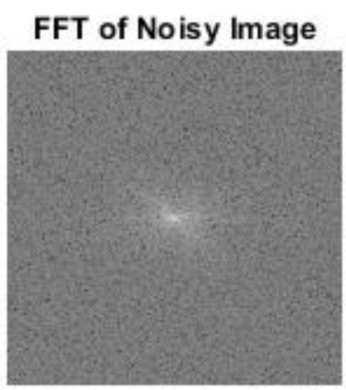
EEE 508 - Fall 2022

Project 1- Image Denoising using sub-band wavelet transform.

A walk-through of the project:

Step 1: Reading the data. The given images are 512x512-8bit images.



- One of the given images is a clear black-and-white image.
- The other is a noisy version of the same.
- In this initial step, the Fast Fourier Transform of the noisy image is plotted.
- The following show the Image, the noisy version and the FFT of the noisy image:

Step 2: 16-band dyadic decomposition.

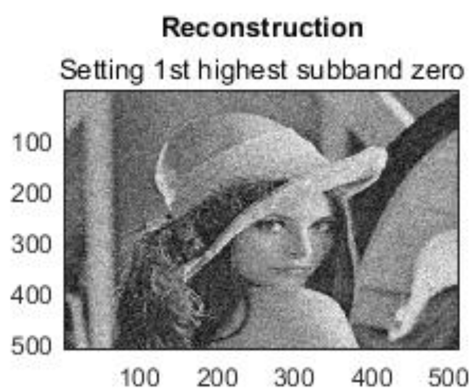
- The 16-band dyadic decomposition is performed by using the inbuilt MATLAB function "[A,H,V,D] = swt2(X,N,wname) returns the approximation coefficients A and the horizontal, vertical, and diagonal detail coefficients H, V, and D, respectively, of the stationary 2-D wavelet decomposition of the image X at level N using the wavelet wname." Since 16 bands are needed, a 5-level swt2 would satisfy the requirements.

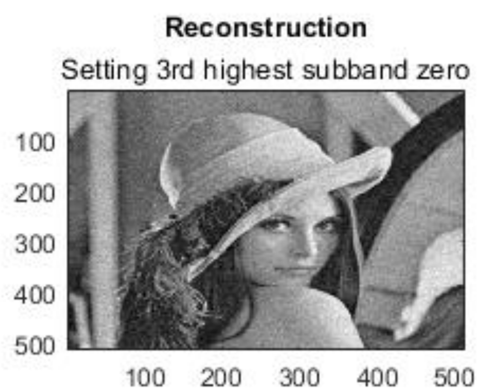
Step 3: Reconstruction.[1]

- Designed a for loop to reconstruct approximation at Level 5-1 taking the s details from coefficients.
- My next goal was to reconstruct and display approximations at Levels 1, 2, 3, 4 from approximation at Level 5 and details at Levels 1, 2, 3, 4 and 5.

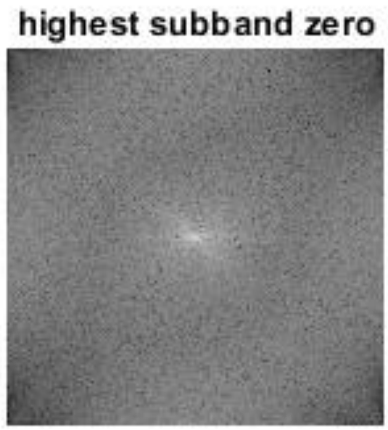
Step 4: Set the required High frequencies to zero.

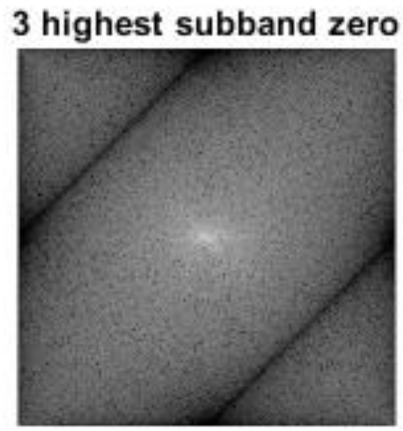
- Used a zero matrix of size 512x512 to force the required bands to 0.
- Found the Fourier transform of the noisy image when 1st,3rd and 6th highest frequencies are zero respectively.
- The following displays the reconstructed image in all three cases:

