ECE 418 Lab 7

Aahan Thapliyal
aahant2

In this lab, we use histogram modification methods to enhance images to improve their quality to human perception. In this lab we use two main histogram modification methods: inverse gamma correction point operation and histogram equalization. We use these methods to enhance images with very narrow range of intensities because the narrow range intensity images do not convey enough information to the viewer.

Part1: Histogram Modification

In part 1 of the lab, the gamma correction point operation is implemented on an image to restore its original contrast. This restoration can be seen from the following images:

Figure 1: Original Image

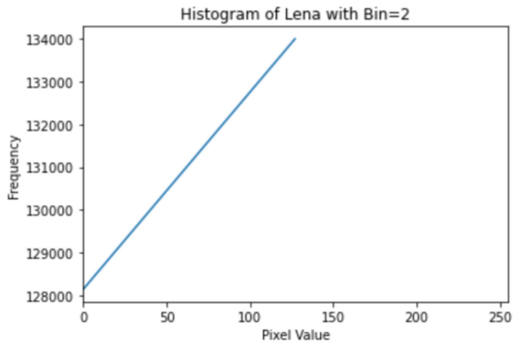
Figure 2: Restored Contrast Image

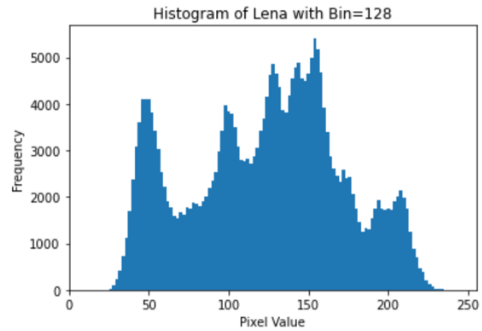
1. The operation $F(x) = 255 * \left(\frac{x}{255}\right)^{\gamma}$ where $\gamma = 2.5$ is indeed a valid point operation. The function $F(x)$ modifies the grey level of each of the pixel x of the original image where pixel values is independent which can be seen in the formula as it only takes into account the current pixel value x. Since the each pixel in the original image is real valued, each pixel could be mapped to the new pixel value using the function F while remaining in the same range as before, i.e. $0 - 255$.

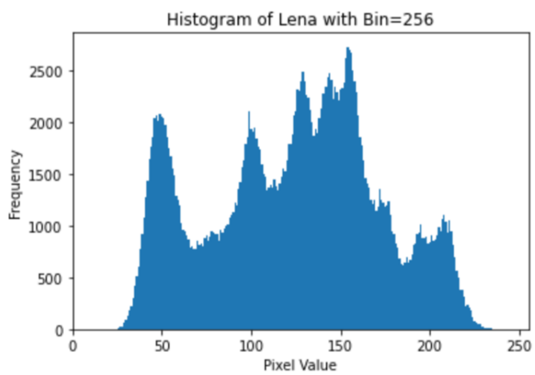
Part2: Image Histogram

In part 2 of the lab, given an image and the number of bins, we generated a histogram and plotted it. Following are the histograms:

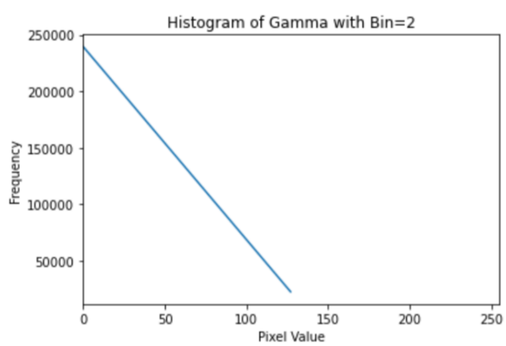
Histogram of Original Lena Image:

