Fundamentals of Satellite Remote Sensing

Digital Image Processing

Dr. Hassan Mohamed

Digital Image Corrections

- Radiometric:
  - Reduce noise en raw DL.
  - Generation of biophysical parameters: reflectance, temperature.
- Geometric:
  - RPCs.
  - Ground Control Points models.

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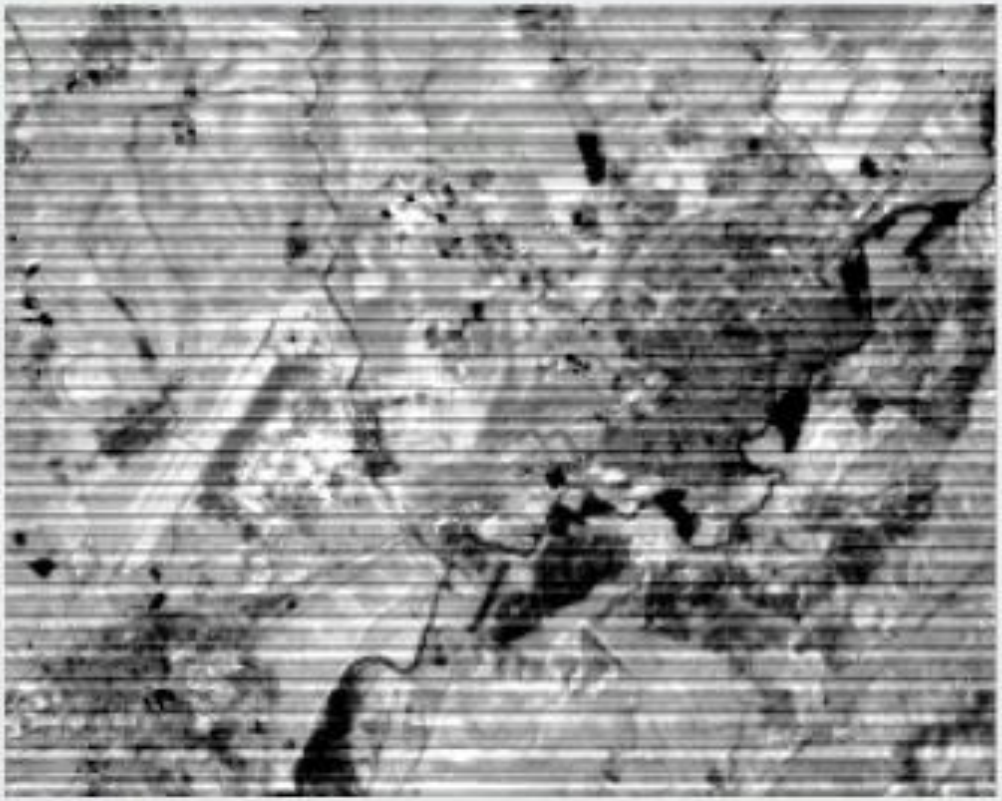
Radiometric noise



Stripping effects in a thermal band of Landsat-ETM+ sensor

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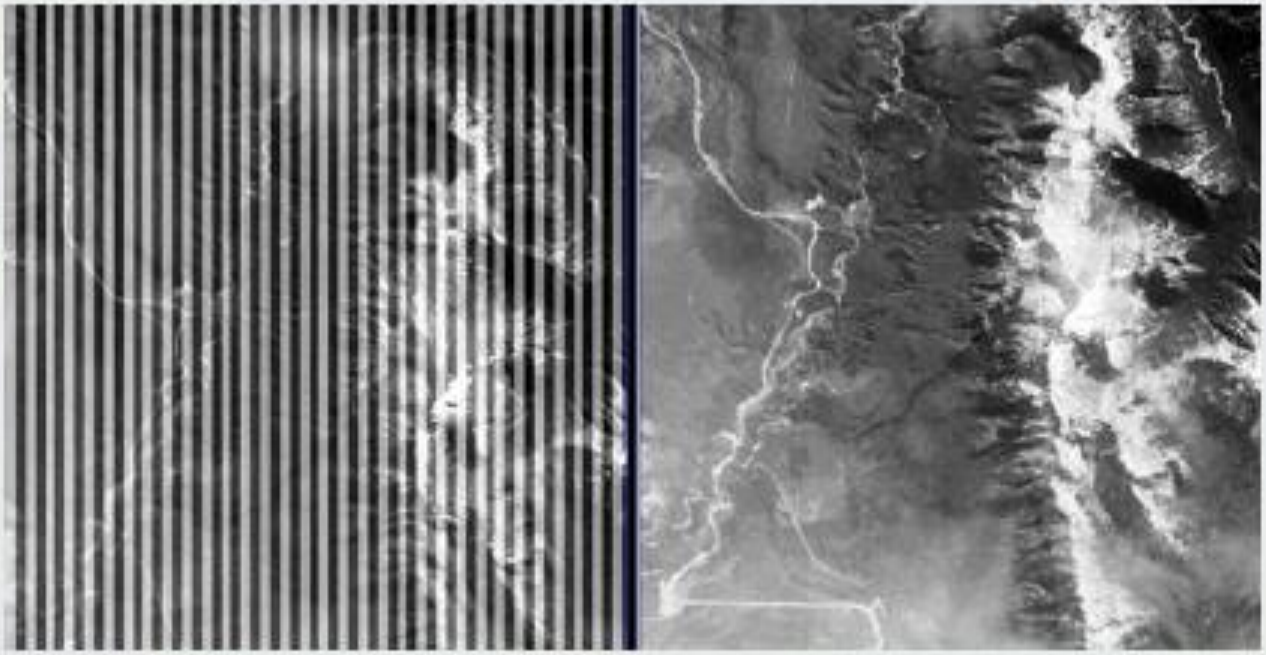
Radiometric noise



Calibration problems in an ALI image. To the right, the original DL; left, the calibrated radiance values. The image was acquired on the Mendoza province (Argentina) on March 27, 2001. (Courtesy: Ruiliang Pu, U.C. Berkeley).

