Lab7 report Shuchen Zhang (szhan114)

Introduction:

In this lab, we learned an image enhancement method, histogram modification. If the image has very narrow range of intensities, it would be hard for us to perceive many information in this image. There are two histogram modification methods implemented in this lab: histogram equalization and gamma correction.

Part1:

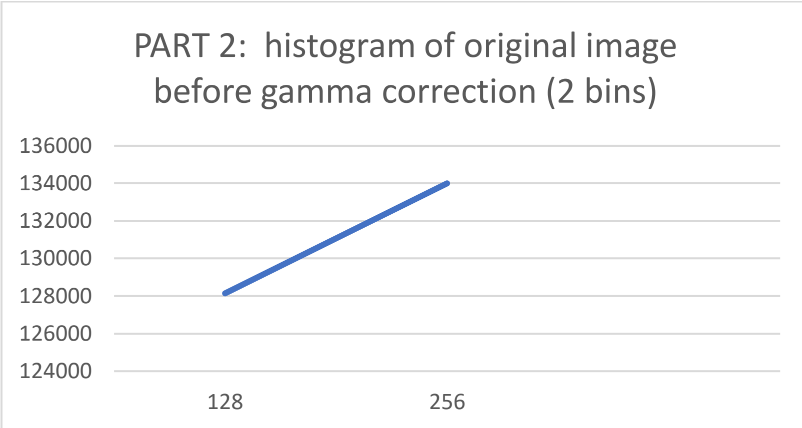
In part 1, the gamma correction method is implemented to restore the original contrast of image. Each pixel in the original image is being mapped to the new pixel intensity value calculated as F(x) = 255*(x/255)^ γ where γ = 2.5. This operation would produce an image which has to be gamma corrected to restore its original contrast. The inverse gamma corrected image is as follows:

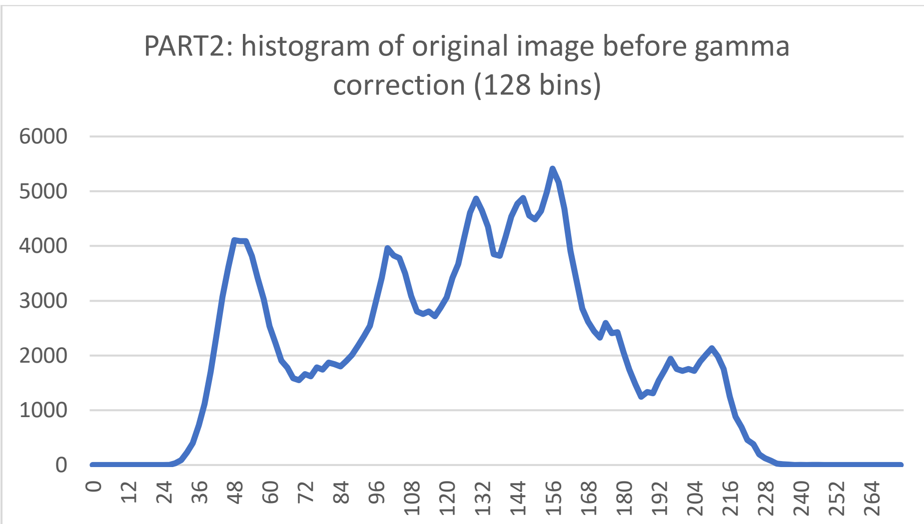
Given the operation of F(x) = 255*(x/255)^ γ where γ = 2.5, we are to verify that operation performed is indeed a valid point operation. This point operation F modifies the graylevel of each pixel x of the original image in which every pixels are independent of other pixel values. Also, F(x) is monotone increasing as pixel intensity x increases. The graylevel of each pixel of original image is real valued. Each original pixel value could be mapped with the function F to a new pixel value within the same range as the original 0-255.

