APP PHY 157 WFY-FX-2

*LAB REPORT 3*

# FT Properties and Applications (Part 2 of 2)

Source code here!

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*https://github.com/lovelyandeo/AP157-Computational-Analysis-and-Modeling-in-Physics*

# Background

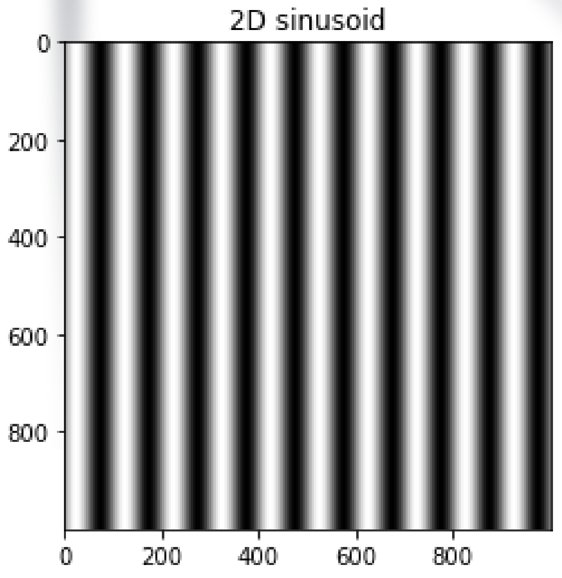
Fourier transform (FT), as mentioned in the previous lab report, is a very useful image processing technique used in a wide array of applications such as image analysis, image filtering, image convolution, etc. Getting the FT of a signal will return a histogram of spatial frequencies which, unlike ordinary histograms, can be reversed.

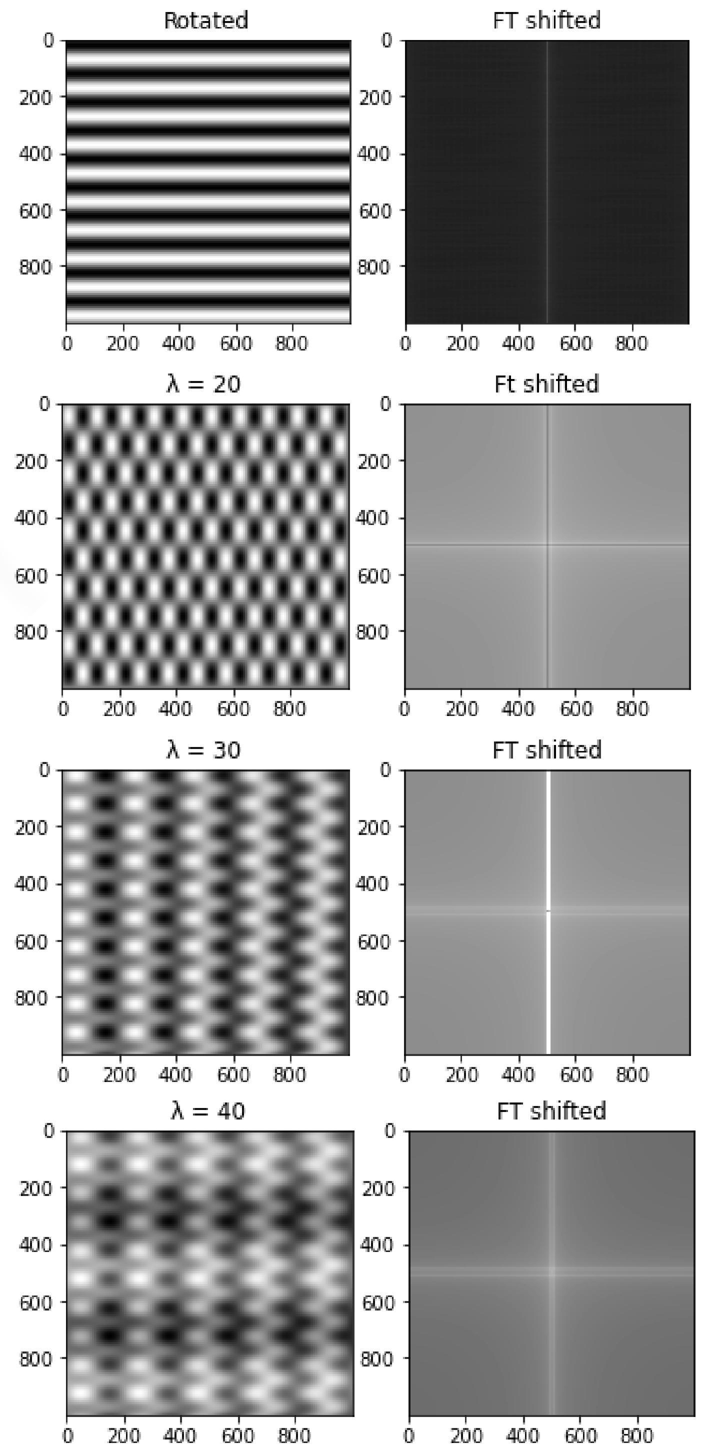
# Objectives

*In this activity, we aimed to explore the property and different applications of FT in terms of:*