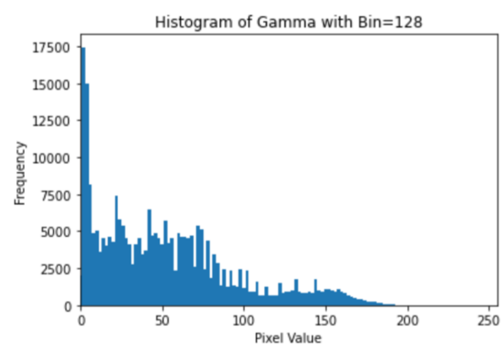


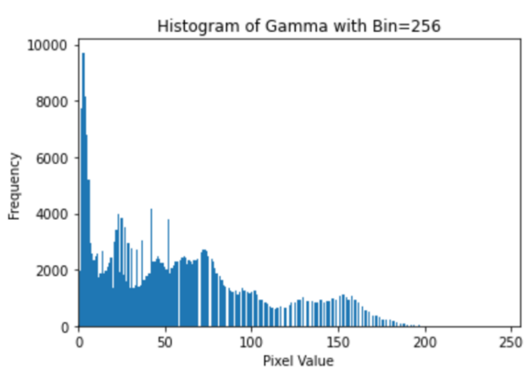




Histogram of Gamma Corrected Lena Image:







2. 2-bin: As we can see with the trend in gamma correction images, the frequency is shown to be much higher in the lower pixel value than higher pixel values in the gamma correction images when compared to the original image. In the original image, the frequency is higher at higher pixel values in the histogram.

   128-bin and 256-bin: In the histograms of the original images, we can see the intensity of pixels are mostly distributed in the middle with the frequency being really low in the pixel values less than about 25 and more than 225. However, the histogram of the gamma corrected image is mostly distributed in the lower pixel values and there is a general decrease in frequency as the pixel value increases.

3. Complexity for each pixel: finding index of the histogram requires 1 multiplication and 1 division, or we can just take it as 2 multiplication and then adding one to the histogram index value requires 1 addition. Therefore each pixel requires the complexity 2 multiplication and 1 addition per pixel. Since there are M*N pixels, the total pixels, the operation complexity is: $Complexity = M * N * (1addition + 2multiplication)$. The algorithm complexity is $O(N^2)$.

Part3: Histogram Equalization

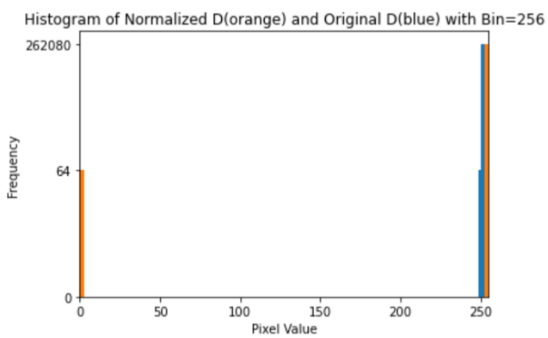
In part 3 of the lab, we implement the histogram equalization method on an image using 256 bins. We perform histogram equalization on image D with I = 255 and F = 254 from lab4 and on the original Lena image. In this method we first calculate the histogram and then use the histogram to find the cumulative distributive function of the image. We then modify each pixel value using the formula $F(x) = (cdf(x) * 255)/(imageHeight * imageWidth)$. The following are the results from this part:

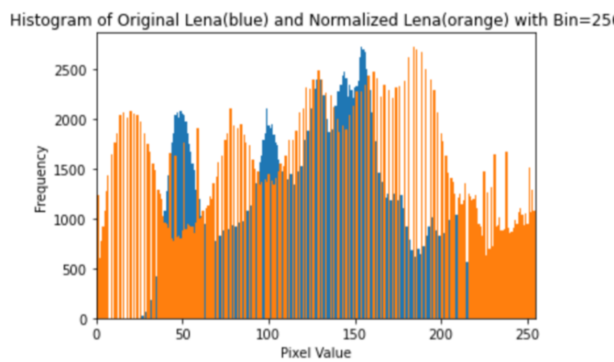
Figure 3: Original Image D from Lab4

Figure 4: Image D after Histogram Equalization

Figure 5: Original Lena Image

Figure 6: Lena Image after Histogram Equalization





4. Image D: The equalized image has a dark small square box in the middle of the image surrounded by white background whereas in the original image, since the intensity of the small box and the surrounding only differs by 1, it seems like the image is blank. The histogram of the original image also has peaks at pixel values 254(64) and 255(262080). Whereas the equalized image has peaks at pixel values 0(64) and 255(262080).