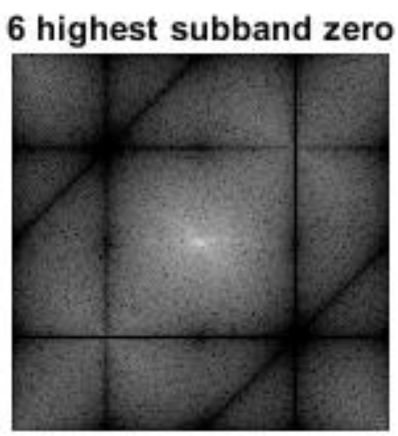




- The following displays the Fourier transform of the three cases:

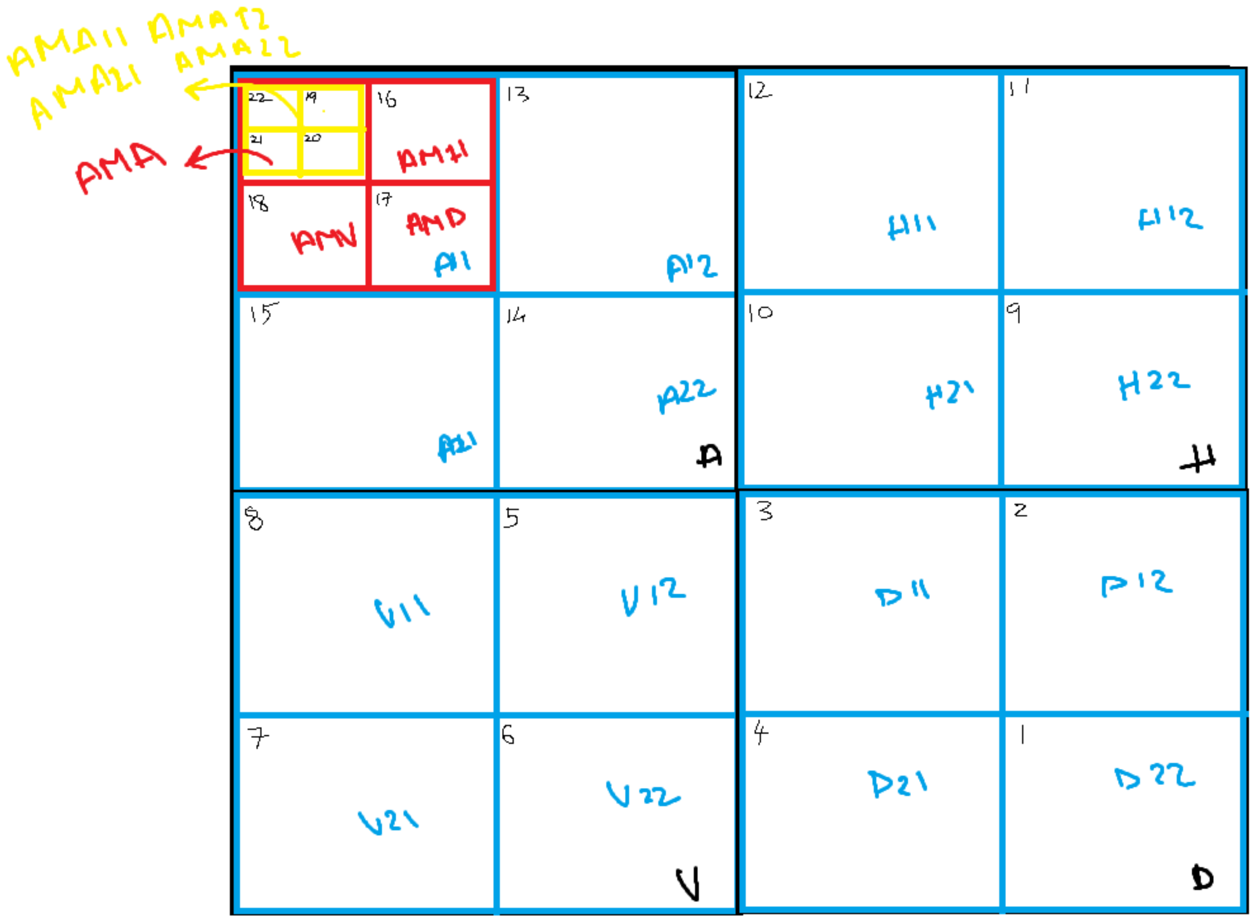






Step 6: Modified dyadic decomposition, with 22 sub-bands.

- The following shows the nomenclature used for each sub-band in the project.