1. Its rotation property
2. Canvas weave modeling and removal
3. Convolution theorem redux
4. Ridge enhancement
5. Line removal

# Results and Analysis



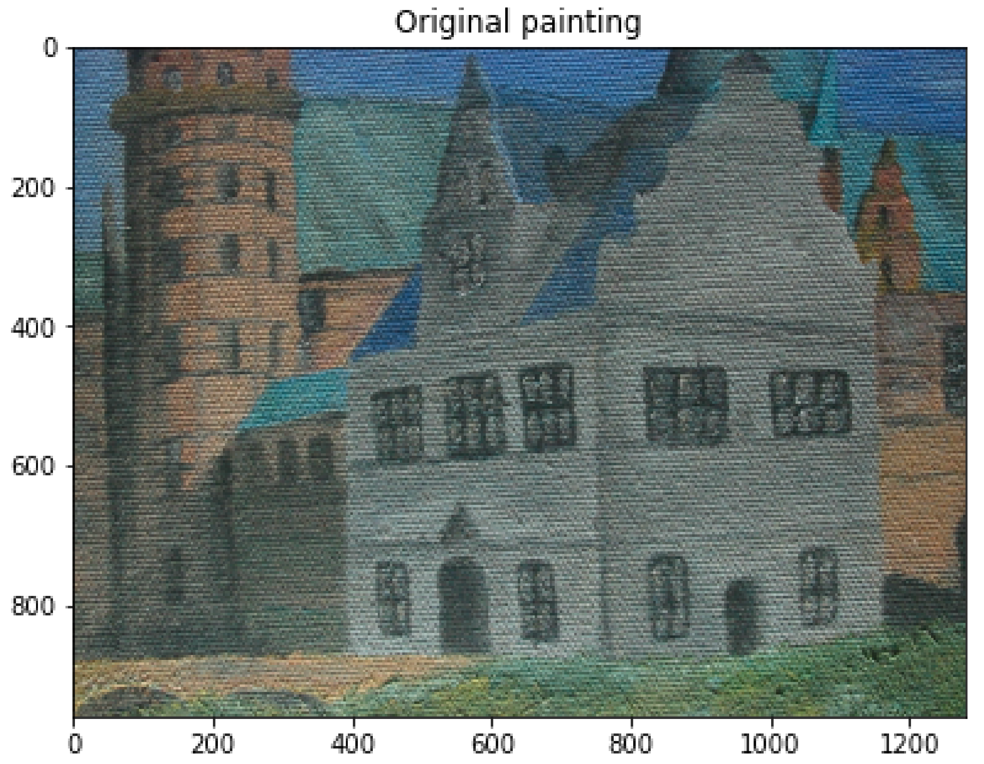




The goal of this activity is to analyze what happens to the FT of the sinusoid when rotated and when more sinusoids of different frequencies are added to it. On the leftmost image is the original sinusoid, and when rotated by 90 degrees, the weights of the frequency components also changed. This altered the amplitude distribution of the FT, so its frequency domain was also rotated. Moreover, when sinusoids were added, their amplitudes basically added up and created a checkered pattern as they intersect. Their FT also changed as additional straight lines were added corresponding to different amplitudes and frequencies.