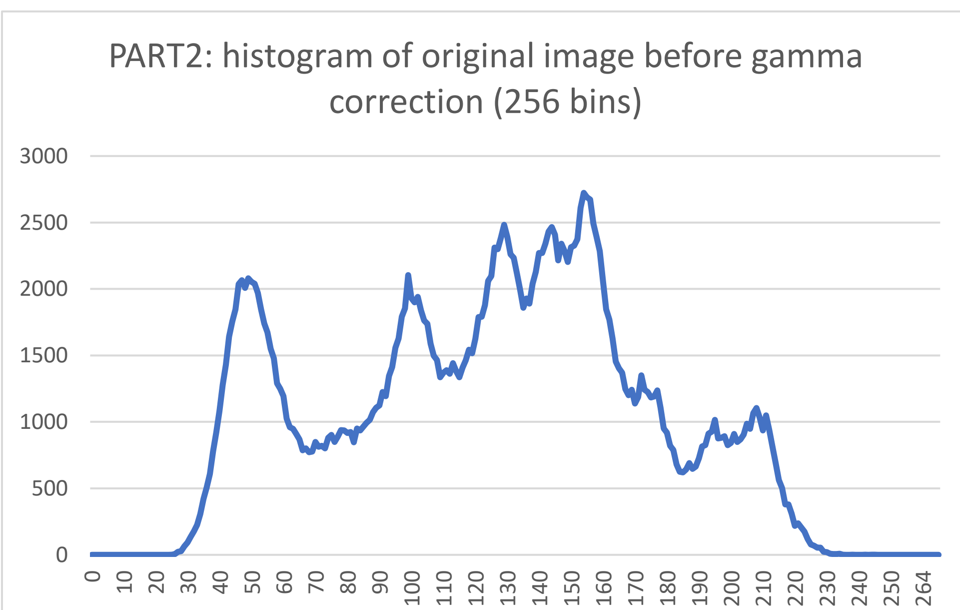
Part2:

In this part, we take both the lena image and gamma-corrected lena image as inputs, and calculated the histogram with bin number = 2, 128, 256 for each image. The resulting histogram is as follow:

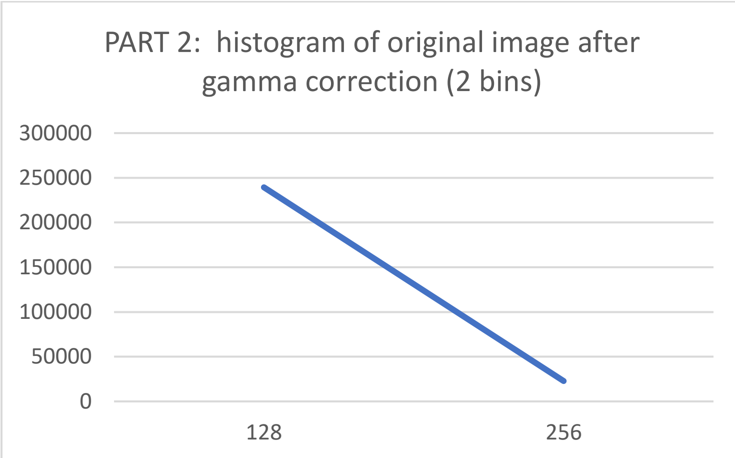
Histogram for original lena image:

