Introduction to Fourier Transform:

In basic understanding, Fourier transform decomposes the Image (time domain signal or spatial domain) into sin and cosine function that represents into the Fourier (frequency domain). In frequency domain plot, each point is represented a frequency of the spatial domain plot. The Fourier transform is used when some one wants to analyse the geometric characteristics (repeating pattern or noise) of the spatial domain signal. Because that geometric characteristic has a frequency that we can easily see (It has major spike or higher magnitude) in the frequency domain plot (Known as Power Spectral Density (PSD) Plot). In basic, Low frequency has more image information than high frequency (Edge). Low frequency term in the frequency domain is defined as when the gradient in the gray scale is changing slowly. And high frequency term is defined as when the gradient in the gray scale is changing rapidly (you can assume the edge). So the application of image processing is used in image enhancement, image reconstruction, image compression.

We have given the thoracic radiograph image of lung, which has Gaussian and fix pattern noise (FPN). we have to remove pattern noise.in this situation, if we plot the PSD, that FPN is easily detectable by having large magnitude peak. And if we remove this peak from the PSD, we are removing the corresponding frequency to FPN, it will remove only the FPN and other data is same as before. So this is the interesting thing about the Fourier transform that.

My Approach:

Step 1 : Read the Image.

Step 2: Plotting the FFT (Fast Fourier Transform) of the Image. Here 2d FFT is performing. In 2d FFT plot, Fourier coefficient dynamic range is very large to display on the screen, so we are using the log transformation of the image to see after performing 2D FFT.

Step 3: we are cutting some of the Lower frequency, because we know most of the image information is lies in the lower frequency that has high magnitude. So when finding the peak for the FPN, we will not detect the lower frequency peak which has actual information. My cut of frequency is 0.15 (as recommended).

Step 4: Plotting the IFFT (Inverse Fast Fourier Transform) to visualise after cut-off low frequency, to make sure that after cutting the Low frequency still we have the FPN in the image. Because when I tried to go above this cut-off frequency, I observed FPN is going blurry.

Step 5: Plotting the PSD for both (Original & cut-off) Images. BY doing step 4, still in PSD Image of cut-off frequency, we have major spikes that correspond to the FPN.

Step 6: Removing the FPN by detection of the peak in the PSD. For this I have directly used findpeaks matlab function. My approach is simple; I have detected all the peaks in the PSD by giving certain threshold to the magnitude of FFT. Here I did this analysis in 3 phase. Because at the central if I am doing thresholding with the actual threshold they are detecting some more peaks from the Low frequency, that might be other noise. So made 3 different loop (total image has 901 rows). Loop 1: analyse the row 1:300, that has less threshold. Loop 2: 301:600 rows, that has higher threshold(So it will detect only peak from FPN). Loop 3: 601:901 rows, that has lower threshold. Threshold value is commented in the code.

Step 7: Here we know, in the PSD plot we have large peak line in horizontal and vertical direction from the central DC point. It is the information of the edge in the corresponding horizontal & vertical direction. So I am not removing anything from that direction. So, after doing the peak detection, I am putting back those all cut-off frequency data and horizontal and vertical line data ascites. SO if there is some peak point in that 3 area it should be removed.

Step 8: After finding the peak, I am saving the location of that peak. This is further used to make an image of all the peaks inside the PSD, according to their location.

Step 9: after this I realised that some of the peak it is detecting from the Low frequency which is actually not a FPN. SO I have made a matrix with zeros and placed into the centre (DC). So that detected Low frequency components are zero.

Step 10: I have made the image of the peak according to their location. So, I make the loop, that work is to if the spike is detected it will multiply with the 5x5 kernel of ones. So, all the surrounding pixels are automatically detected and make the value 1. And making a mask (where the binary mask has value 1, where the peak is there)

Step 11: Invert that mask and applying this mask the original 2D FFT. That will remove this all spikes. And find the IFFT.

Step 12: Plotting the reconstructed Image.

Step 13: For finding the angle of the FPN, I have choose the 1 point which is detected in peak detection algorithm. And find the same pixel location in 2D FFT plot. That point in 2D FFT is complex. So directly using the angle matlab function. And find the angle of the FPN.

Results:

1. Image 7A:



Fig 1: Reconstructed Image 7A:

Here In fig 1, we can see that the FPN is successfully remove.

1. Image 7G:



Fig 2: Reconstructed Image 7F

Here in both Images, I observed that my thresholding is working well. But they are detecting some unnecessary peaks in the PSD. That might be other noise present in the image. If I tried other threshold combination, some how it is not detecting major high frequency FPN peaks. And I observed that in my final mask after eliminating that peaks, somewhat near the center and after the cut-off frequency, some peaks are detecting, that might be supress some of the low frequency peaks, but still I am assuming that it is noise peaks. So it is fine that I am removing that.

For Image G, angle of FPN = 75 degree or 165 degree.

For Image A, angle of FPN = 10 degree or 100 degree.

Disadvantage : Sometimes if we are cutting off some low frequency components(by Using filters) to prevent the data. After that, we are doing the FFT and again IFFT. If we compare both images side by side, we can see some ringing effect (especially at the boarders). So at this time we cannot remove that kind of ringing. But we can average that thing to remove the ringing effect.