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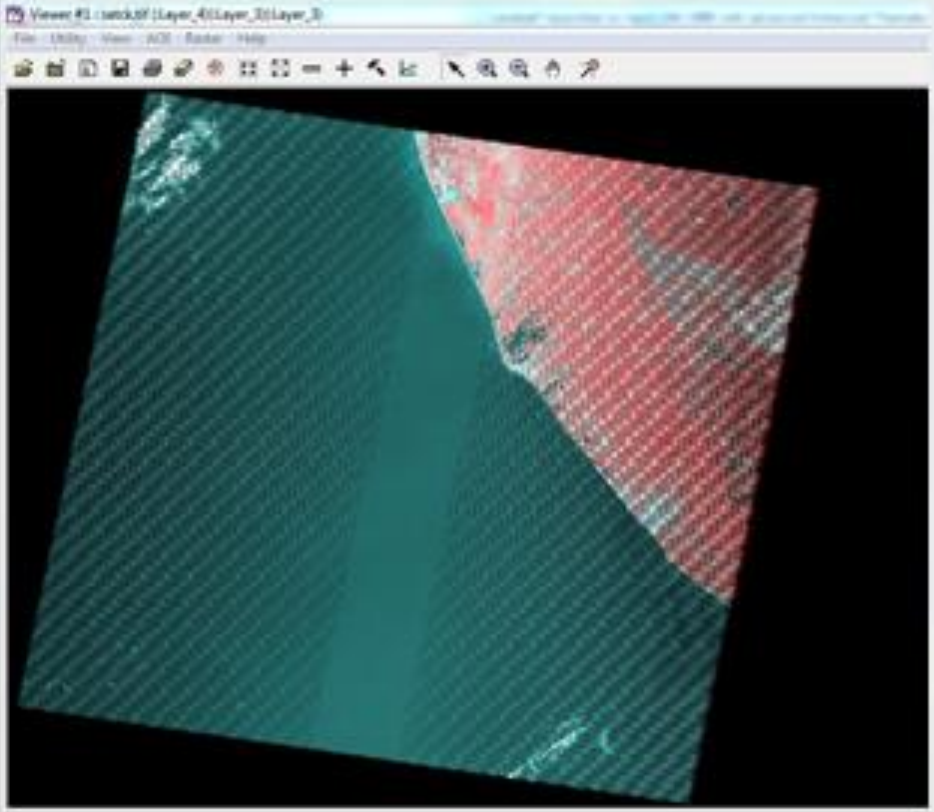
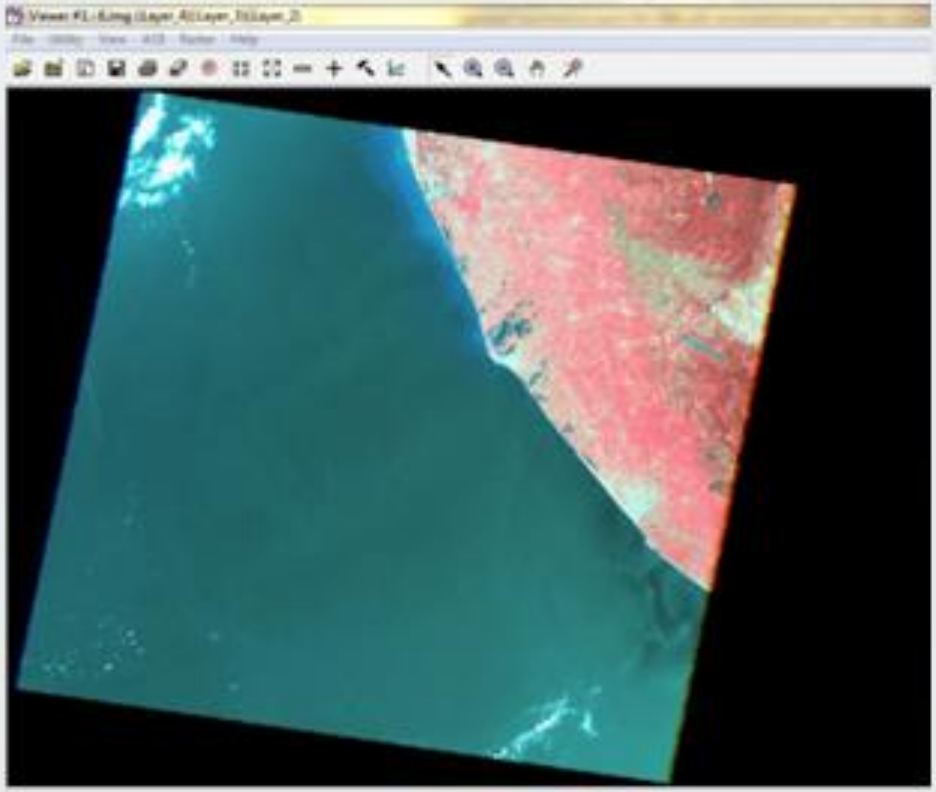
Gapfilling or Destriping Landsat 7 Image for Display





https://www.youtube.com/watch?v=qMlUcmKl3o4

http://grindgis.com/blog/slc-correction-landsat-imagine-erdas-qgis-7

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Conversion to physical units

- Reflectance:
  - Calibration (DL to radiance).

https://landsat.usgs.gov/using-usgs-landsat-product-8

  - Atmospheric correction.

https://www.youtube.com/watch?v=9ED3jnYod6w

- Temperature:
  - Calibration (DL to radiance).
  - Atmospheric correction.
  - Cloud masking.