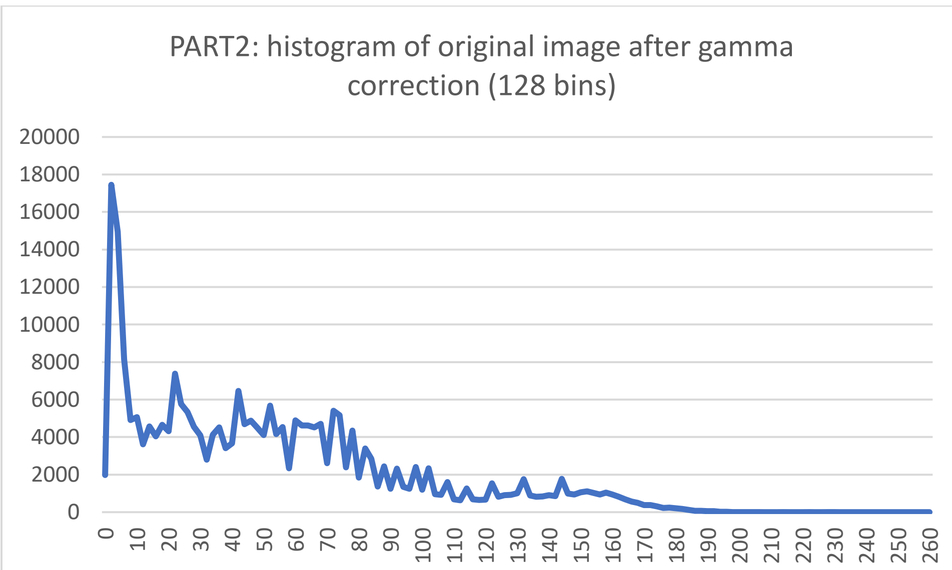


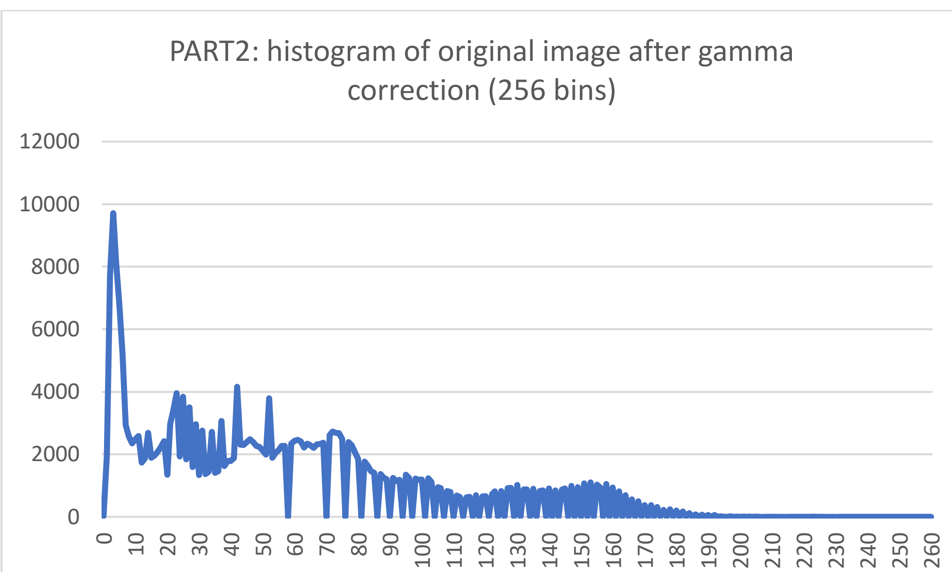




Histograms for gamma corrected lena image:







Q1: Compare the histograms of the pre-gamma corrected and the original images for each number of bins:

Bin = 2: The number of pixels in both intensity range 0-128 and 128-256 are higher in gamma-corrected image than the original image.

Bin =128 and 256: From the histogram for the original image, we could see that the intensities of pixel values are mostly distributed in the middle range of pixel intensities instead of having high distribution at the minimum range close to 0 or the maximum range close to 256. From the histogram for the gamma-corrected image, there Is a higher distribution of lower pixel intensity range and there is a general decrease in frequency as the pixel intensity range gets higher.

Q2: What is the complexity (in terms of operations per pixel) of the routine you wrote above on an image of size M rows and N columns?

By doing gamma correction operation, there is one operation of replacing each pixel intensity x with 255*(x/255)^ γ per each pixel. So the complexity is M*N. In the histogram computing operation, there is one operation of adding 1 to its corresponding intensity range, thus the complexity of computing histogram is also M*N.

