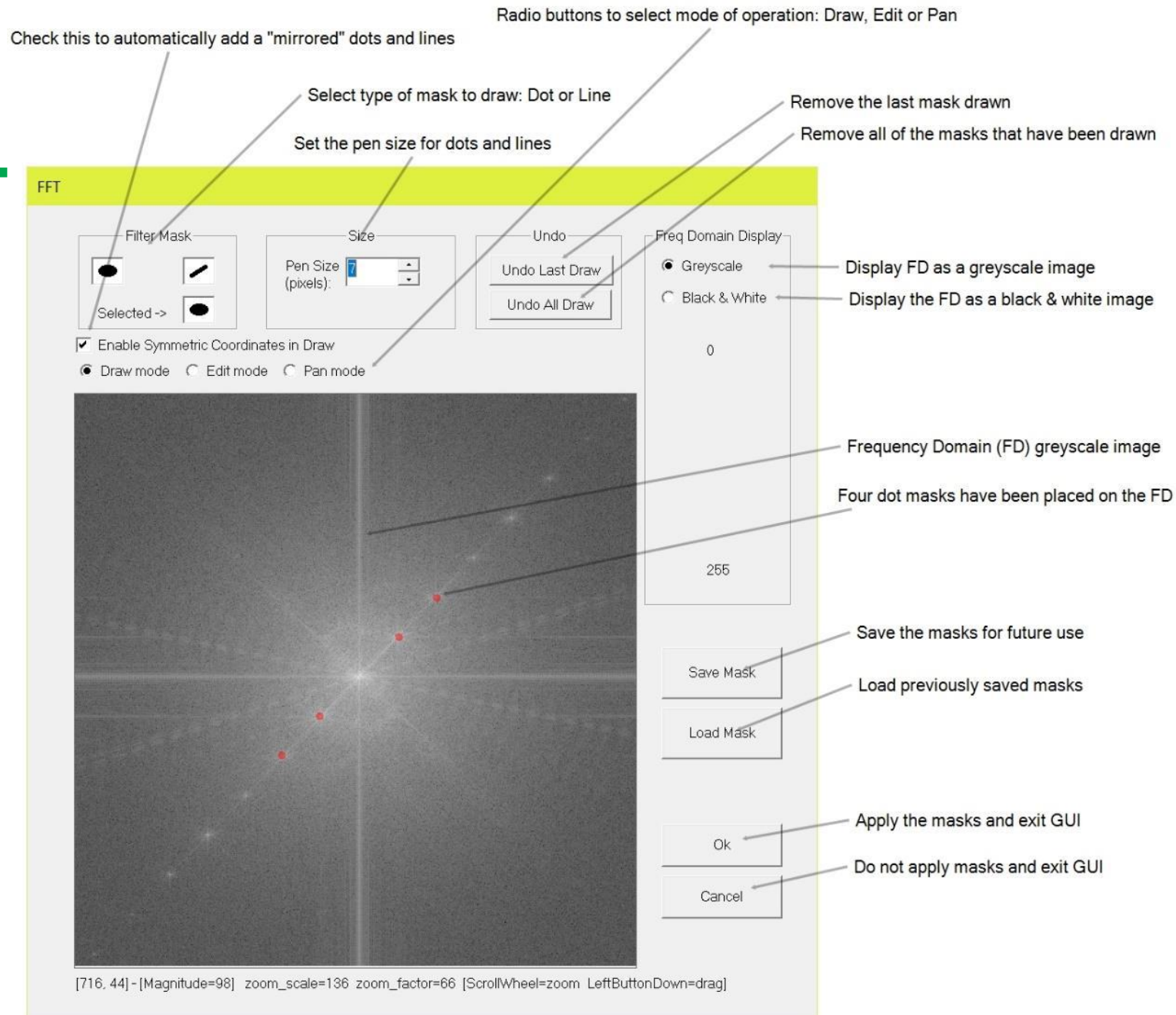
[663,10] - [Magnitude=96] zoom_scale=78 zoom_factor=84 [ScrollWheel=zoom LeftButton/Down=drag]

Menu: Levels: Auto Manual Filters: Brightness Invert Local Equalization Sharpen Median Smooth Color to Grayscale White Balance Background Removal: Color Sliders Light & Dark Select Region: ☒ Rectangular ☐ Polygon Undo Last

Tip: Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode.