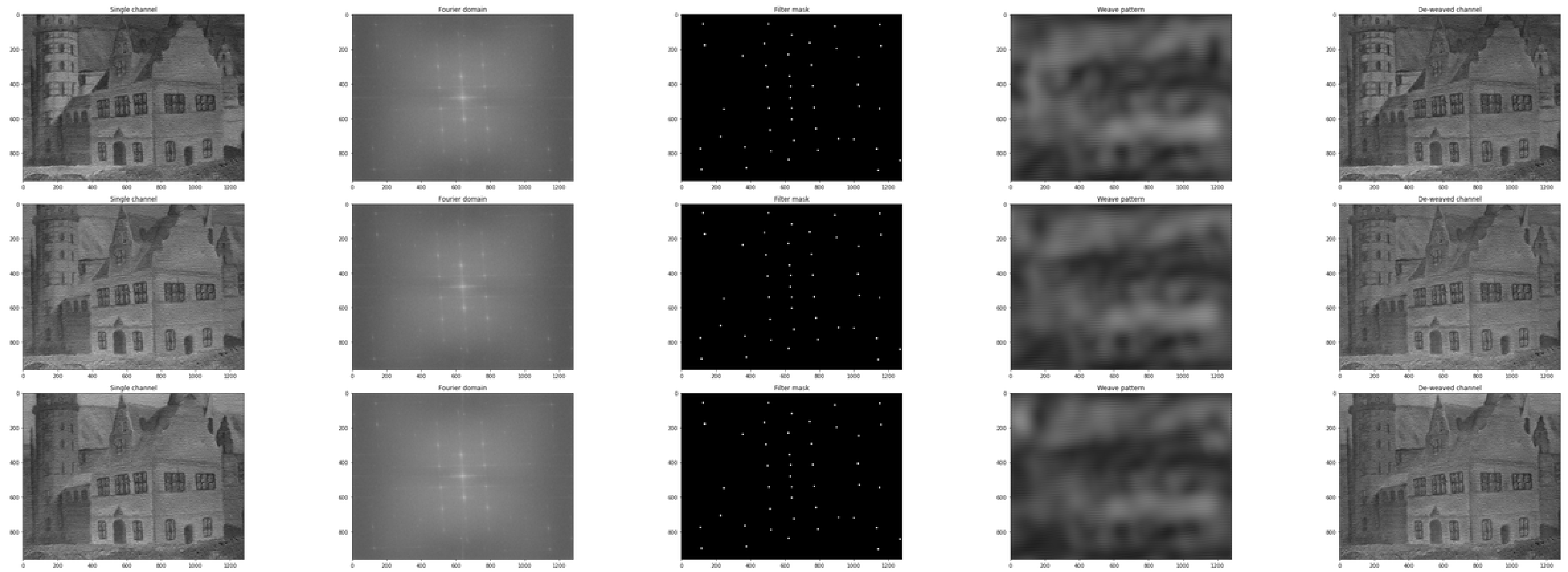
Therefore, the rotation property of the FT says that rotating an image in the spatial domain corresponds to a phase shift in the frequency domain. And the FT of added sinusoids corresponds to just the added FT of individual sinusoids.