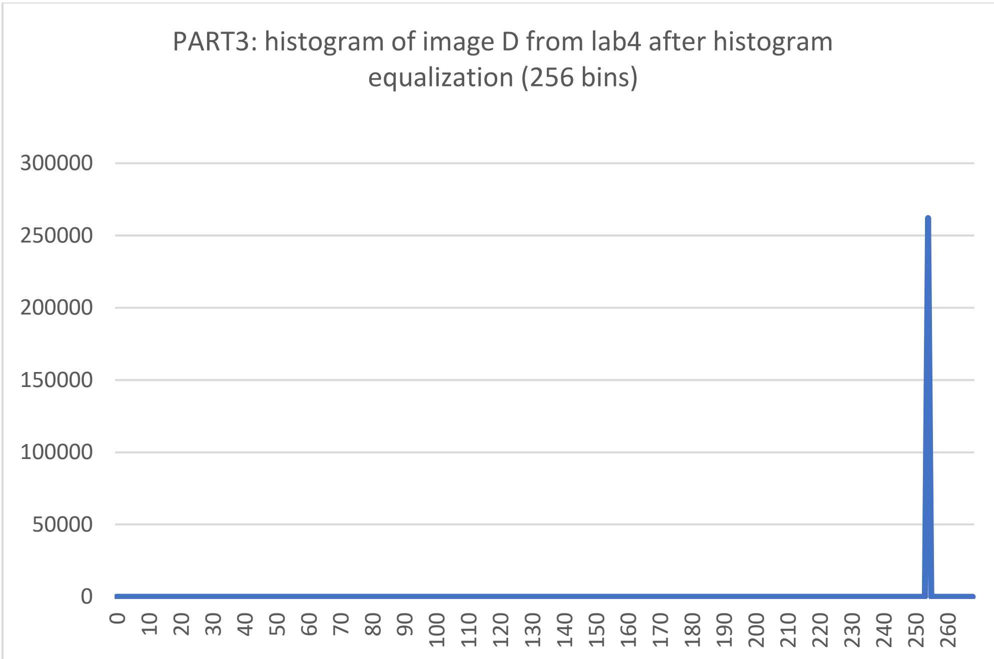
Part3:

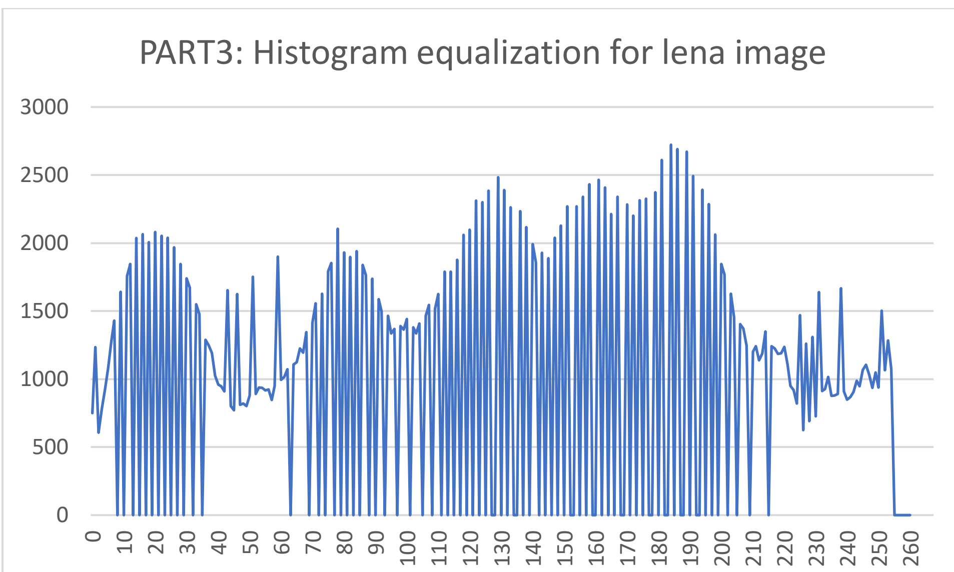
Histogram equalization method is implemented in this part. Both image D of lab4 with background intensity I=255 and foreground intensity F=254 and the original lena image are processed using histogram equalization. In this method, we first calculated the histogram of the original image and then calculated the cumulative distribution function based on the histogram. Then each pixel value x is modified with the calculation: F(x) = round[(cdf(x) -1)/# of pixels *255], where # of pixels is calculated as img.width * img.height. The resulting image is:

Original Image D of lab4:

Image D of lab4 after histogram equalization:

Lena image after histogram equalization:





Q4: Compare the equalized images and histograms with the originals:

Image D from lab4:

The equalized image has a 8*8 dark square in the center of the white background while the original image has all pixels with same value 254. The histogram of the original image has a single peak at intensity equals to 254. The histogram of the equalized image has two peaks with the larger one at intensity equals to 254 and the smaller one at 0.