FFT Interface

As you add masks, the spatial image will update. The math for this is intense, so it may take a while if the image is large or if your computer is slow.



FFT for Pattern Removal

CSipix 7 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Rotate Crop Unwarp Matcher Split 10print AFIS Zoom Measure Left Right Compare Swap Help License

☐ Grid ☐ Ghost ☐ Smooth Load Left Image ☐ Lock Zoom Load Right Image ☐ Smooth

Left Image: zoom=150 %

TestImage10.bmp
800 x 768 x 8 bits Res: 500 pixels
xy: [799, 421] [R,G,B]: [62,62,62]

N	Filename	Size	Date
39	TestImage7.bmp	2435	05/23/02
40	TestImage8.bmp	79 KB	05/23/02
41	TestImage9.bmp	889	05/23/02
42	TestImage10.bmp	615	07/28/02
43	TestImage11.bmp	815	07/28/02

Right Image: Size Resolution: [xy]: 0, 0, 0

FFT

Filter Mask: ☐ Selected: ☐

Size: Pen Size (pixels): 10

Undo: Undo Last Draw Undo All Draw

☐ Enable Symmetric Coordinates in Draw

☒ Draw mode ☐ Edit mode ☐ Pen mode

Freq Domain Display: ☒ Greyscale ☐ Back & White

0

255

Save Mask Load Mask

OK Cancel

[663,10] - [Magnitude=96] zoom_scale=78 zoom_factor=84 [ScrollWheel=zoom LeftButton/Down=drag]

Menu: Levels: Auto Manual Filters: Brightness Invert Local Equalization Sharpen Median Smooth Color to Grayscale White Balance Background Removal: Color Sliders Light & Dark Select Region: ☒ Rectangular ☐ Polygon Undo Last

Tip: Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode.

FFT for Pattern Removal

CS!pix 8 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Rotate Crop Dewarp Matcher Split_10print AFIS Zoom Measure Left Right Compare Swap Help License

Grid Ghost

Smooth Load Left Image Lock Zoom Lock Pan Load Right Image Smooth

Menu

Enhance

Left Image zoom=196 %
TestImage10.bmp (Unsaved)
800 x 768 x 8 bits Res: 500 pixels/inch
[x,y]: [687, 636] [R,G,B]: [129 129 129]

00002312_3_... .x4TestImage10.b...

0 x 0 x 0 bits Res: UNKNOWN pixels/inch
[x,y]: [128, 0] [R,G,B]: [210 210 210]

Right Image zoom=313 %
00002312_3_... .x4TestImage10.b...

0 x 0 x 0 bits Res: UNKNOWN pixels/inch
[x,y]: [128, 0] [R,G,B]: [210 210 210]

Menu

Tips:
Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode

Filter Mask

Size

Undo

Enable Automatic Symmetric Masking

Draw mode Edit mode Pan mode

Pen Size (pixels)

Selected ->

Undo Last Draw

Undo All Draw

Save Mask

Load Mask

Ok

Cancel

FFT

Filter Mask

Size

Undo

Enable Automatic Symmetric Masking

Draw mode Edit mode Pan mode

Pen Size (pixels)

Selected ->

Undo Last Draw

Undo All Draw

Save Mask

Load Mask

Ok

Cancel

688, 101] - [Magnitude=104] zoom_scale=99 zoom_factor=77 [ScrollWheel=zoom LeftButtonDown=drag]

Enhance

Levels

Filters

Background Removal

Color Sliders Light & Dark

Undo Redo

Menu

Enhance

Menu

Tips:
Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode

A small thumbnail image of a fingerprint, showing the ridge patterns. A red rectangular bounding box is drawn around the fingerprint, indicating the region of interest for the FFT analysis.

FFT Mask Size Effect

CS!pix 8 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Botate Crop Dewarp Matcher Split_10print AFIS Zoom Measure Left Right Compare Swap Help License

Grid Ghost

Smooth Load Left Image Lock Zoom Lock Pan Load Right Image Smooth

Enhance

Levels: Auto Manual

Filters: Brightness Invert Local Equalization Sharpen Median Smooth Color to Grayscale White Balance FFT

Background Removal: Color Sliders Light & Dark

Select Region: Rectangle Polygon

Undo Redo

Thumbnail

FFT

Filter Mask: Selected ->

Size: Pen Size (pixels):