**Rotation Property of the FT**

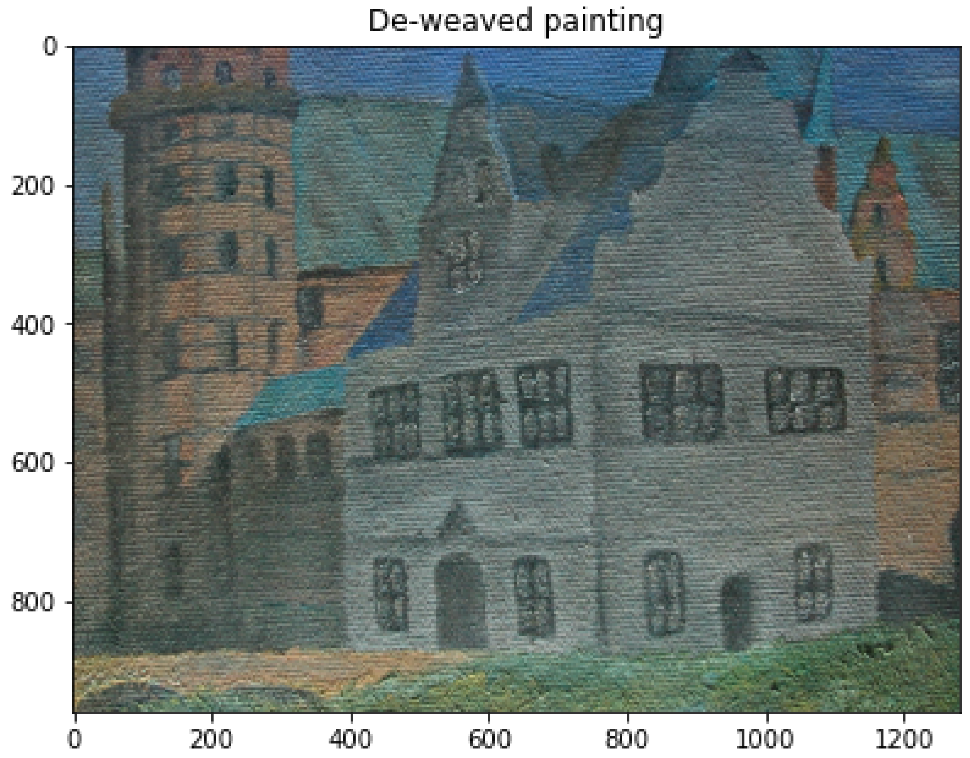
# Canvas Weave Modeling and Removal



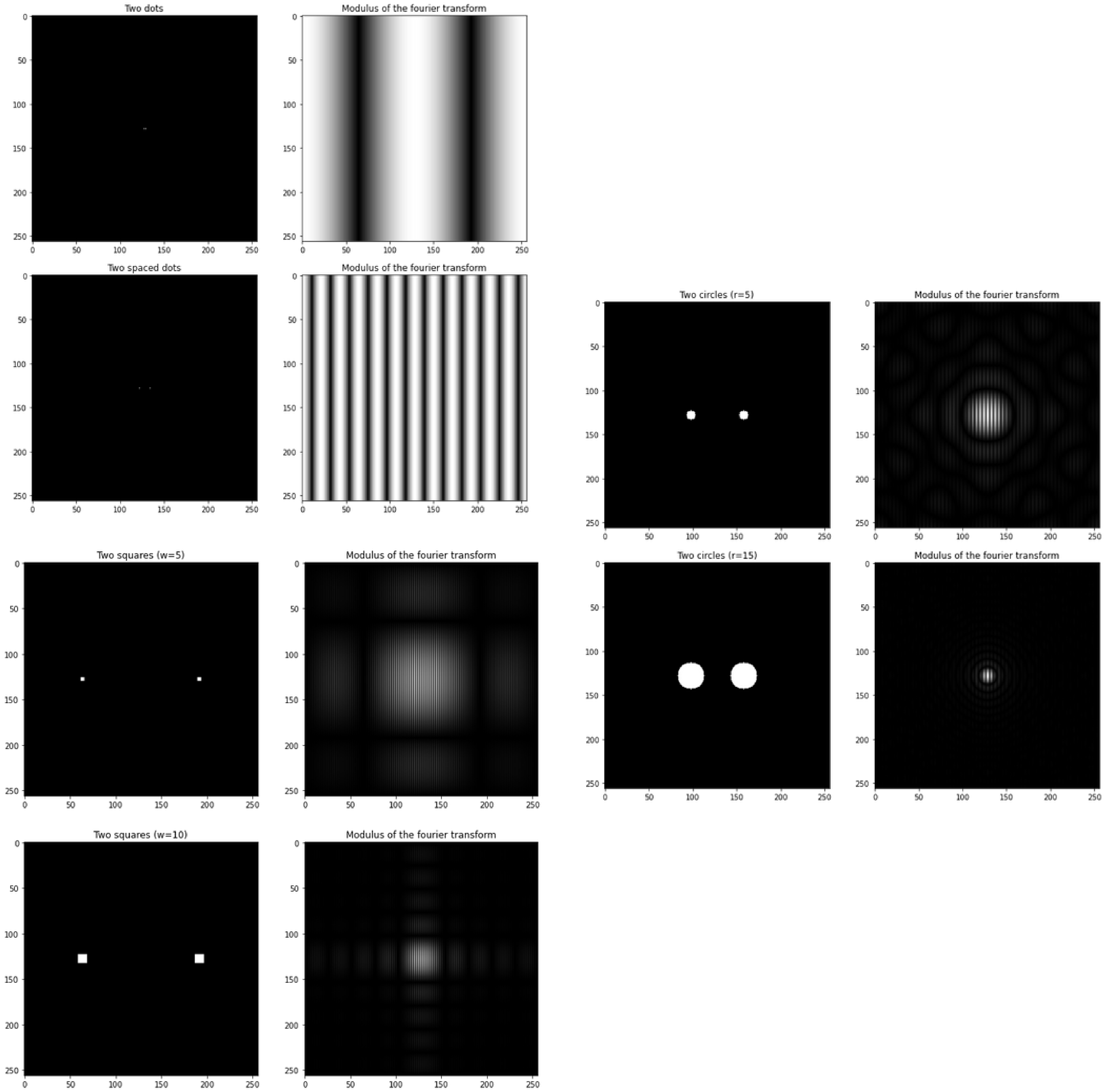

From the original painting, we can see the weave patterns peeking through due to the texture of the canvas. Another great application of the Fourier transform is that we were able to eliminate or at least reduce these patterns, by taking advantage of the fact that the FT of an image separates it into different frequency components representing certain patterns or details of the image.



In order to do that, we created a mask based on the peaks of the patterns in the Fourier domain. It was then multiplied with each of the color channels giving us the final deweaved painting below. What essentially happened is that the convolution modified the pixel value of the original image removing the unwanted pattern.




