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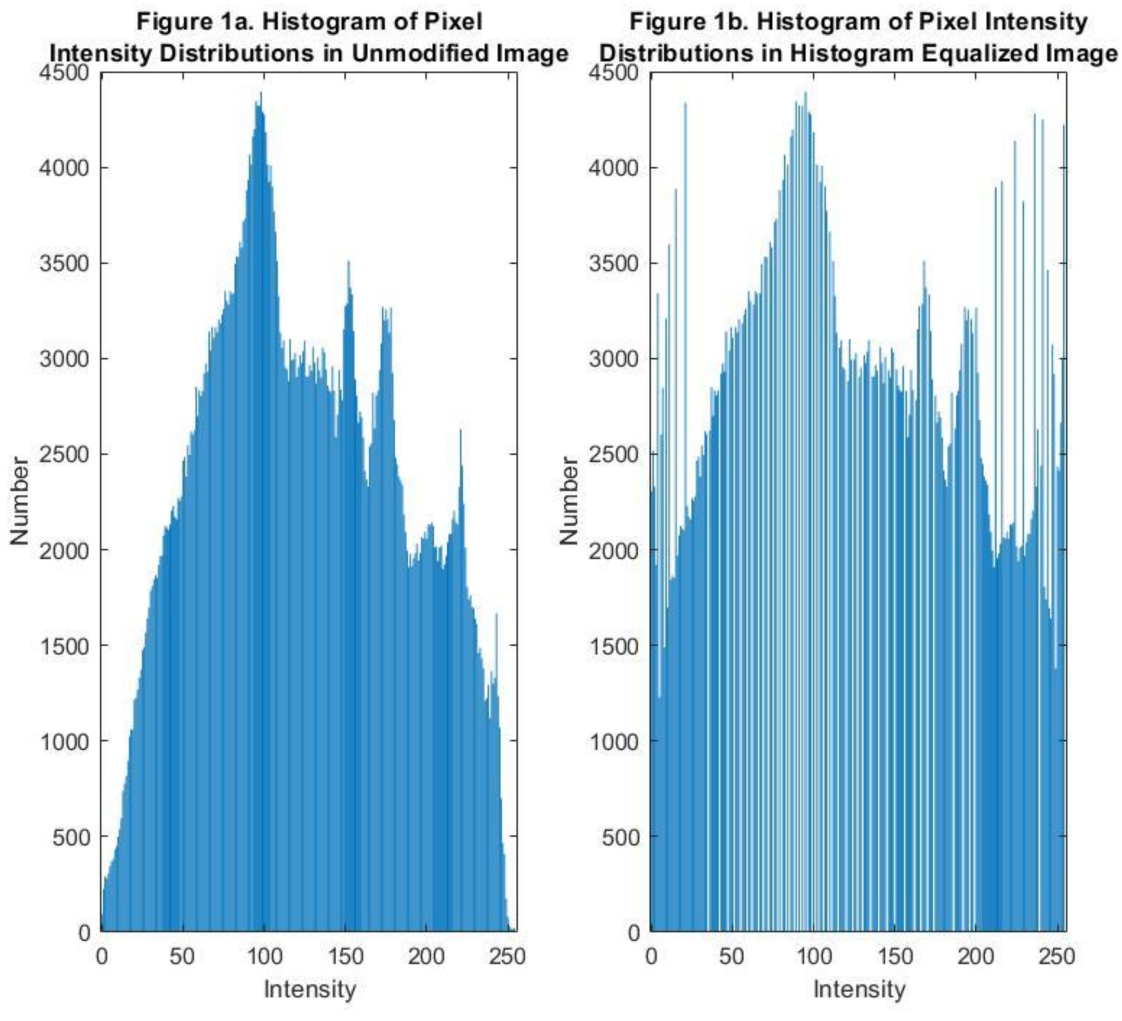
Assignment 4

Point processing or point transformations map pixel intensities rather than the pixels themselves. One use of this kind of transformation is to enhance contrast in images, as we will explore in this assignment.

The histogram of pixel intensities shows the intensity distribution of the grayscale image in Figure 1a. Figure 1b. illustrates the intensity distribution after histogram equalization. The equalized histogram is visibly less dense around 'medium' intensities, while 'low' and 'high' intensities are much more frequent, indicating that the histogram is at least more uniformly distributed than before.

