ECEN 314-200: Signals and Systems, Fall 2021

Final Project: Image Editing through Fourier Transform Filtering Report

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Objective

Show how altering Fourier transforms can alter the images they create; use this information to describe how a Fourier transform represents the information of the image it is produced from.

Assumptions

This report assumes that the reader has some familiarity with Fourier transformations and their role as representations of signals in the frequency domain.

Results

The following is a collection of images produced using this project's final code.

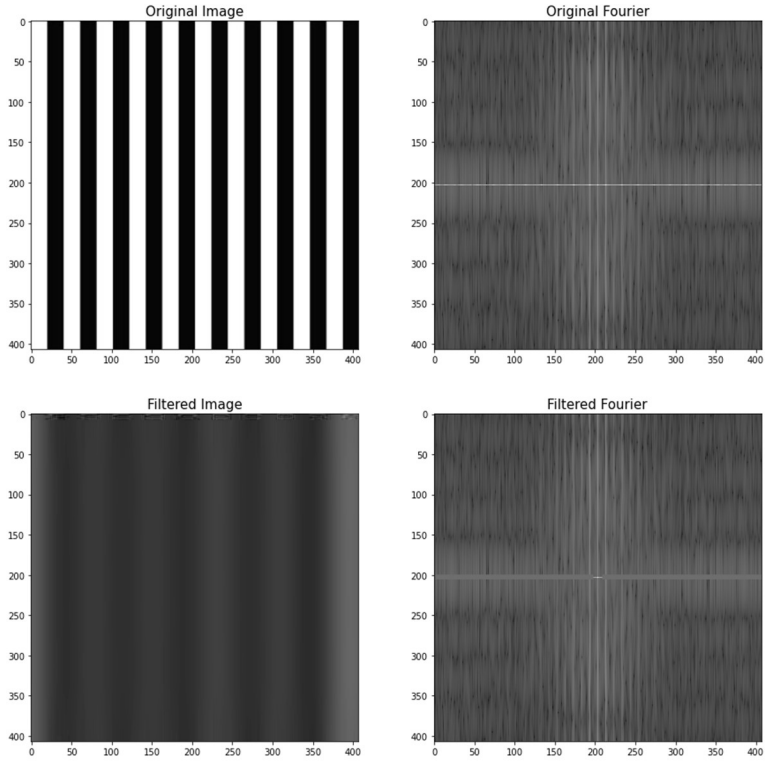

Figure 1: Vertical line weakening applied to lines-v.png.

Figure 2: Vertical line weakening applied to img3.jpg.