Finally, comparing the final image with the original, it shows that the weave pattern was somewhat lessened although not a hundred percent. Since the weave pattern itself takes up the entirety of the image, it's possible that removing all the frequency components associated with the pattern may also remove some of the underlying details or features in the image. However, using a better mask will probably result in a better image output and will lessen the visibility of the pattern alot more.

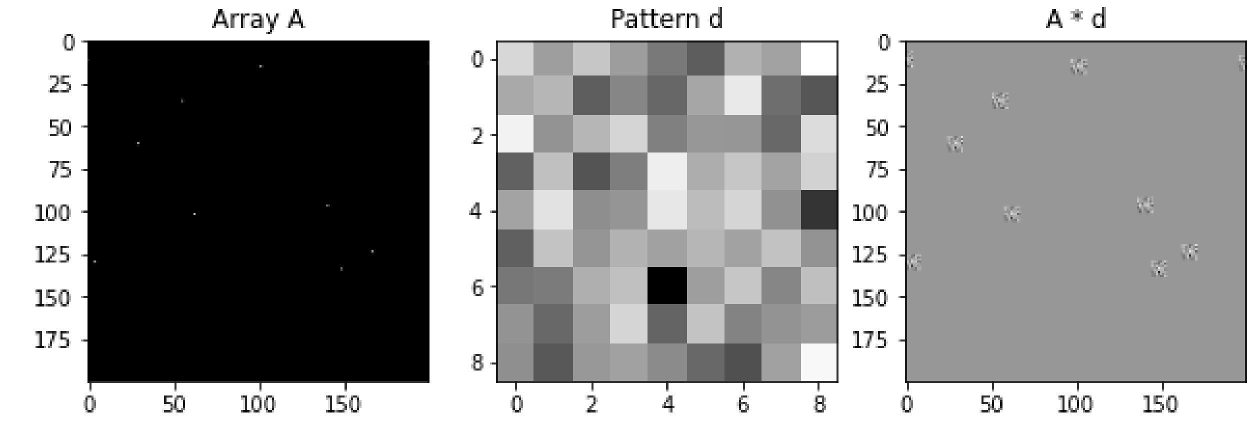



For this part, the Fourier transform modulus of different shapes was observed. The two dots that were closely spaced in the spatial domain created a sinusoidal pattern. This is due to the interference of the dots in the Fourier domain. Whereas the FT modulus of the two circles shows the intensity of the peaks with vertical lines inside corresponding to the high-frequency components of the image. The same phenomena were observed with the square image.

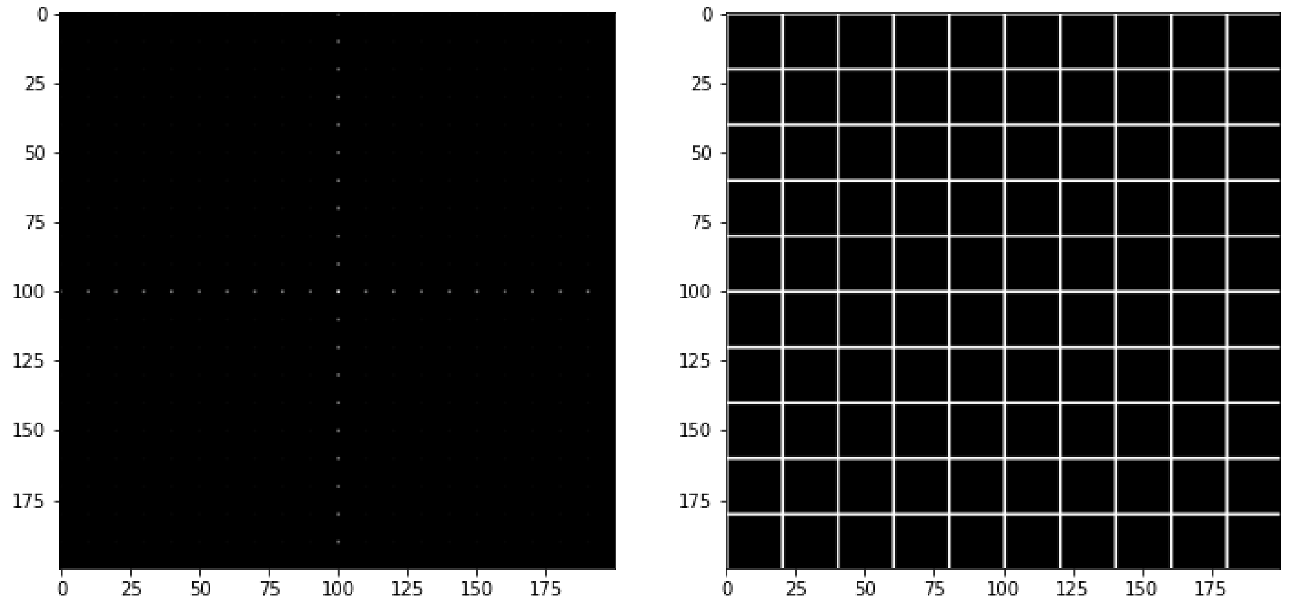
Generally, the peaks of the image in the Fourier domain depend on the radius, width, and or position of the patterns in the images. The larger the radius and with, the smaller the smaller the pattern was in the Fourier domain.