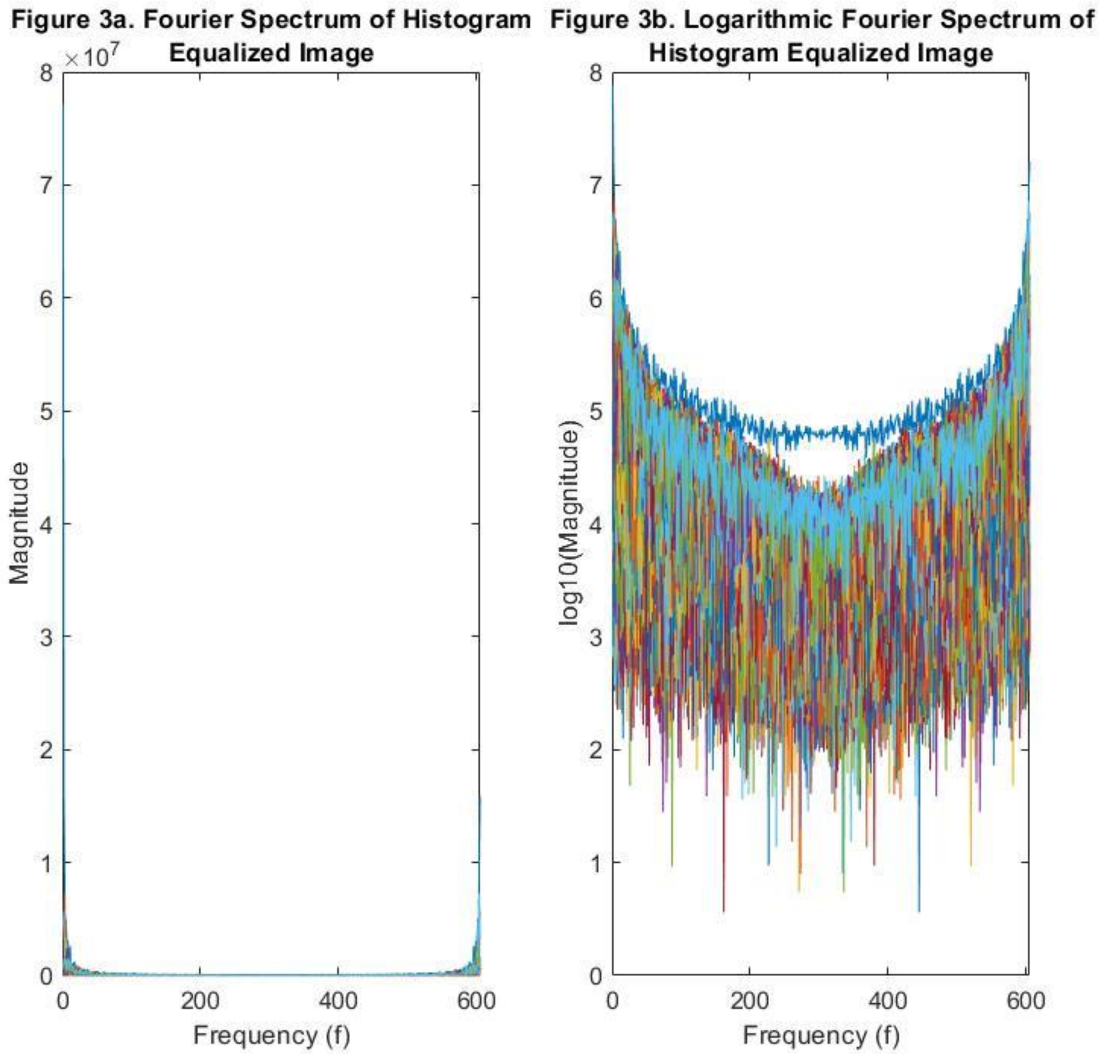


The results of histogram equalization to the original image can be seen in Figure 2b. When compared to the original image in Figure 2a., the contrast has been dramatically increased in the rocky water areas where pixel intensities are rapidly changing. It is notable that the top half of the image appears visibly unchanged; this is attributed to the fact that pixel intensities are relatively low and similar to one another, and would therefore not enhance contrast. For this image, the effect is pleasing, but images with lots of noise or poor resolution will have these contrasts amplified, which is undesirable.

Figure 2b. Histogram Equalized Grayscale Image

Figure 2a. Unmodified Grayscale Image

Using the histogram equalized image, the magnitude of the Fourier spectrum coefficients can be seen in Figure 3a. It appears nothing is plotted, but spikes around the zero and maximum frequencies are barely noticeable. This does not convey the behaviour of the waves, but Figure 3b. shows the Fourier spectrum with a logarithmic magnitude. The behaviour of each coefficient can be seen more clearly, and separate plots of each coefficient would show the individual waves. A logarithmic scaling of the magnitude discerns the details of the Fourier spectrum because it scales very large magnitudes down, while not affecting smaller magnitudes much. The large magnitudes come from the DC value of the zero frequency, or average of all frequencies.



Spatial filtering was applied to the histogram equalized image using a function that accepts an image and mask size *k* (kernel size is *k* x *k* since it is square). The choice of kernel for this application was a uniform averaging kernel, where all values of the kernel are $\frac{1}{k^2}$. The kernel is convolved with the image to 'smooth' or average out the pixel intensities using its neighbours. My function accounts for edges where the kernel would be outside the image pixels by ignoring the contributions of those kernel values. The effect of this is that border pixels will be reduced in intensity, with these pixels appearing completely black when *k* is large. The number of pixels that become shadowed in this way also increases as *k* increases. For large *k,* a better method may be to pad the image in some way. The submitted image must also be scaled to be square, otherwise the use of a square kernel will clip away parts of the image in which the width surpasses the height, or vice-versa. The effects of filtering with three different kernel sizes can be seen in Figure 4a, 4b, and 4c, with *k*=3, *k*=9, and *k*=15, respectively. A larger kernel size causes the image to become smoother, where pixels are averaged with neighbours that are further away, causing a washed-out and blurry effect. Figure 4a. still looks fairly detailed where a 3x3 kernel was used, but is certainly not as sharp or detailed as Figure 2b. Figure 4b and 4c show a dramatic smoothing of pixels as the kernel size increases.

Figure 4a. Smoothed Histogram Equalized
Image using 3x3 Kernel

Figure 4b. Smoothed Histogram Equalized
Image using 9x9 Kernel

Figure 4c. Smoothed Histogram Equalized Image using 15x15 Kernel