Undo: Undo Last Draw Undo All Draw

☒ Enable Automatic Symmetric Masking

☐ Draw mode ☒ Edit mode ☐ Pan mode

Greyscale

Black & White

Save Mask

Load Mask

Ok

Cancel

[232, 160] - [Magnitude=127] zoom_scale=64 zoom_factor=336 [ScrollWheel=zoom LeftButtonDown=drag]

Left Image zoom=313 %

6384a0d4a55b1c41b0555c94030a1a196672cf5c.jpg 382 x 418 x 8 bits Res: UNKNOWN pwlinch [x,y]: [304, 417] [R,G,B]: [37 37 37]

N	Filename	Size	Date
1	00002312_3_X_0416_IN_	387	10/03/2
2	6384a0d4a55b1c41b0555c	97 KB	11/28/2
3	TestImage10.bmp	615	07/29/2

Menu: > < 3

Right Image zoom=313 %

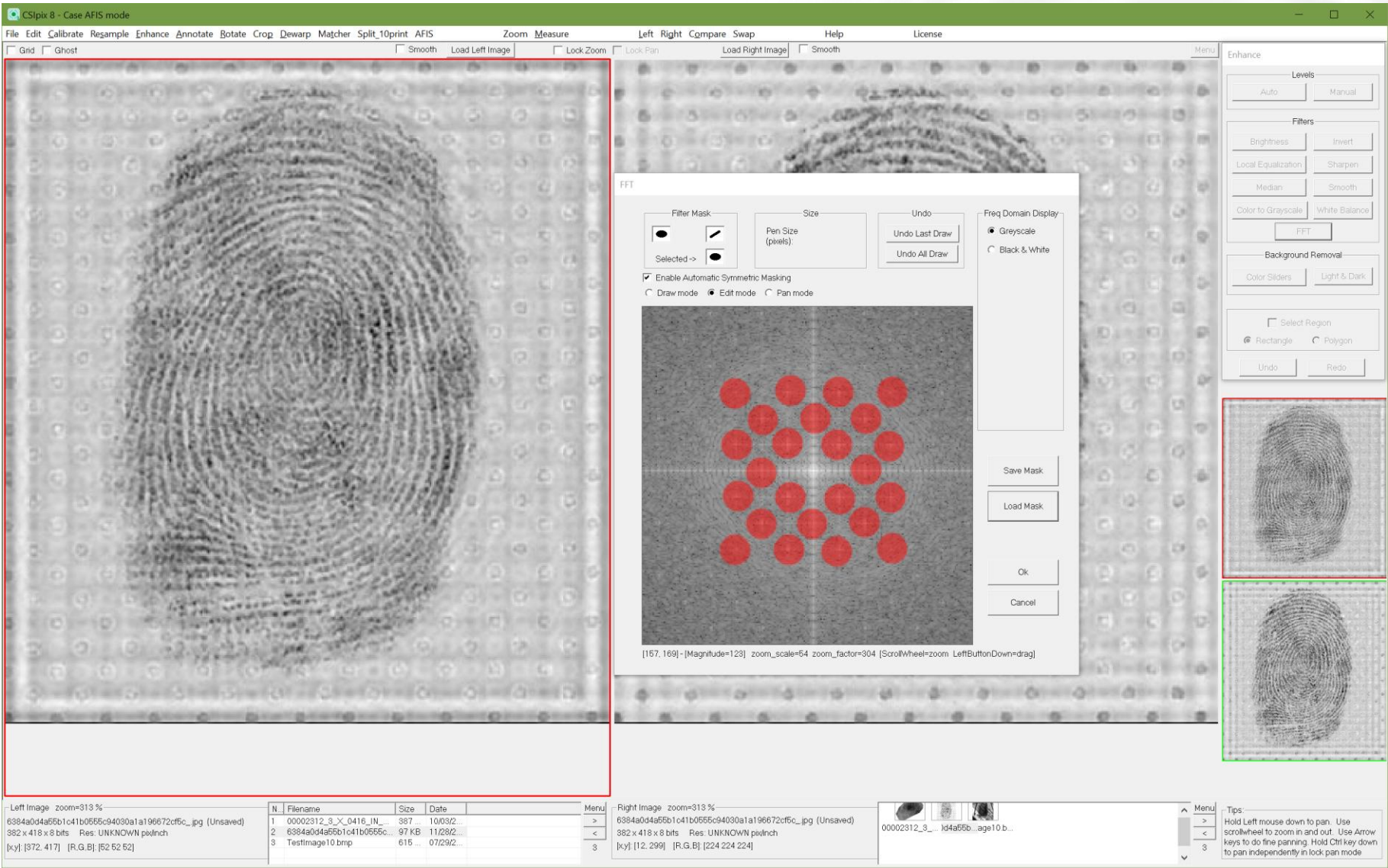
0 x 0 x 0 bits Res: UNKNOWN pwlinch [x,y]: [128, 0] [R,G,B]: [210 210 210]