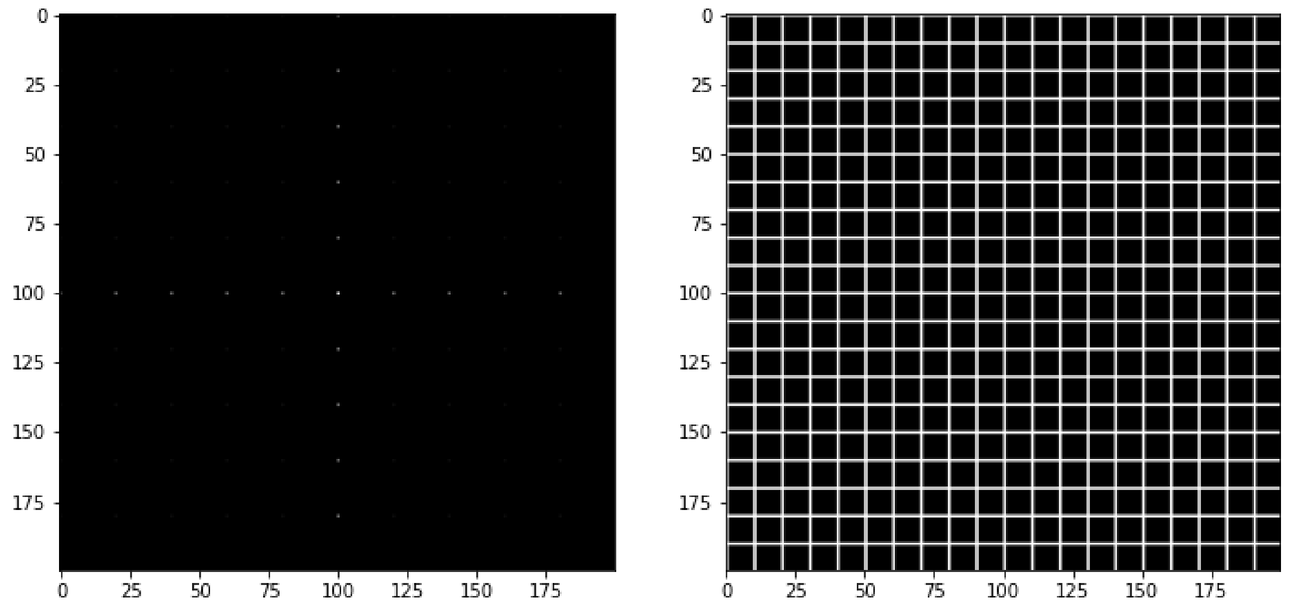
# Convolution Theorem Redux

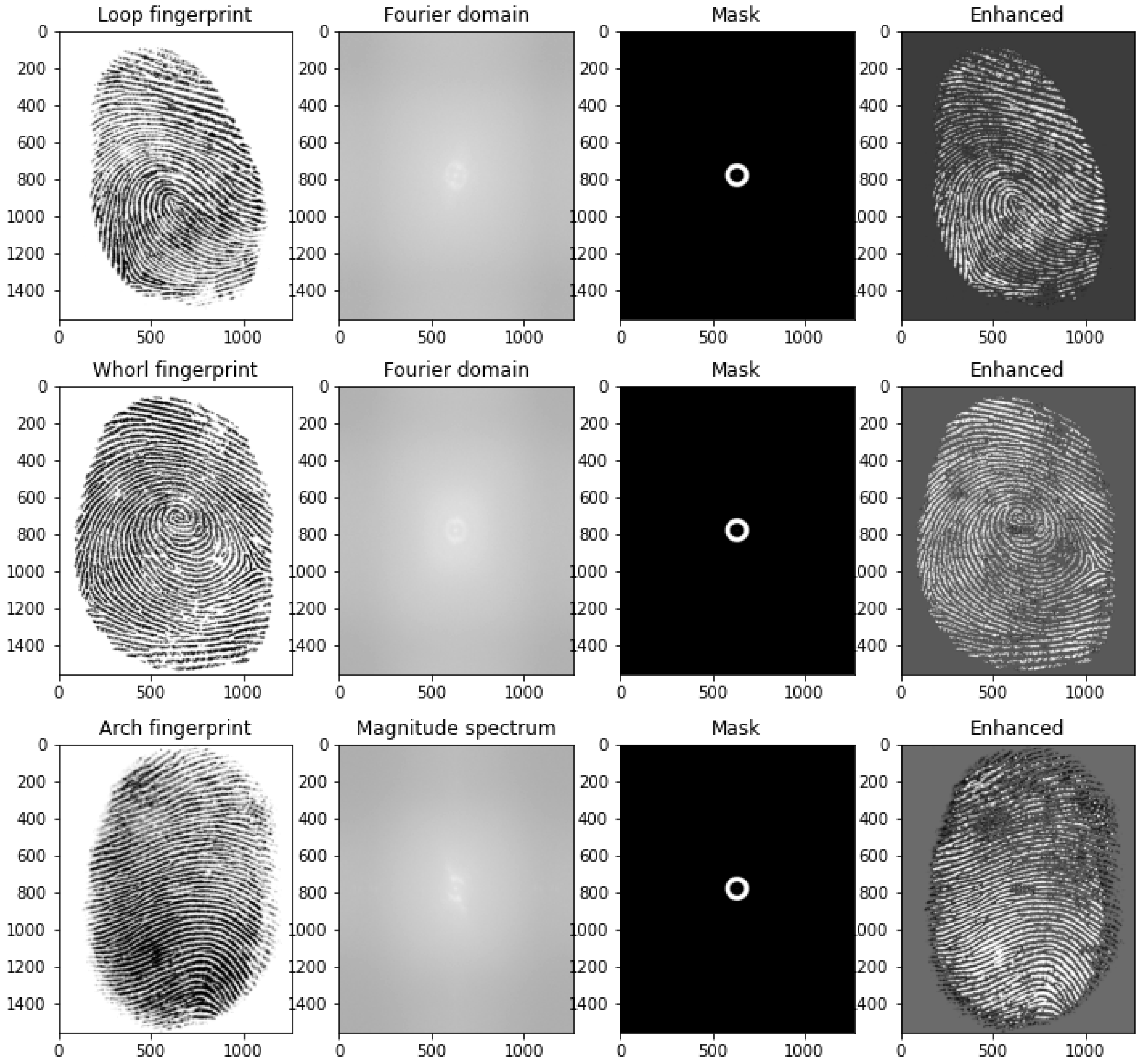
By approximating the dirac deltas in an image and convolving it with a random pattern, it can be observed that the result was a blurred version of the original pattern placed in the position of the dirac deltas in the original images.




Trying another case, we placed equally spaced 1s in the x and y-axis, and this created a grid pattern. After taking the Fourier transform, we observed that the modulus displayed dots along the x and y-axis. It also showed that the closer the spacing of the 1s in the spatial domain, the farther the spaces of the dots are in the Fourier domain.








*The images used for this activity were from Alamy.com*

# Ridge Enhancement

For this part, the goal is to enhance the appearance of the ridges of the fingerprint pictures. In particular, I used three different fingerprint patterns such as loop, whorl, and arch to observe if there will be a difference.

Like in previous activities, the Fourier domain of each image was first inspected. The frequency content is basically concentrated in the ridges and valleys that make up the fingerprint pattern, and the bright circular shape at the center of the Fourier domain is the zero-frequency component which represents the average brightness value of the image. Based on that, the mask was made wherein the circular part was used for the actual frequencies of the image, and a dot in the middle was used to cut off the central frequencies. The same mask was used for all three of them.