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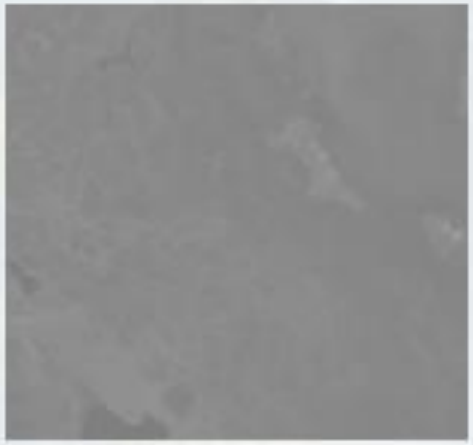
Contrast enhancement

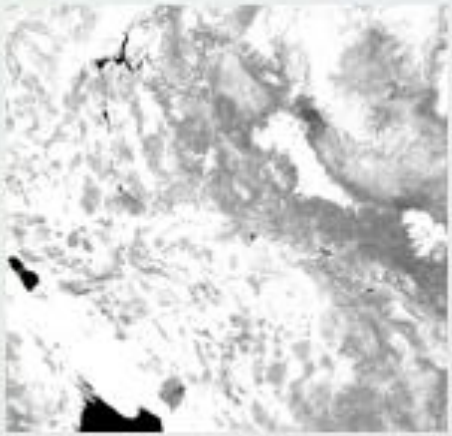
a)



b)

c)

d)



Different types of contrast enhancement over the MODIS image: a) original data; b) linear enhancement; c) frequency enhancement; d) selected enhancement over areas of low radiance

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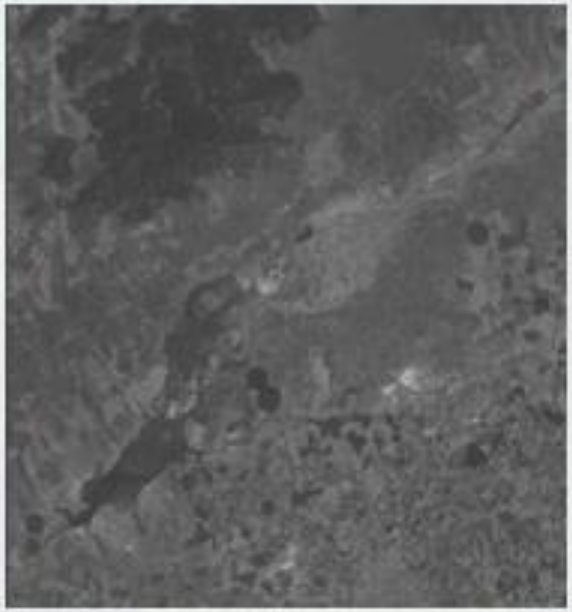
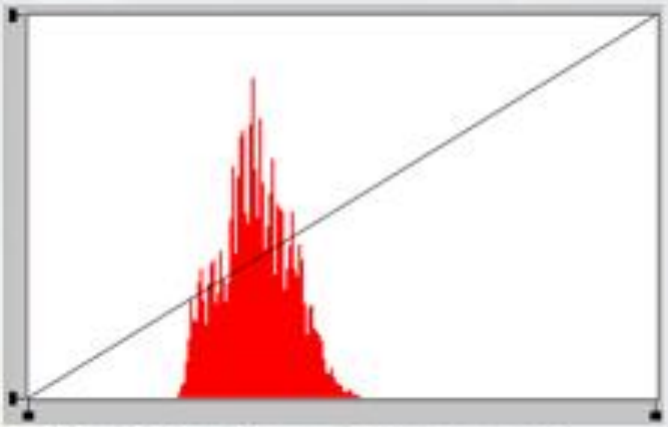
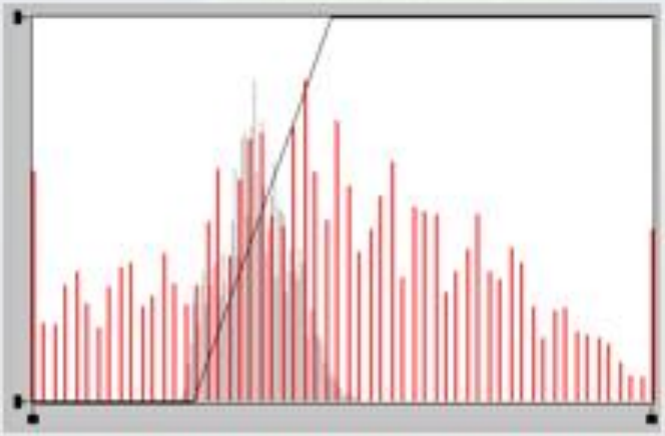
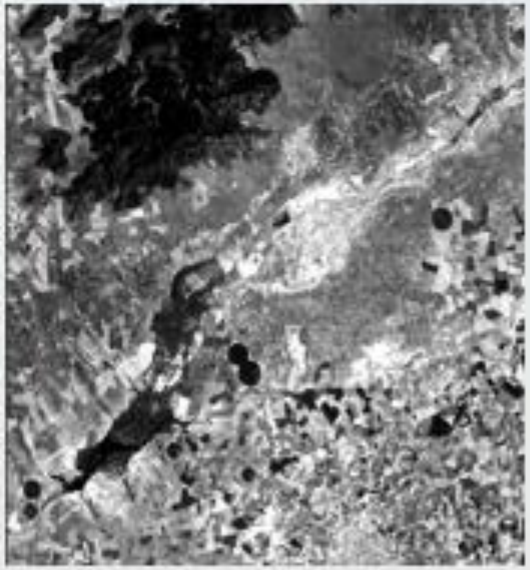
No stretch versus linear stretch