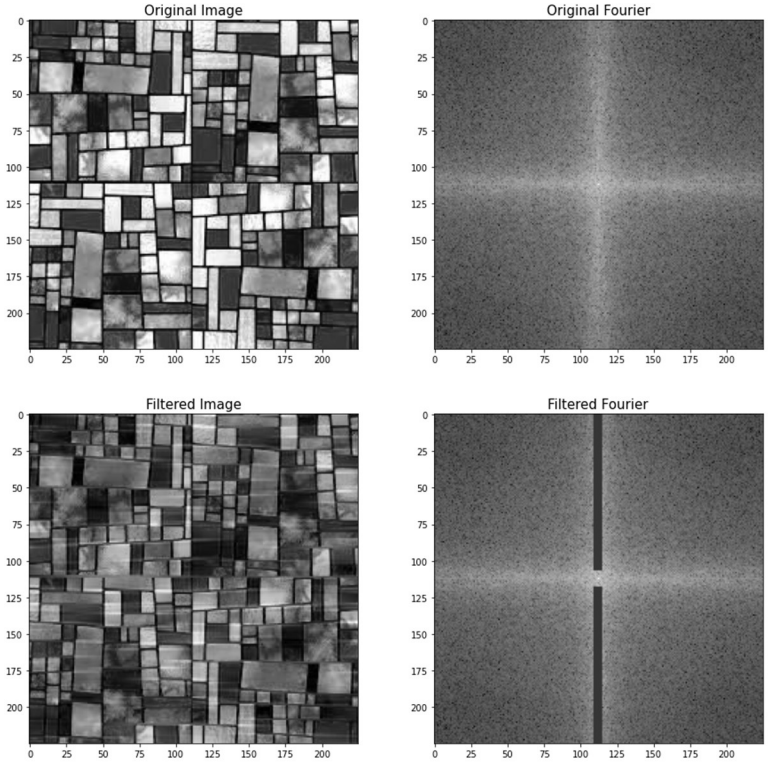

Figure 3: Horizontal line weakening applied to img2.png.

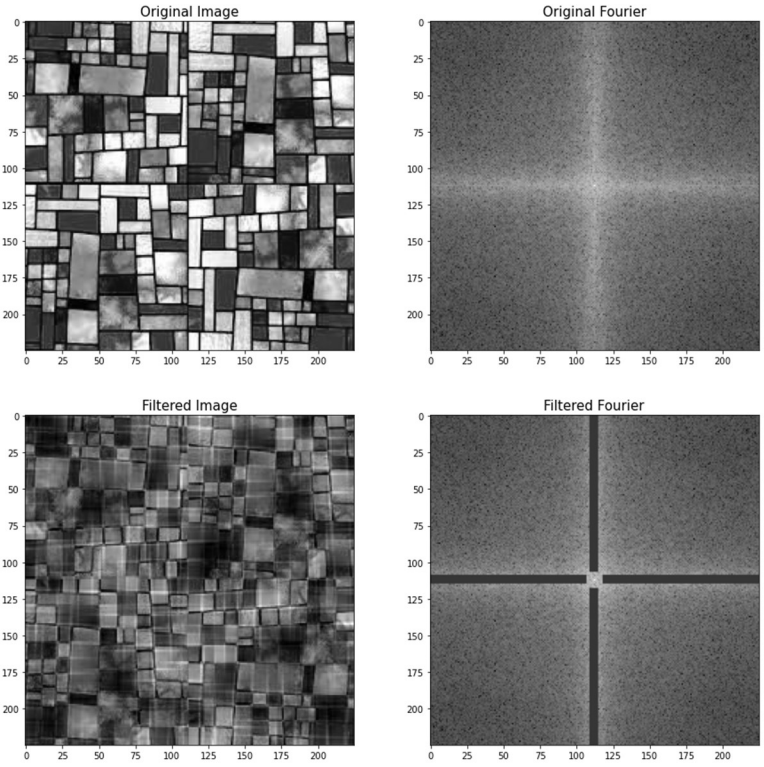

Figure 4: Vertical and Horizontal line weakening applied to img2.png.