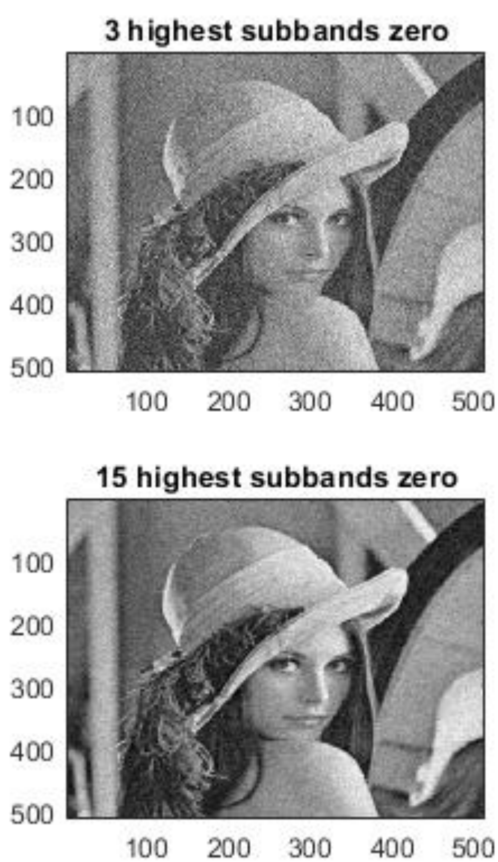


- The swt2 is used again, but instead of using 5 levels, we level 1 decomposition to different sub-bands.
- To achieve 22 sub-bands, we perform a level two swt2 on the approximation layer A11 (from the figure shown above).

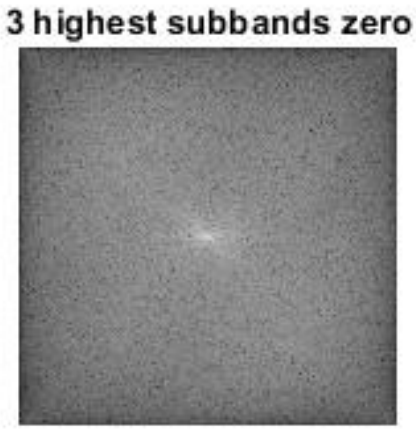
Step 7: Reconstruction.[1]

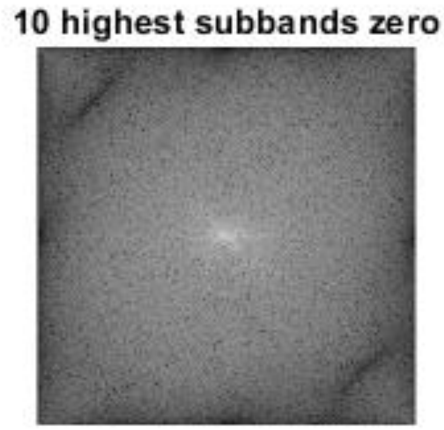
- Performing the inverse Fourier transform of all the decomposed levels for the reconstruction.
- On the contrary a for loop is not used in this as it’s not the same as the 16-band.
- Here we can just perform the inverse for the coefficients that aim towards the three given Cassie. 3 highest sub bands zero,10 highest sub bands zero
- For the reconstruction without the 3rd highest frequency, we need A,H,V and D11 from the figure above, and force the rest to zero.

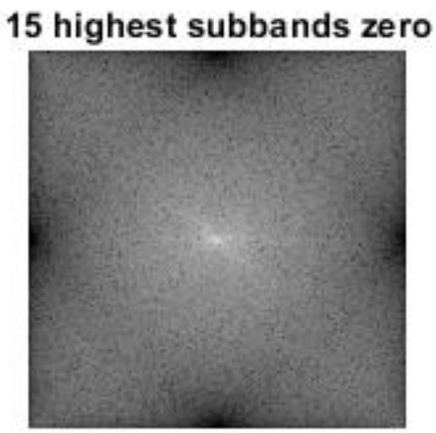
- For the reconstruction without the 10th highest frequency, we need A, Inverse of H11and inverse of V11 from the figure above and force the rest to zero.
- For the reconstruction without the 15th highest frequency, we need A11 from the figure above, and force the rest to zero.
- Found the Fourier transform of the noisy image when 3rd, 10th and 15th highest frequency are zero respectively.
- The following displays the reconstructed image in all three cases:



- The following displays the Fourier transform of the three cases:







Conclusion:

- As we go removing higher frequency components, we achieve better denoising but at the same time we lose detail.
- We do this, as noise usually is at a higher frequency.
- This is seen in the case of 16-suband dyadic decomposition. On the contrary we observe that the detail is not lost in the case of the 22-suband modified dyadic decomposition.
- The modified achieves better results with lesser computation.
- The dark regions in the FFT graphs signify the removing of the frequencies.

References:

1. https://www.mathworks.com/help/wavelet/ug/two-dimensional-discrete-stationary-wavelet-analysis.html