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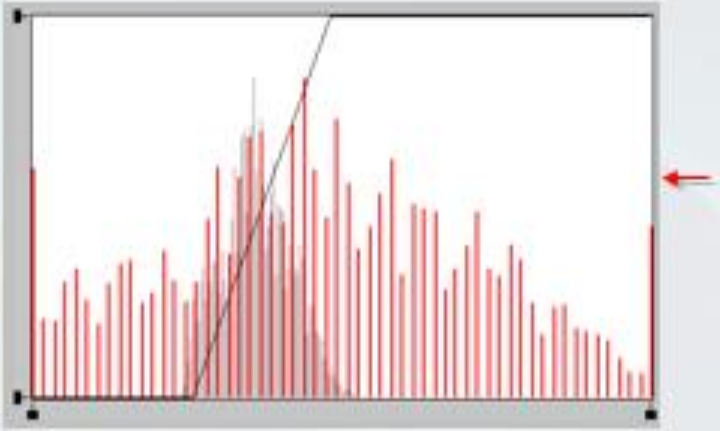
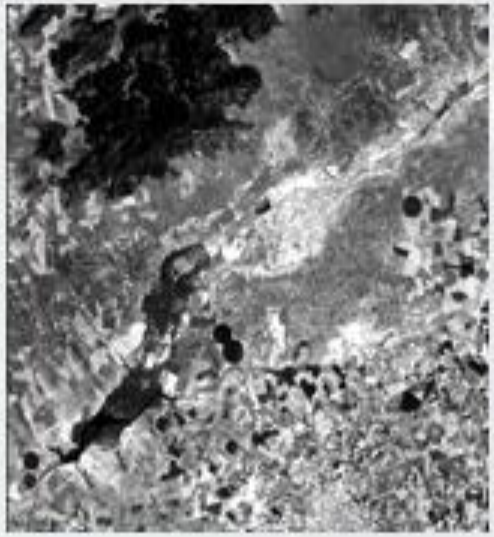
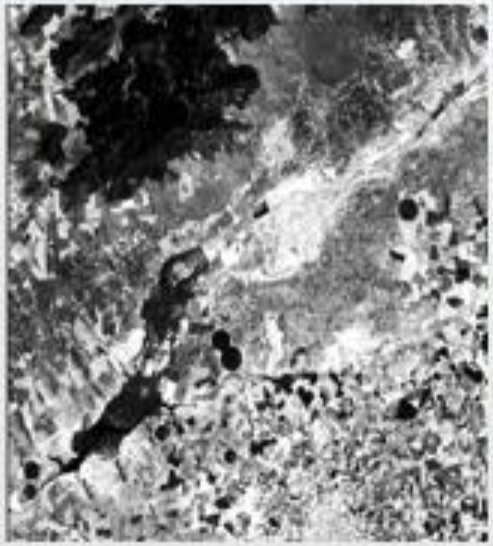
Linear – Gaussian stretch







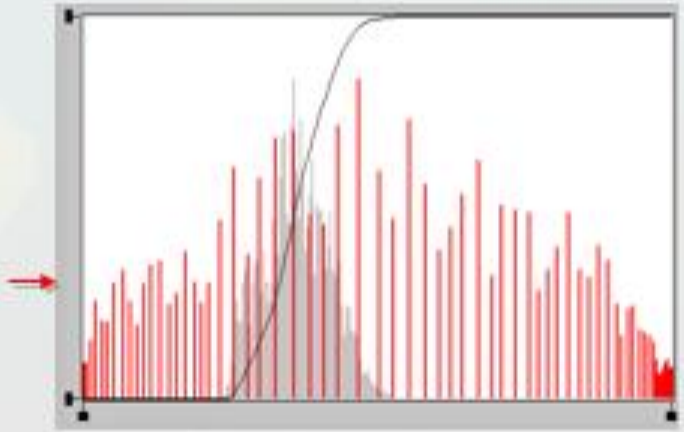


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Image Enhancement Examples in Matlab

```
J = imadjust(I)
J = imadjust(I,[low_in high_in],[low_out high_out])
J = imadjust(I,[low_in high_in],[low_out high_out],gamma)
newmap = imadjust(map, __ )
RGB2 = imadjust(RGB, __ )
gpuarrayB = imadjust(gpuarrayA, __ )
```

Adjust the contrast of the image, specifying contrast limits:

```
K = imadjust(I,[0.3 0.7],[]);
figure
imshow(K)
```

https://www.mathworks.com/help/images/ref/imadjust.html

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Image Enhancement Examples in Matlab