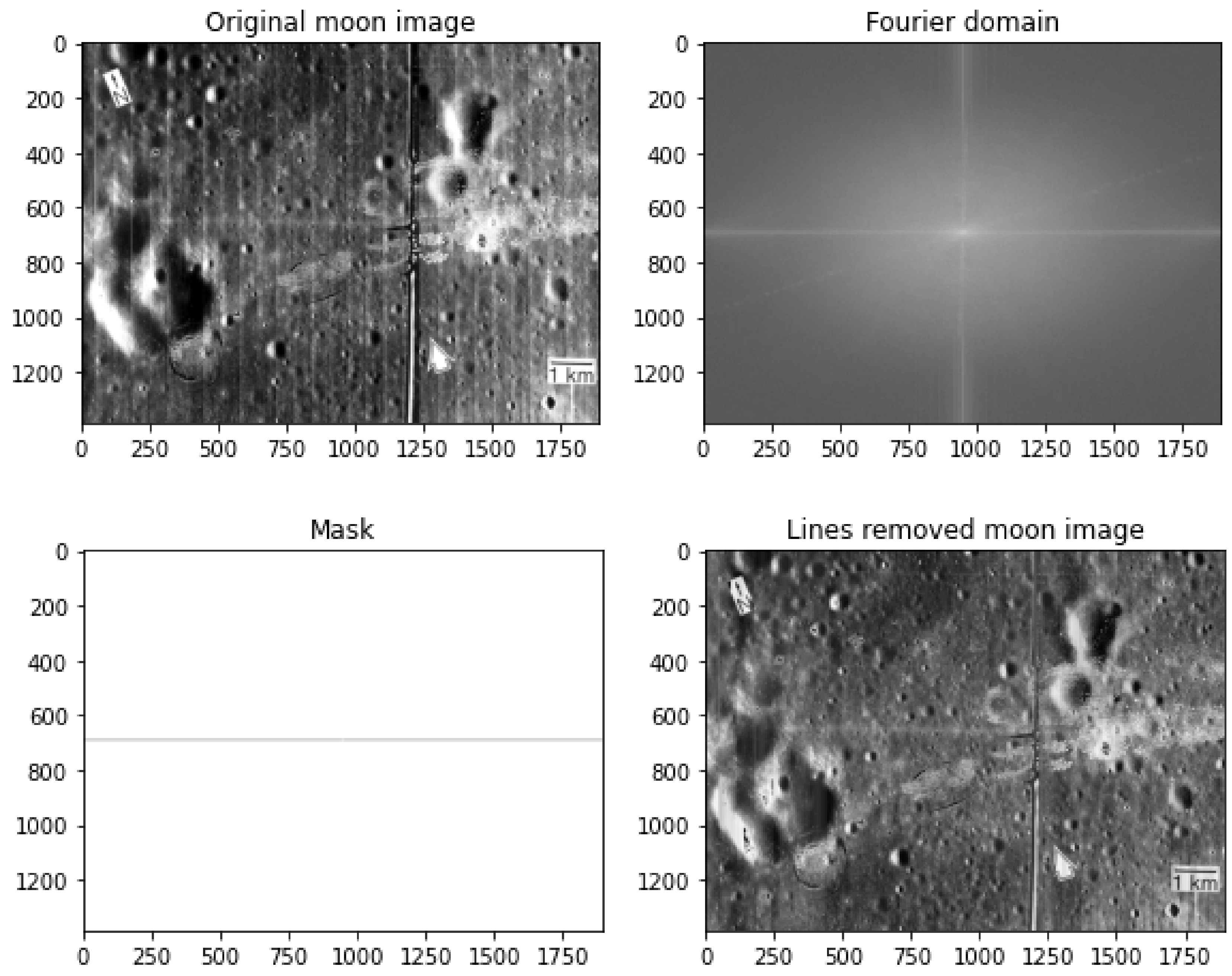
As a result, the binarized form of the images is shown in the figures on the left wherein the ridges became more defined, especially on the arch fingerprint.

# Line Removal

As for the last application, a moon picture from the Apollo mission was used. The picture was basically stitched together using multiple shots indicated by the vertical line pattern. To eliminate or minimize that, I again inspected the Fourier domain of the image to see where the main frequency values lie in the image.

Through convolution using the horizontal lines as a mask, the vertical pattern of the image was significantly reduced, if not, removed. Although a horizontal line is still observed, along with a vertical stitch pattern, the result is significantly cleaner than the original.

I was not able to show it here, but if I added vertical lines on the mask, the output image would be expected to appear cleaner filtering any line pattern left.



# Reflection

This activity was really insightful as it introduced us to different applications of the Fourier transform. I definitely got the most eureka moments here every time my code worked, compared to the previous activities. I think where I struggled the most was creating the perfect mask for the filtering of the images. I tried to automate the creation of each, but I found it really challenging. Hence, thanks to my classmates for helping me out and convincing me to just do the maks manually as they will still work the same anyway. I would have loved to still do the automated, though. Overall, I would say this has been the most challenging for me yet, but still really fun, like all the previous activities.

## Self-evaluation

**100/100**

I believe I was able to deliver what was required for this lab report. Not additional points this time, due to time constraint :')

# References

*Here are the materials I used to accomplish this activity:*


Soriano, M. (2023). Activity 2. Properties and Applications of the 2D Fourier Transform. https://uvle.upd.edu.ph/pluginfile.php/863634/mod_resource/content/1/Activity%202%20Part%202%20%20Properties%20and%20Applications%20of%20the%202D%20Fourier%20Transform%202021%20-%20Copy.pdf

Image Transforms - Fourier Transform. (2019). Ed.ac.uk. https://homepages.inf.ed.ac.uk/rbf/HIPR2/fourier.htm