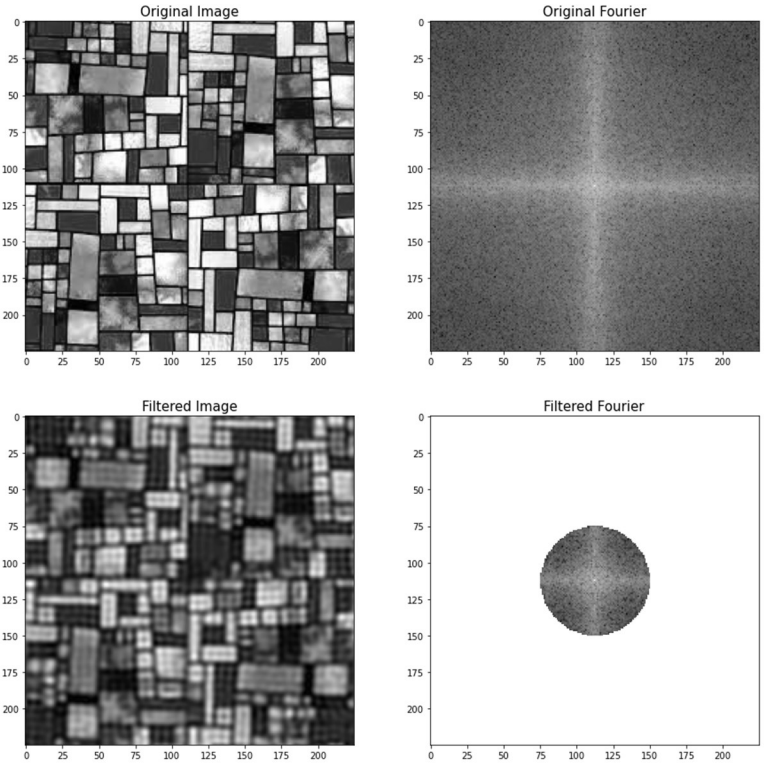

Figure 5: Low pass filter applied to img2.png.

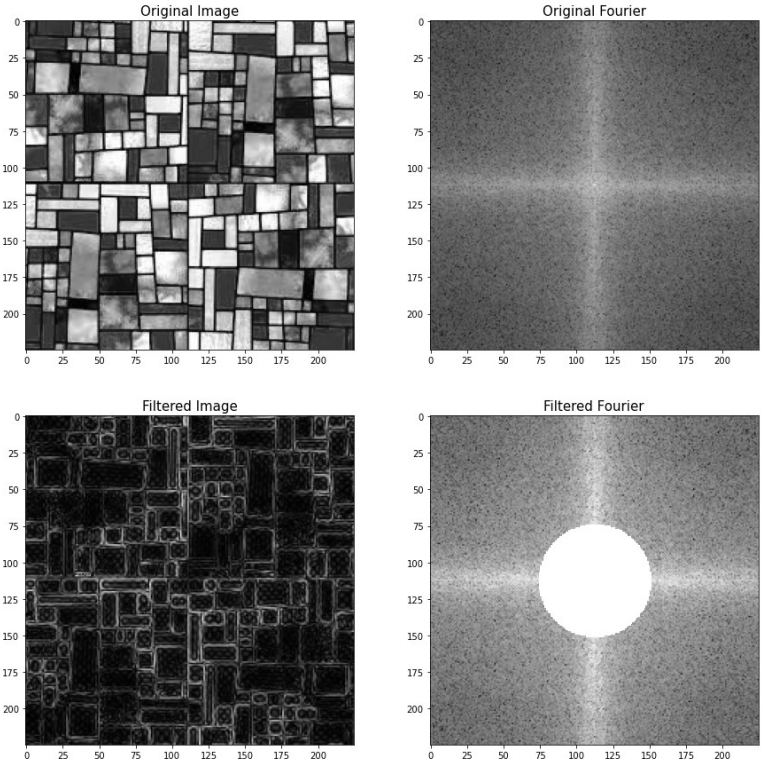

Figure 6: High pass filter applied to img2.png.