Menu: > < 3

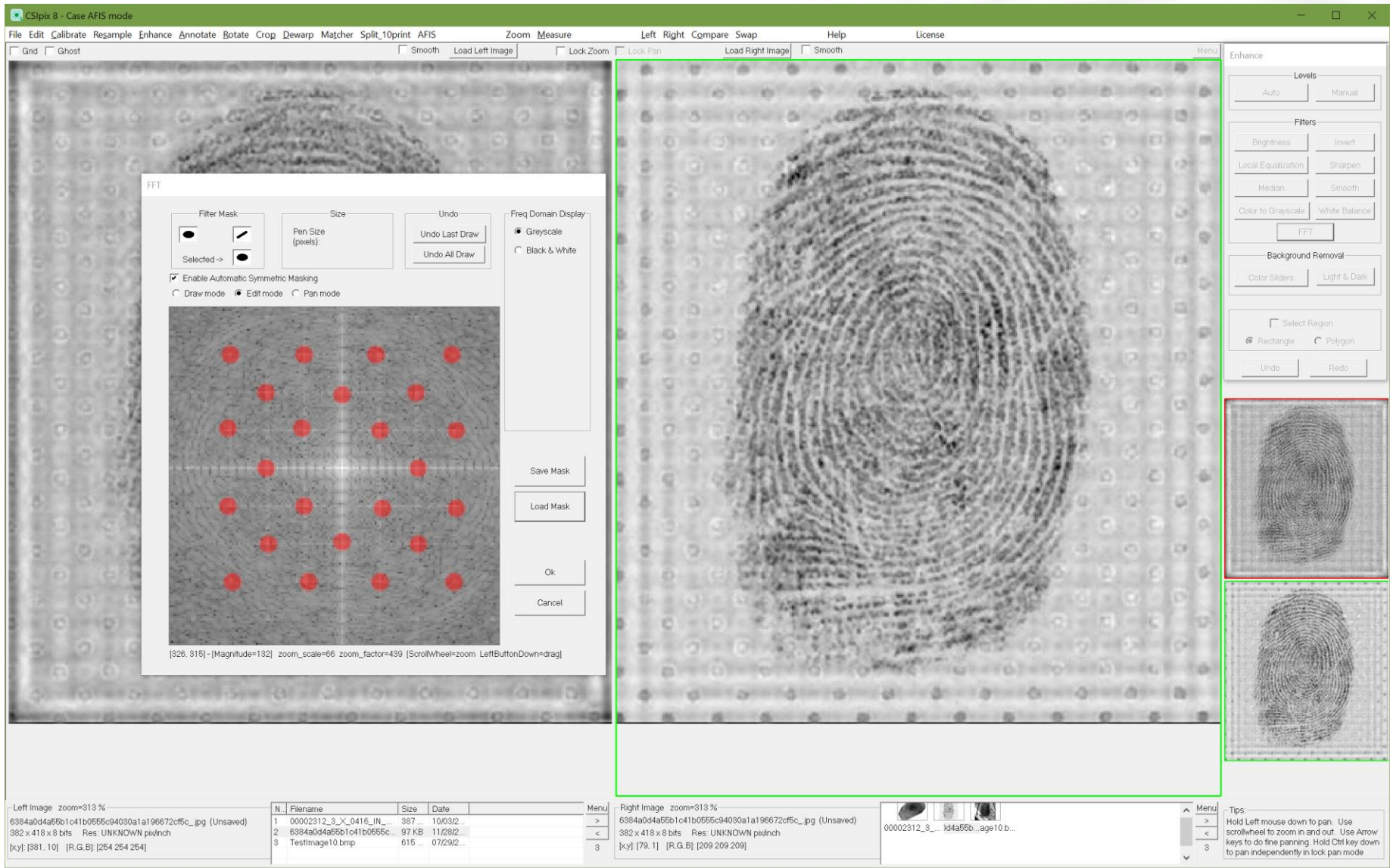
Tips:

Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode.