Adjust the contrast of RGB image:

```
RGB = imread('football.jpg');
imshow(RGB)
```

```
RGB2 = imadjust(RGB,[.2 .3 0; .6 .7 1],[]);
figure
imshow(RGB2)
```

https://www.mathworks.com/help/images/ref/imadjust.html

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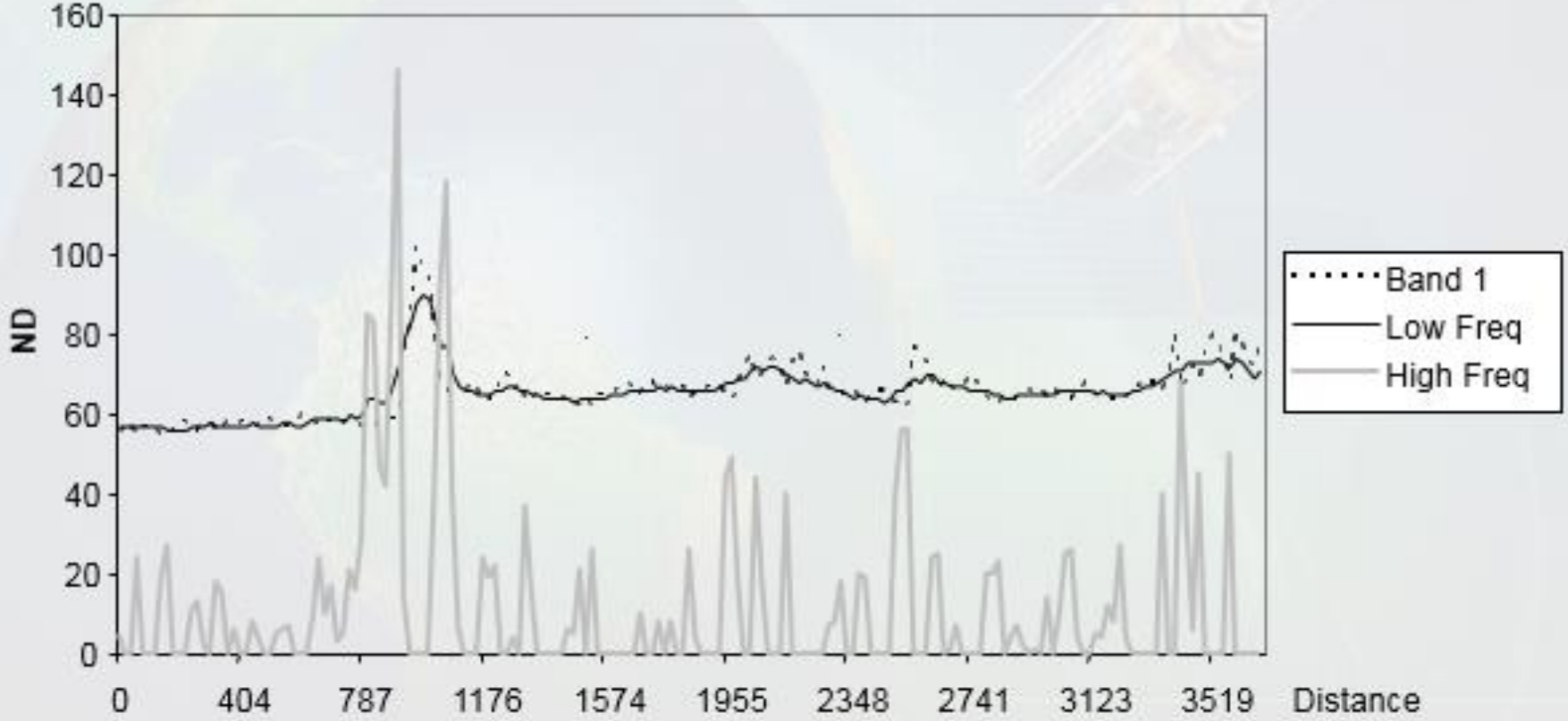
Filtering basics



A radiometric profile is composed of low and high frequencies of spatial variation

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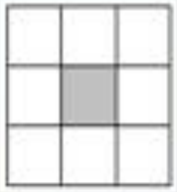
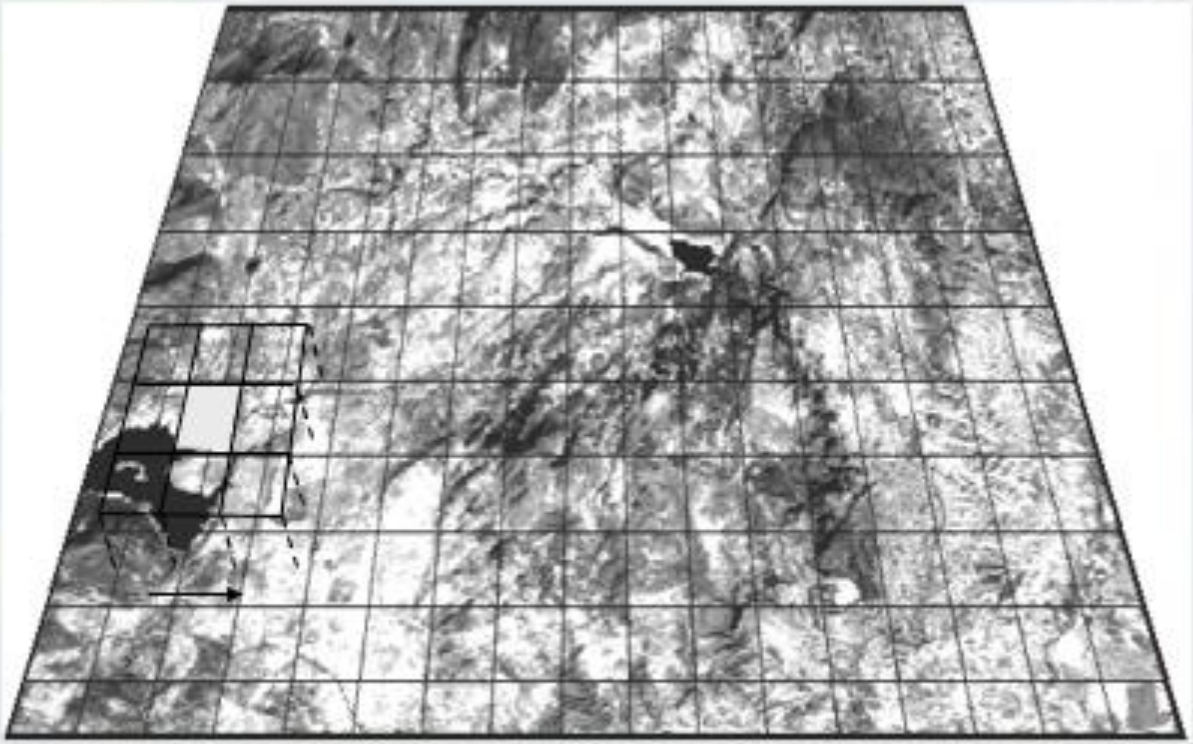
Spatial filters