Lena image:

The equalized image has stronger pixel intensity contrast compared with the original image. The light part becomes lighter and dark part becomes darker. The histogram of the original image is stretched out after the equalization and the intensity value frequencies are more spread out in the equalized histogram. The new histogram is more uniform than the original one.

Q5: Why is the histogram not equalized?

For both input images, the original image lacks of continuity of grayscale values in the range 0-255, thus the histogram is not equalized.

Q6: What conditions should the original histogram satisfy for it to be truly equalized.

For both lena and image D from lab4, in order for them to be truly equalized, the histogram of the original image should be H(g) as a continuous of g, where H is the number of occurrence and g is the pixel intensity value ranging from 0-255.

Q7: What can you conclude about the contrast of the original and equalized histograms for simulation using image D?

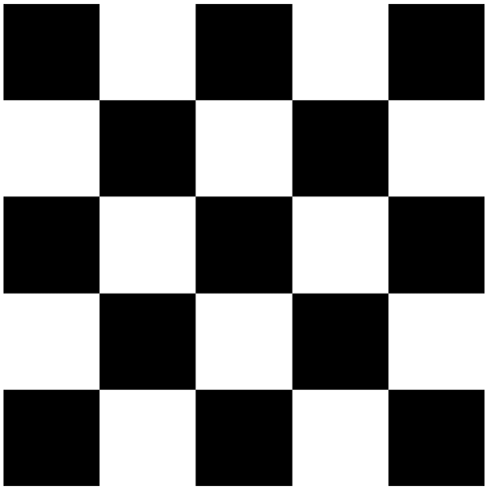
The original image D has only one pixel intensity value through all pixels thus the resulting equalized image doesn't show increasing contrast effect, but only create a small number of pixels with intensities other than the one in the original image.

What can you conclude about the contrast of the original and equalized histograms for simulation using lena image?

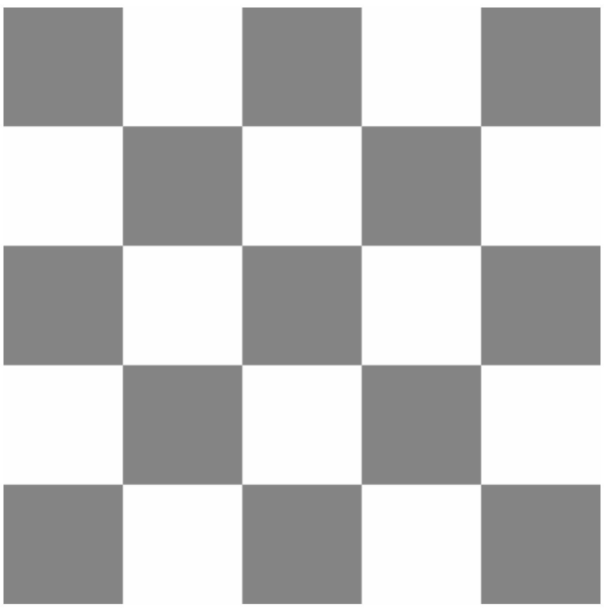
By applying equalized histogram method, the lena image has an increase in the contrast. The dark pixel becomes darker and light pixel becomes lighter.

Q9: Will equalization always improve the contrast?

No, histogram equalization not always improve contrast. In some case if the original image already has very strong contrast, there might be a decrease in contrast. For example, the original image like:



The histogram equalized image of this check board image is :



This equalized image has a decrease in the contrast.

Conclusion:

In this lab we explore two histogram techniques to enhance the image quality: By doing histogram modification, we could restore the original image contrast with inverse gamma correction. The histogram equalization method could increase image contrast by making the new histogram uniform.