FFT Mask Size Effect



FFT Mask Size Effect

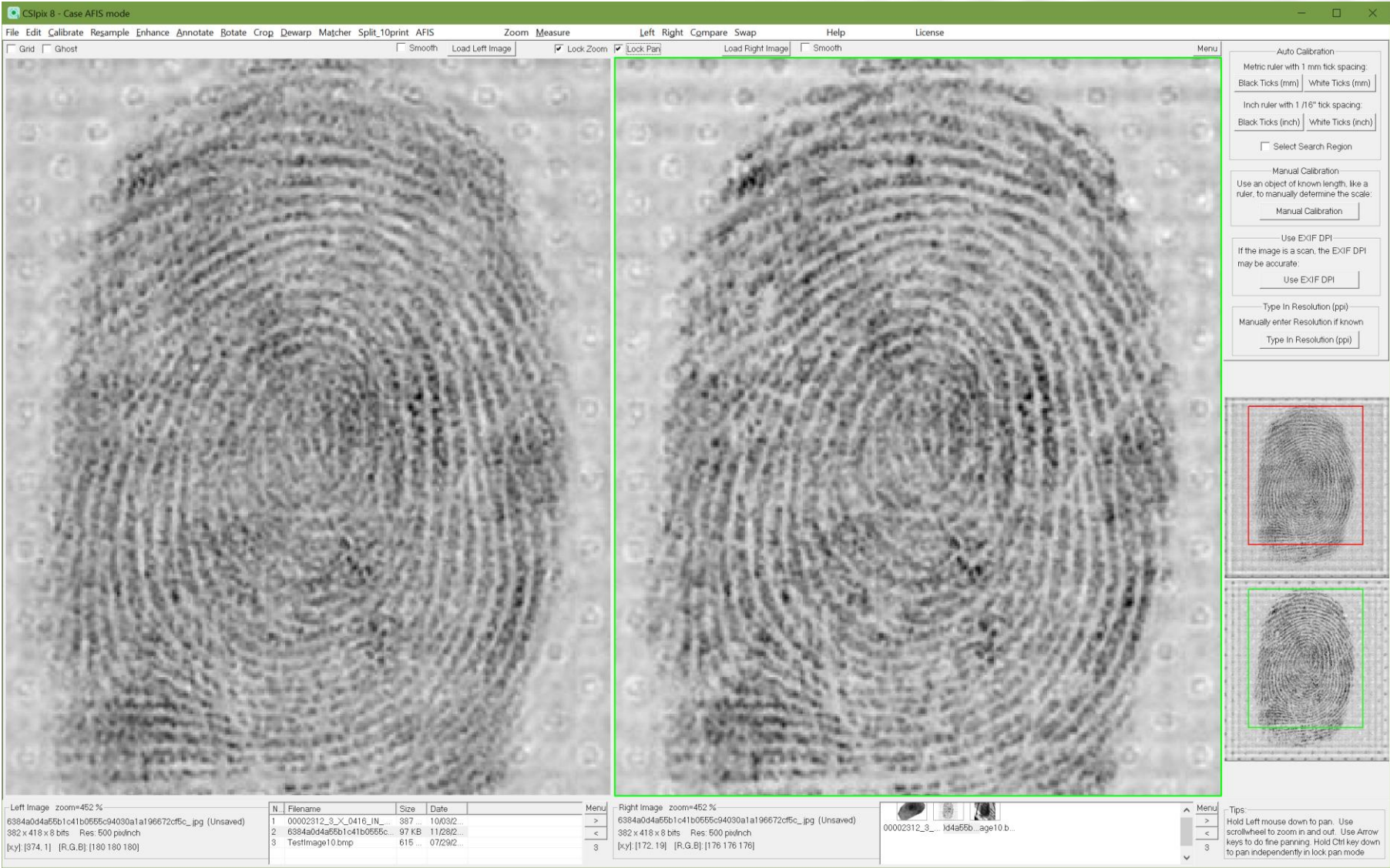


FFT Mask Size Effect

Large Masks

vs.