   Image Lena: As expected, the equalized image has a stronger pixel contrast compared to the original image. The light part of the original image becomes lighter and the dark part becomes darker for the equalized image. The histogram of the equalized image is more evenly distributed than the original distribution as well.

5. The histogram is not equalized for both the images because both the input images lack the continuity of greyscale value in the range 0 -255 making the histogram not equalized. i.e. the greyscale values are discrete in nature and not continuous making it not equalized.

6. For a histogram to be truly equalized, the histogram of the images should be continuous in nature i.e. the greyscale values should be continuous in nature and not discrete.

7. The original image D only has a pixel intensity difference of 1 between the background and the box, thus making it seem that the whole image just had the same pixel intensity as our eyes cannot differentiate that small of a intensity difference. Therefore the resulting image after the equalization doesn't show an increasing contrast effect but results in a small amount of pixels having different pixel intensity than the background resulting in a small visible box inside the image.

Test Image

Figure 7: Original Test Image

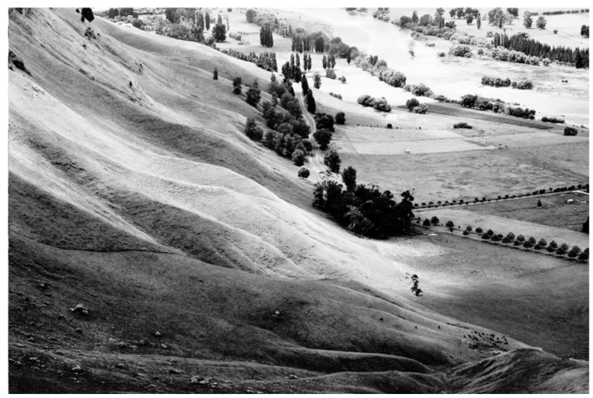
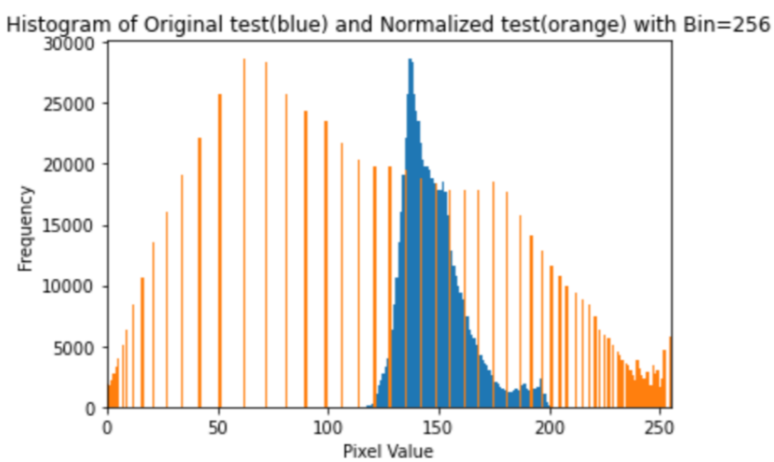


Figure 8: Equalized Test Image



As we can see from the images above, the equalized image looks much better than the original test image as it seems to have much more depth and seems to show a lot more details as compared to the original image. In the original histogram, the distribution is mostly distributed in the middle pixel intensities and have almost no frequency in values less than 100 and greater than 200. However, in the equalized histogram we can notice that the distribution is somewhat uniform and the lower intensity values then to have higher frequencies.

The Histogram is not completely equalized because the pixel intensities are not continuous variables so the histogram cannot be fully equalized. Therefore, We can conclude that the equalized image does have a stronger pixel contrast when compared to the original image which can be seen in the images and the histogram leading to the dark pixels becoming darker and the light pixels becoming lighter.

Overall in this lab we explore the histogram techniques used to enhance the image quality of the images namely, histogram modification, inverse gamma correction to restore the original image contrast, and histogram equalization which increases the image contrast by making the new histogram somewhat uniform.