Kernel



Filtering through the use of spatial moving window (kernel) that is used to define the neighbor pixels.

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Example of digital filtering

12	14	17	24	32	34
10	18	21	35	38	40
25	15	17	27	40	43
18	16	18	24	29	39
14	16	20	20	27	36

Original Image

1	1	1
1	2	1
1	1	1

0	0	0	0	0	0
0	17	21	29	35	0
0	17	21	28	35	0
0	18	19	25	31	0
0	0	0	0	0	0

Filtered Image

https://www.youtube.com/watch?v=pFWmqGbkoWg

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Filter kernels (Low Pass Smoothings)

- A low pass filter is the basis for most smoothing methods. An image is smoothed by decreasing the disparity between pixel values by averaging nearby pixels.
- This electronic filter, on the other hand, is the opposite of the high-pass filter which allows frequency that is below the cutoff frequency to pass through.
- The edge content is reduced. +

(1)

1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00

(2)

1.00	1.00	1.00
1.00	2.00	1.00
1.00	1.00	1.00

(3)

0.25	0.50	0.25
0.50	1.00	0.50
0.25	0.50	0.25

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Filter kernels (High Pass Sharpining)

- A high pass filter is the basis for most sharpening methods. An image is sharpened when contrast is enhanced between adjoining areas with little variation in brightness or darkness.
- The High-Pass filter is the type of electronic filter that allows high frequency waves that are above a certain boundary or a cut off frequency to pass through.
- The edge content is increased. + -

(4)

-1	-1	-1
-1	9	-1
-1	-1	-1

(5)

0	-1	0
-1	5	-1
0	-1	0

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Effects of different filters

High pass

Original

Low pass

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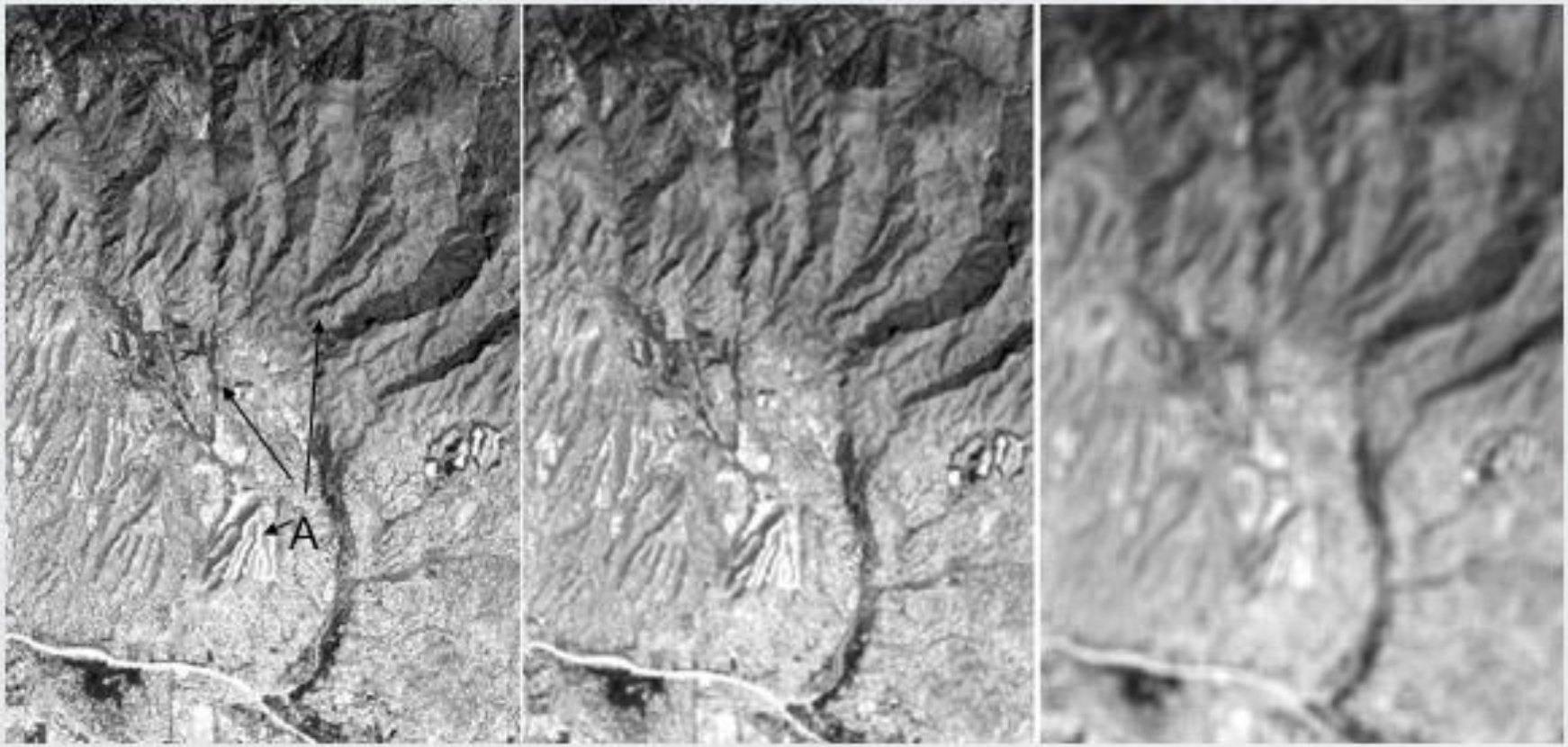
Effects of low-pass filters