Small Masks



FFT for Pattern Removal

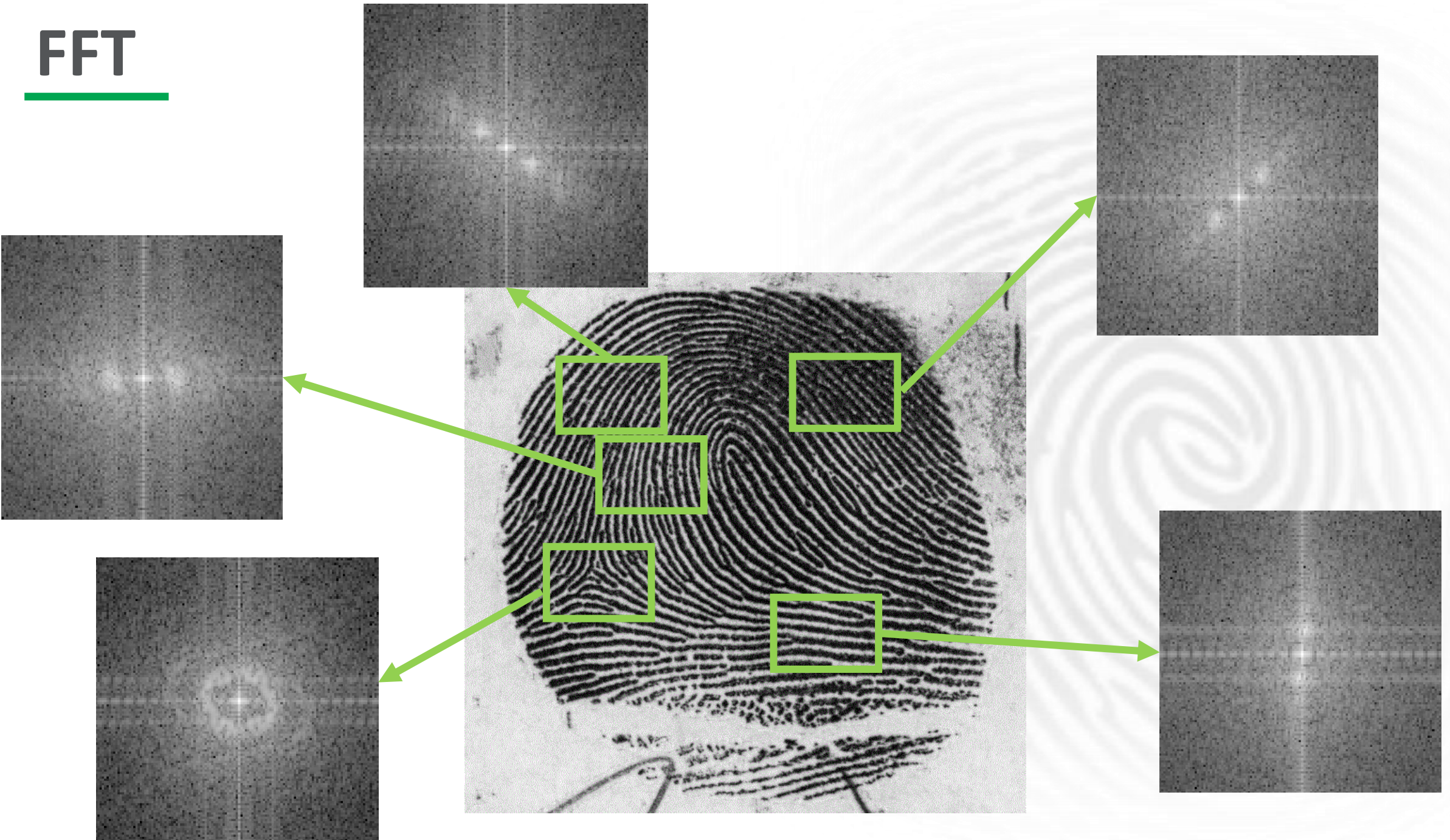
Demos



FFT for Overlapping Prints



FFT



FFT for Overlapping Prints

CS!pix 8 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Botate Crop Dewarp Matcher Split_10print AFIS Zoom Measure Left Right Compare Swap Help License

Grid Ghost Smooth Load Left Image Lock Zoom Lock Pan Load Right Image Smooth Menu

Enhance

Levels: Auto Manual

Filters: Brightness Invert Local Equalization Sharpen Median Smooth Color to Grayscale White Balance FFT