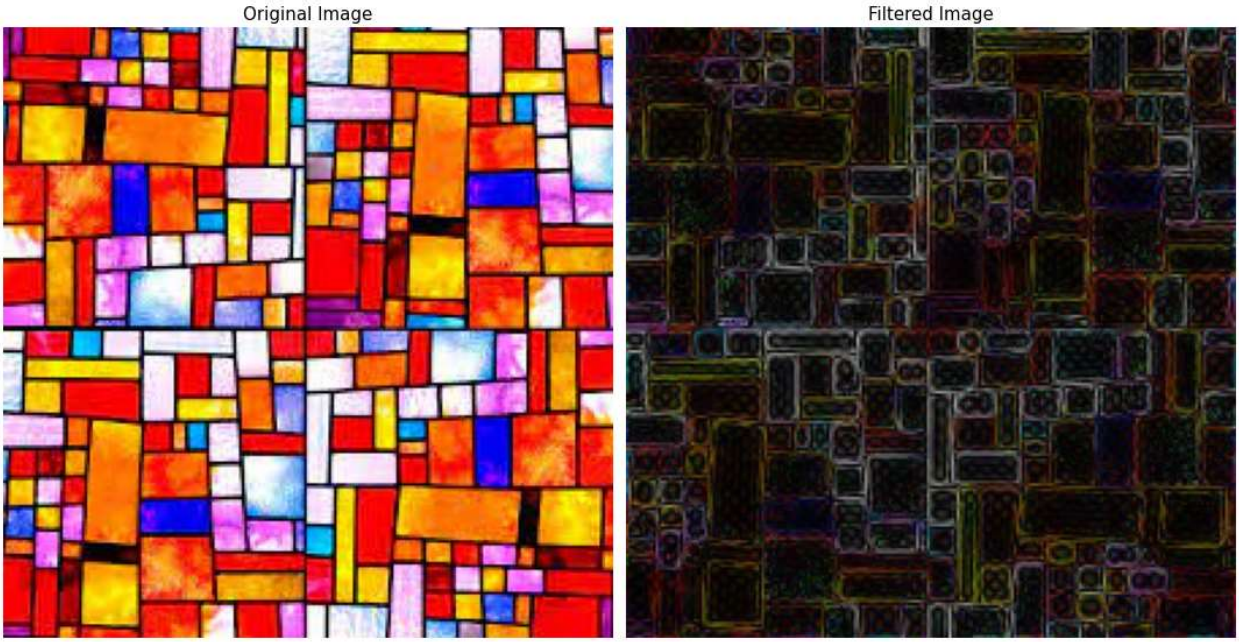

Figure 7: High pass filter applied to colorful img2.png.

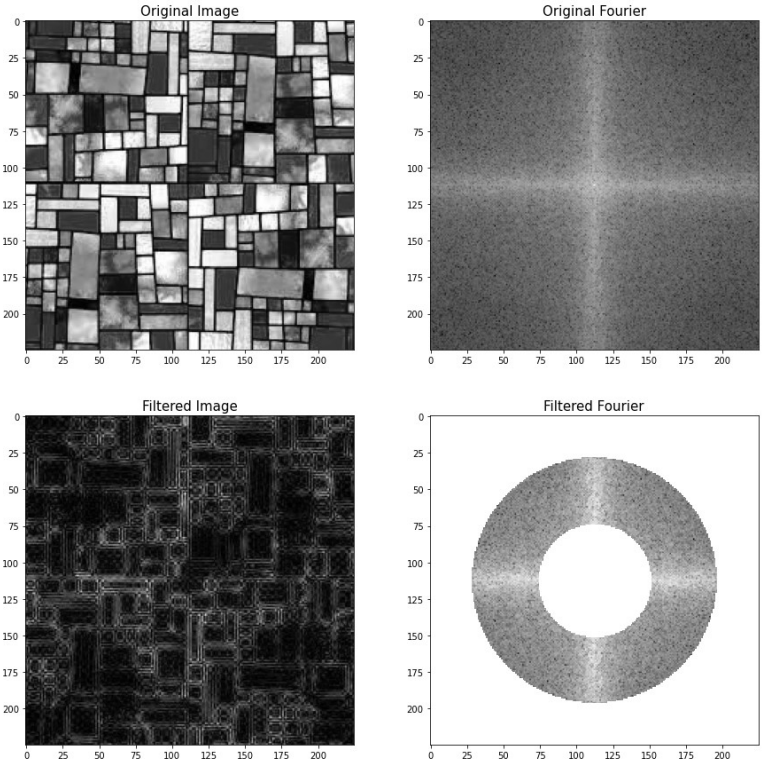

Figure 8: Band pass filter applied to img2.png.