Low pass filters on a band 3 window of the Tucson ETM+ image. From left to right: original image, 3x3 filtered, and 9x9 filtered images

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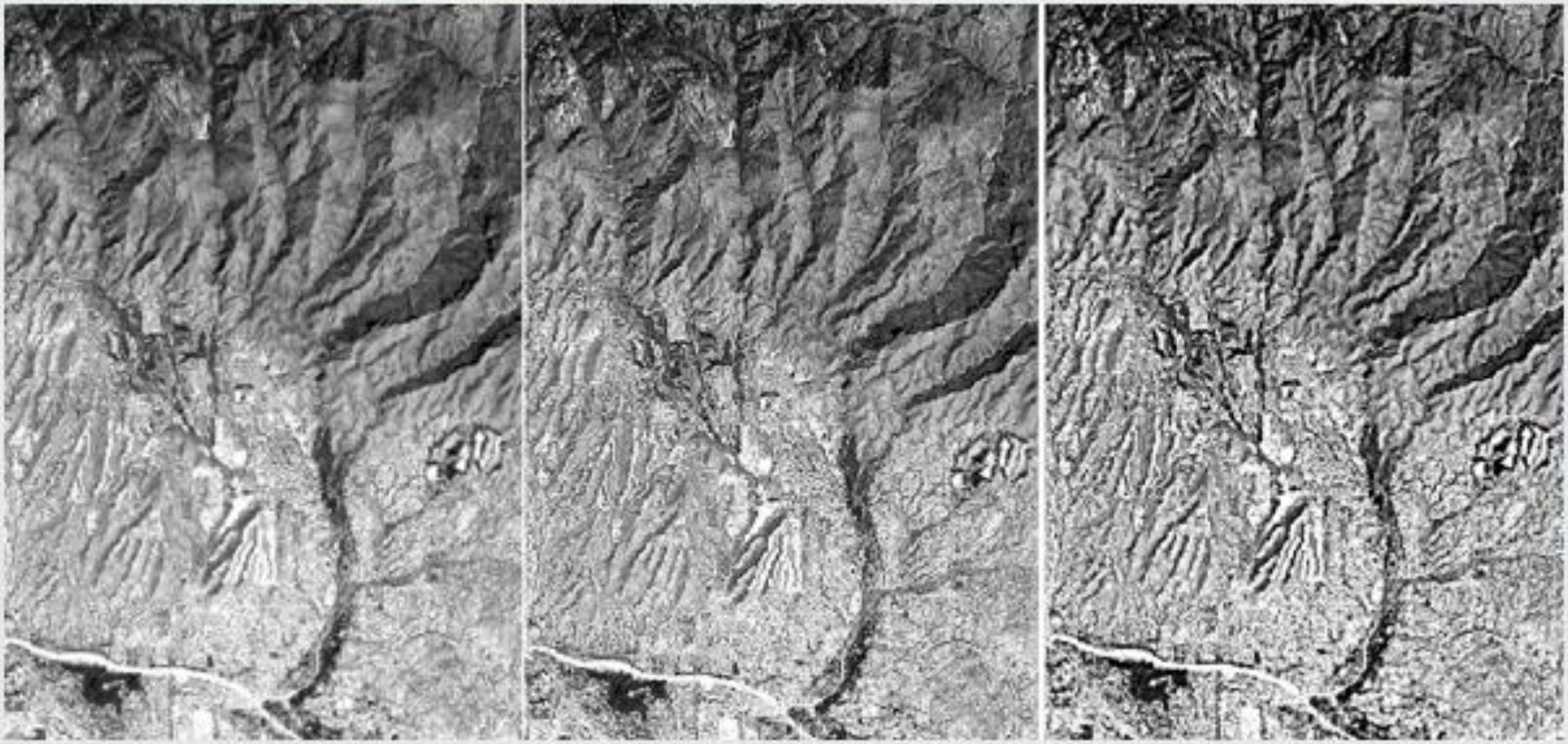
Effects of high-pass filters



