MCMASTER UNIVERSITY

Project 2 – Halftone Image Restoration

COMPENG 4TN4 Image Processing

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This report outlines a procedure for halftone image restoration using harmonic modeling. Halftone images are purposely distorted images for printing which have periodic dot-like structures. Techniques to restore the image involve low pass filtering, Fourier analysis and harmonic frequency modeling. The model is made to match the periodic distortion in the half tone image and used to mask out these frequencies.

Background:

The original image in this lab is focused around a screenshot of a young man. This screenshot is not a computer-generated image, making it more prone to variance and noise. This fact becomes apparent in the end, when comparing it to the computer-generated, halftone image of Lenna.

Initially for the first demo of this project, I explored a few options regarding low-frequency filtering and identification of periodic points in frequency. In figure 1, it can be discerned visually that the halftone image contains many dot-like frequencies that compose the periodic distortion. The low-pass filters seem to remove the dots but evidently remove the other high frequency components that contain the details of the image. I explore this idea further in figure 2, where I set a condition for if the magnitude of the image exceeds 0.63, it will be part of the threshold mask otherwise the value is ignored. Furthermore, I manually remove the low frequencies from the mask, seen by the black square in the center of the frequency image, to preserve the general details of the image. Then, the mask used as a weighting mechanism to be applied onto the frequency of the original image. The shortcomings in this implementation is that it is mostly manual calibrated and would not work for different images.

Figure 1: Low-pass filtered images (a) original image, (b) average filtered image and (c) Gaussian filtered image.

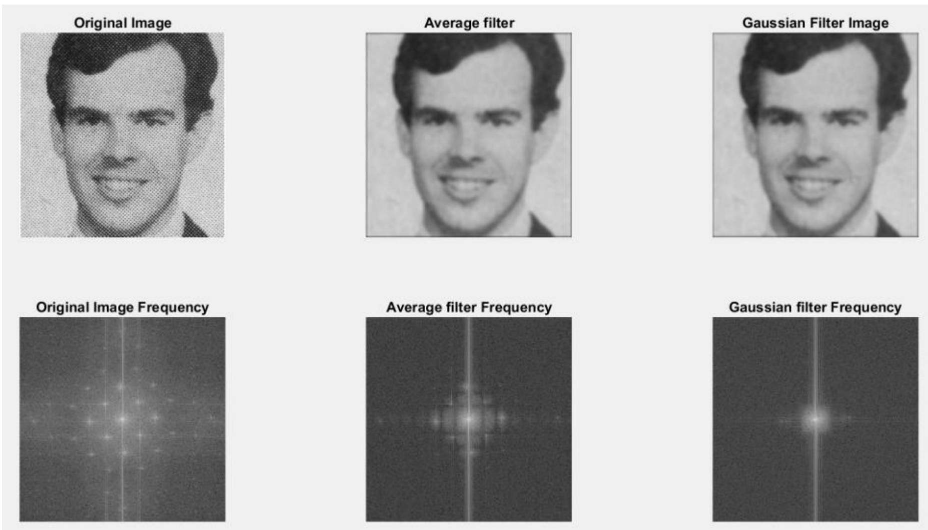
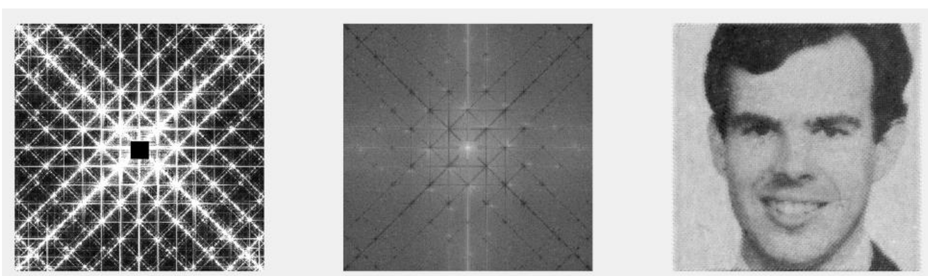


Figure 2: Figures left to right: threshold mask, applied threshold, newly created image.



Objective

The next step for this project was to find a consistent method of restoring the halftone image. As the frequency of the image implies, the dot-like patterns are repetitive, symmetric and decrease in magnitude moving away from the center. This structure is like harmonic gaussian pulses in frequency.

Calculations

In figure 3, the frequencies of the image is shown relative to the center of the image, the center row, the center column and the diagonal. I show this because it helps conceptually understand how to find the harmonic signals in the image in one dimension. There will be further discussion of the calculation in the conclusion where I will go over some assumptions and processes that can be improved.

To begin constructing the mask, I again generate the initial threshold mask in figure 2. Then sum the values in the height dimension of the image to create a 1-D signal where I can measure the harmonics. Figure 4 shows the flatten/summed image in the y-direction for simplifying calculations. The maximum of the signal is found as the first harmonic and the image is further divided into smaller segments to find the subsequent harmonics. Now knowing the harmonics, sine waves are generated with the corresponding harmonics. The waves are made into two matrices, multiplied together and converted into frequency. Sine waves appear as impulse signals in frequency so convolving the image with a Gaussian pulse will produce a frequency spectrum with a closer resemblance to a dot=like structure. The first harmonic is then removed from the mask in an attempt to maintain the low frequency components. The mask is scaled to be more sensitive and applied to the original image.