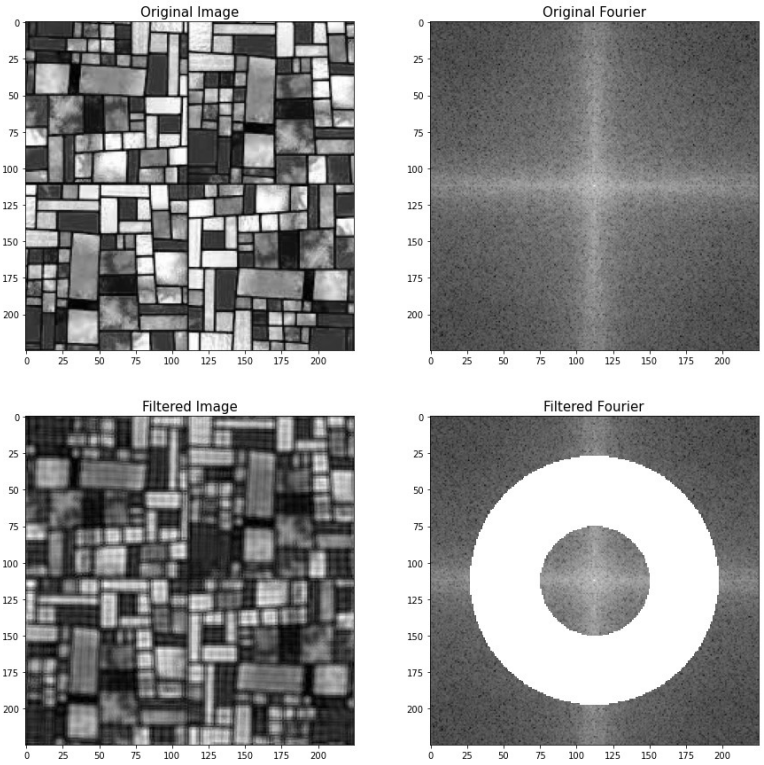

Figure 9: Band cut filter applied to img2.png.

Description

The provided figures are meant to show the ways in which altering a Fourier transformation can affect the image it represents. Figure 1 shows how masking the bright horizontal line through the original Fourier transform's center results in the vertical lines of the original image becoming incredibly blurry, retaining only vague verticality. Figure 2 shows how this same change can appear in images with color and with fewer vertical lines, manifesting as the blurring and weakening of the original image's most vertical aspects: its trees. Similarly, Figures 3 and 4 show how this same process can be used on horizontal lines by masking the bright vertical line through the Fourier transform's center, and how both methods can be applied simultaneously.

In contrast, Figures 5, 6, 7, 8, and 9 show how altering information before or beyond some distance from the transform's center can affect the final image. Figure 5 shows that the loss of information beyond the transform's innermost area only seems to blur the final image without making it unrecognizable, while Figure 6 shows that removing only this innermost area can greatly change the image's color, making the original image's outlines and borders the new image's most prominent features. These images represent the application of a low pass and high pass filter, respectively, as they remove information before or beyond a certain point.

Through the application of both low pass and high pass filters, band pass and band cut filters can be produced, which are represented by Figures 8 and 9, respectively. From these images, it is clear that band pass filters result in blurry representations of the original image's borders and edges, while band cut filters result in blurry copies of the original image with clearer edges than normal low pass filters.

Analysis

Based on the results of this project, it seems that a Fourier transform represent images using the frequency with which certain information appears, with more common information represented in the image's center and more unique information represented outside of its center.

The Fourier transformation's pixels seem to correlate to the color or brightness and location of the original image's pixels. Common information, like that which represents large or

distinct shapes of one or few colors, seems to be closer to the transform's center, while uncommon information, like the color and location of pixels that make up the edges and borders of shapes, is farther from the transform's center. Figures 5 through 8 support this, as they display how removing the Fourier transform's center removes the image's color, while removing its outer region reduces the image's clarity.

However, while the distinct shapes of the time domain are not directly reflected in the frequency domain, Figures 1 through 5 indicate that some common shapes in the original image can be reflected in its Fourier transformation. Vertical lines in the time domain seem to correlate to horizontal lines in the frequency transform, and vise versa for horizontal lines. While there are not many other structures to observe this behavior from in the images provided, this still shows how structures of the original image can be reflected in its Fourier transform.