High pass filters on a band 3 window of the Tucson ETM+ image. From left to right: original image, 3x3 filtered, and 9x9 filtered images

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Mean Filter

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

```
img = imread('hawk.png');
mf = ones(3,3)/9;
```

```
>> mf = ones(3,3)/9
mf =

    0.1111    0.1111    0.1111
    0.1111    0.1111    0.1111
    0.1111    0.1111    0.1111
```

```
img = imread('cameraman.tif');
imgd = im2double(img);   % imgd in [0,1]
f = ones(3,3)/9;
img1 = filter2(f, imgd);
subplot(121);imshow(img);
subplot(122);imshow(img1);
```

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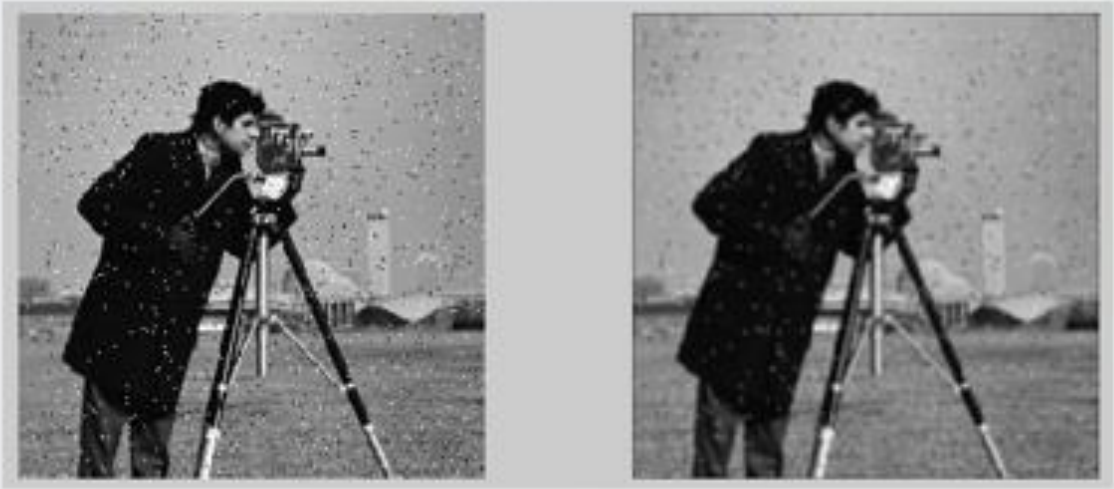
Imagery Denoising

```
img = imread('cameraman.tif');
imgd = im2double(img);   % imgd in [0,1]
imgd = imnoise(imgd,'salt & pepper',0.02);
f = ones(3,3)/9;
img1 = filter2(f, imgd);
subplot(121);imshow(imgd);
subplot(122);imshow(img1);
```



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Median filter - medfilt2()

```
I = imread('cameraman.tif');
J = imnoise(I,'salt & pepper',0.02);
K = medfilt2(J);
subplot(121);imshow(J);
subplot(122);imshow(K);
```

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Removing noise in RGB image

```
I = imread('hawk.png');
J = imnoise(I,'salt & pepper',0.2);

% filter each channel separately
r = medfilt2(J(:, :, 1), [3 3]);
g = medfilt2(J(:, :, 2), [3 3]);
b = medfilt2(J(:, :, 3), [3 3]);

% reconstruct the image from r,g,b channels
K = cat(3, r, g, b);

figure
subplot(121);imshow(J);
subplot(122);imshow(K);
```

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fspecial()

```
h = fspecial(type)
h = fspecial(type, parameters)
```

Value	Description
average	Averaging filter
disk	Circular averaging filter (pillbox)
gaussian	Gaussian lowpass filter
laplacian	Laplacian of Gaussian filter
motion	Approximates the linear motion of a camera
prewitt	Prewitt horizontal edge-emphasizing filter
sobel	Sobel horizontal edge-emphasizing filter

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High Pass Filters

```
% Filter 1
kernel1 = -1 * ones(3)/9;
kernel1(2,2) = 8/9
% Filter the image.  Need to cast to single so it can be floating point
% which allows the image to have negative values.
filteredImage = imfilter(single(grayImage), kernel1);
% Display the image.
subplot(2, 2, 2);
imshow(filteredImage, []);
title('Filtered Image', 'FontSize', fontSize);
```

```
% Filter 2
kernel2 = [-1 -2 -1; -2 12 -2; -1 -2 -1]/16;
% Filter the image.  Need to cast to single so it can be floating point
% which allows the image to have negative values.
filteredImage = imfilter(single(grayImage), kernel2);
% Display the image.
subplot(2, 2, 3);
imshow(filteredImage, []);
title('Filtered Image', 'FontSize', fontSize);
```

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Gaussian High pass Filter

```
function GaussianHighpass
a=imread('cameraman.tif');
figure(1)
imshow(a)
[m n]=size(a);
f_transform=fft2(a);
f_shift=fftshift(f_transform);
p=m/2;
q=n/2;
d0=70;
for i=1:m
for j=1:n
distance=sqrt((i-p)^2+(j-q)^2);
low_filter(i,j)=1-exp(-(distance)^2/(2*(d0^2)));
end
end
filter_apply=f_shift.*low_filter;
image_orignal=ifftshift(filter_apply);
image_filter_apply=abs(ifft2(image_orignal));
figure(2)
imshow(image_filter_apply,[])
```

https://www.youtube.com/watch?v=z_dkB7vtDL0

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Thank You!

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