Figure 3: Frequencies for different 1-D dimensions of the image

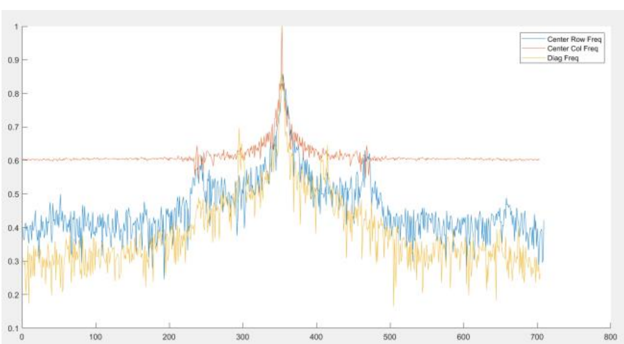
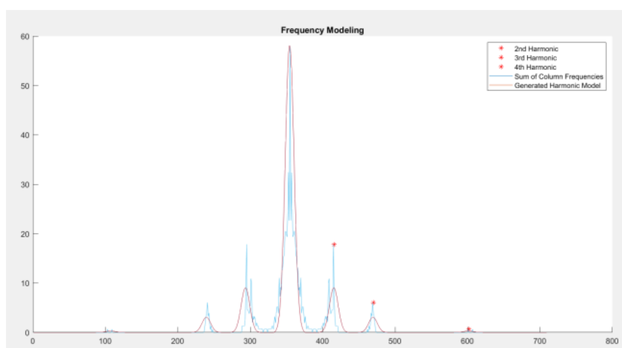


Figure 4: Modeling the sum of the y-direction frequencies using harmonics



Assumptions

These assumptions are may for simplicity sake and may be approved upon in further iterations of the project.

- Threshold magnitude for frequency is 0.63
- To find maximum approach must first find minima
- Contrast of mask is emphasized by remapping values 0 - 1 above 0.99

Results

The results of the image are shown below. A final median filter is applied to the image as a final touch to remove smaller artifacts.

Figure 5: (a) mask in frequency, (b) mask applied to original image (c) restored image

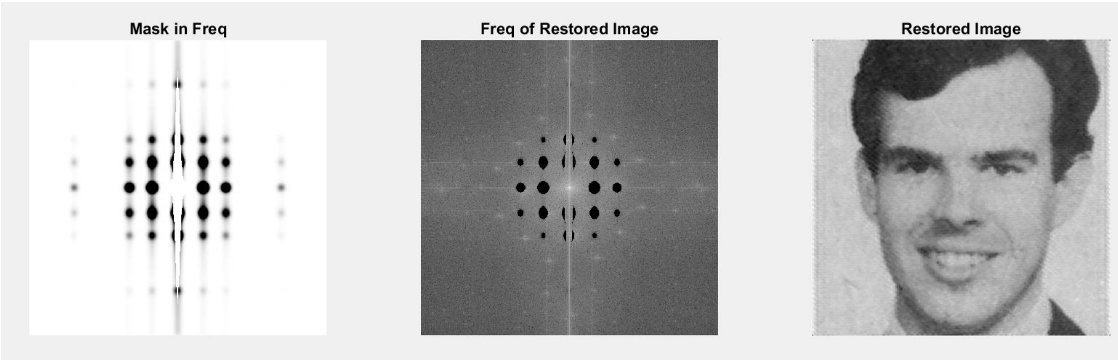
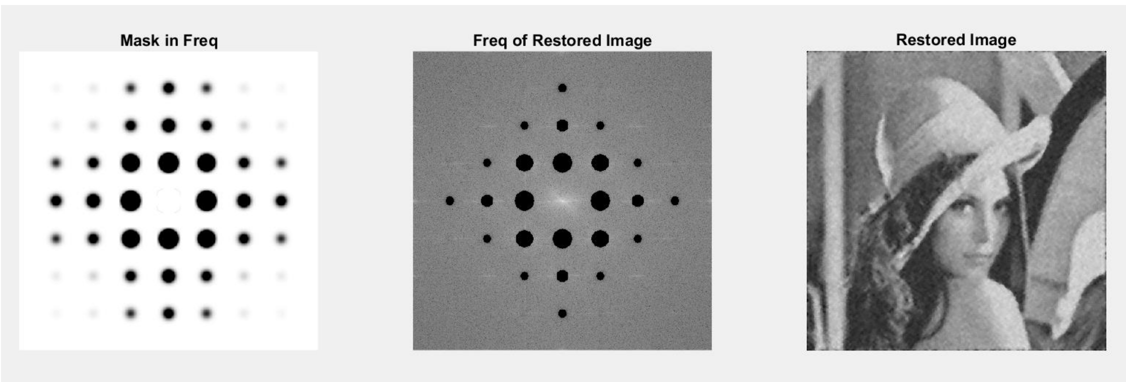


Figure 6: (a) mask in frequency, (b) mask applied to original image (c) restored image



Discussion

There are multiple things that can be improved upon to better restore the image. The current approach is simplified to one dimension due to time constraints. Otherwise, instead of finding the maximum searching and finding the maximum points as a sum in the x-direction, it would be a two-dimensional search. As well, the harmonics would not need to be found at a set amount but instead it would be known that the harmonics are equidistance apart in terms of frequency.

The assumptions can be improved upon by changing the method to which the harmonics are found. The first threshold mask generated for figure 2 would not be necessary moving forward because relatively it would be the same. It is just easier to understand when values below a certain threshold is ignored. The algorithm used to find the harmonics is very simple and can be improved to be more robust, it fails in cases where the maximum is not obvious. The last assumption is a way of increasing contrast so that the dots of the mask are more visible. This just remaps the range of the intensity closer to white because that it where most of the pixels reside.