Background Removal: Color Sliders Light & Dark

Select Region: Rectangle Polygon Undo Redo

FFT

Filter Mask: Selected ->

Size: Pen Size (pixels): 6

Undo: Undo Last Draw Undo All Draw

☒ Enable Automatic Symmetric Masking

☒ Draw mode ☐ Edit mode ☐ Pan mode

Freq Domain Display: ☐ Greyscale ☒ Black & White

0 183 255

Save Mask Load Mask

Ok Cancel

[621, 621]-[Magnitude=0] zoom_scale=99 zoom_factor=510 [ScrollWheel=zoom LeftButtonDown=drag]

Left Image zoom=626 %
OVERLAP_10Print_125.tif
698 x 622 x 8 bits Res: UNKNOWN pix/inch
[xy]: [486, 207] [R.G.B]: [184 184 184]

Right Image zoom=313 %
0 x 0 x 0 bits Res: UNKNOWN pix/inch
[xy]: [128, 0] [R.G.B]: [210 210 210]

Menu: > < 16

Menu: > < 8

Tips: Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode

FFT for Overlapping Prints

CSIpix 8 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Botate Crop Dewarp Matcher Split_10print AFIS Zoom Measure Left Right Compare Swap Help License

Grid Ghost Smooth Load Left Image Lock Zoom Lock Pan Load Right Image Smooth Menu

Enhance

Levels

Auto Manual

Filters

Brightness Invert

Local Equalization Sharpen

Median Smooth

Color to Grayscale White Balance

FFT

Background Removal

Color Sliders Light & Dark

Select Region

Rectangle Polygon

Undo Redo

FFT

Filter Mask

Size

Pen Size (pixels): 5

Undo

Undo Last Draw

Undo All Draw

Enable Automatic Symmetric Masking

Draw mode Edit mode Pan mode

Freq Domain Display

Greyscale

Black & White

0

175

255

Save Mask

Load Mask

Ok

Cancel

[365, 365] - [Magnitude=0] zoom_scale=99 zoom_factor=510 [ScrollWheel=zoom LeftButtonDown=drag]

Left Image zoom=526 %

OVERLAP_10Print_126.tif (Unsaved)

698 x 622 x 8 bits Res: UNKNOWN ppi/inch

[x,y]: [422, 208] [R,G,B]: [178 178 178]

Right Image zoom=313 %

OVERLAP_10... LAP_10... LAP_10... LAP_10... LAP_10... LAP_10... pping1.tif

0 x 0 x 0 bits Res: UNKNOWN ppi/inch

[x,y]: [128, 0] [R,G,B]: [210 210 210]

Tip:

Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode

FFT for Overlapping Prints



FFT for Overlapping Prints



FFT for Overlapping Prints

CS!pix 8 - Case AFIS mode

File Edit Calibrate Resample Enhance Annotate Rotate Crop Dewarp Matcher Split_10print AFIS Zoom Measure Left Right Compare Swap Help License

Grid Ghost Smooth Load Left Image Lock Zoom Lock Pan Load Right Image Smooth Menu

Enhance

Levels

Auto Manual

Filters

Brightness Invert

Local Equalization Sharpen

Median Smooth

Color to Grayscale White Balance

FFT

Background Removal

Color Sliders Light & Dark

Select Region

Rectangle Polygon

Undo Redo

FFT

Filter Mask: Selected ->

Size

Pen Size (pixels): 10

Undo

Undo Last Draw

Undo All Draw

Enable Automatic Symmetric Masking

Draw mode Edit mode Pan mode

Freq Domain Display

Greyscale

Black & White

Save Mask

Load Mask

Ok

Cancel

[492, 492] - [Magnitude=0] zoom_scale=82 zoom_factor=308 [ScrollWheel=zoom LeftButtonDown=drag]

Left Image zoom=208 %

OverlappingRidges.png

725 x 690 x 8 bits Res: 1102 pix/inch

[x,y]: [724, 66] [R,G,B]: [196 196 196]

Menu

00002303_6A... 304_5A... 313_6E... ppingRi...

0 x 0 x 0 bits Res: UNKNOWN pix/inch

[x,y]: [128, 0] [R,G,B]: [210 210 210]

Right Image zoom=313 %

Menu

8

Tips:

Hold Left mouse down to pan. Use scrollwheel to zoom in and out. Use Arrow keys to do fine panning. Hold Ctrl key down to pan independently in lock pan mode

FFT for Overlapping Prints

Demos





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