Assignment 3

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# Frequency Domain Filtering

A close up of a fabric surface

Description automatically generated with low confidence

Figure a DFT of Sinusoidal Image

A picture containing text

Description automatically generated

Figure Ideal Low Pass Filter with D0 = 100

The ringing effects generated by the ideal low pass filter are visible.

A picture containing text

Description automatically generated

Figure Gaussian Low Pass Filter with D0=100

The ringing artifacts are not generated by gaussian low pass filter.

# Image Deblurring

A picture containing text

Description automatically generated

Figure Inverse Filtering output of Low Noise Image with Threshold t=0.1

A sign on a wall

Description automatically generated with low confidence

Figure Inverse Filtering output of High Noise Image with Threshold t=0.1

Inverse filter deblurring amplifies the noise frequencies in the Fourier domain which in turn causes noise boost in the spatial domain.

A sign on a building

Description automatically generated with low confidence

Figure Weiner Filtered Image with High Noise

A picture containing text

Description automatically generated

Figure Weiner Filtered Image with Low Noise

# Image Denoising

A sign on a window

Description automatically generated with low confidence

Figure Mean Filtered Image with 5x5 square window

A picture containing text

Description automatically generated

Figure Median Filtered Image with 5x5 Square Window

A sign on a window

Description automatically generated with low confidence

Figure 10 Bilateral Filtered Image

Bilateral Filter Function takes about 1.5 minutes to compute.

The difference between Bilateral Filtered image and Gaussian Low pass filtered image lies around edges. The Gaussian Filter smoothens out the edges along with noise whereas Bilateral can maintain edges along with mitigating the noise. Hence, Bilateral Filter is not exactly a Low Pass filter. It can retain High frequency information.

The second difference is Gaussian Low pass filter is Linear Space Invariant system whereas Bilateral Filter is not.

# Bonus Question

I have used SciPy’s inbuilt gradient descent function ‘fmin’ to perform least mean square minimization.

The following exercise shows that some zero one entries are inevitable and will reflect up in the mean squared error, but any form of discrete Laplacian filter can be approximated using generic Laplacian filter in frequency domain.

The value of K is more in ‘b’ as compared to ‘a’. This means that the second filter boosts the high frequency components more as compared to the first one.

1. K = -3.36499023

Laplacian Matrix:

[[ 0. -0. -0.575 -0. 0. ]

[ -0. -0. 3.94 -0. -0. ]

[ -0.575 3.94 -13.46 3.94 -0.575]

[ -0. -0. 3.94 -0. -0. ]

[ 0. -0. -0.575 -0. 0. ]]

1. K = -4.84643555

Laplacian Matrix:

[[ 0. -0. -0.828 -0. 0. ]

[ -0. -0. 5.674 -0. -0. ]

[ -0.828 5.674 -19.386 5.674 -0.828]

[ -0. -0. 5.674 -0. -0. ]

[ 0. -0. -0.828 -0. 0. ]]