HW3 Report

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Introduction

This program consists of three parts:

Part 1. Read the input source image and generate its original histogram.

Part 2. Adjust the intensity of the original image by 1/3 and generate its histogram.

Part 3. Apply histogram equalization to the darken image in Part 2 and generate its histogram.

Usage

Place the source image and main.py under the same directory. Run the following command in the terminal.

```
python3 main.py -s <source> -b <intensity_multiplier>
```

Parameters

`-s <source>` : the file path of source image, default = `lena.bmp`
`-c <intensity_multiplier>` : the multiplier for intensity adjustment in Part 2, default = `1/3`

Part 1. Original image and histogram

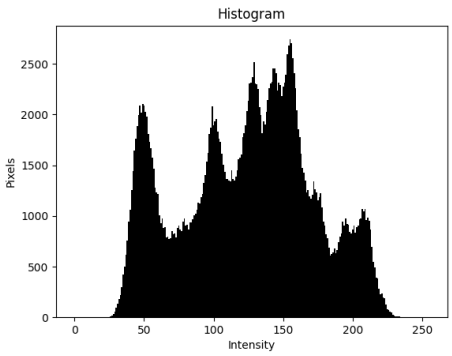
1.1 Method

First, source image is read with grayscale mode.

For each pixel, increment the pixel count of the its corresponding intensity in the histogram.

1.2 Result

The result image and histogram are saved as `original_image.bmp` and `original_histogram.png` as shown below.



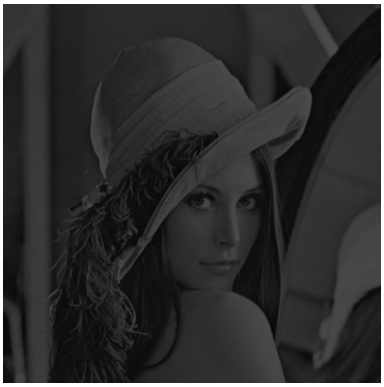
Part 2. Darken image and histogram

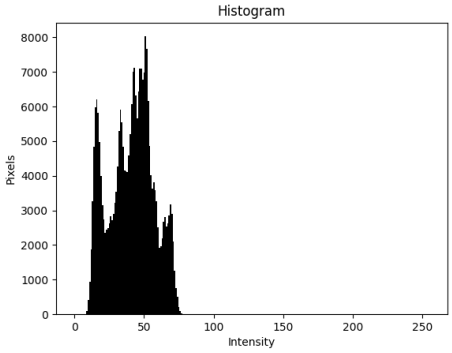
1.1 Method

For each pixel in the original image, multiply the pixel's intensity and then generate its histogram as did in Part 1.

1.2 Result

The result image and histogram are saved as `dark_image.bmp` and `dark_histogram.png` as shown below.





Part 3. Histogram equalization

1.1 Method

The darken image and histogram generated in Part 2 is taken as the input for this process. The goal is to normalize the distribution of intensity within the image, i.e. to flatten the probability density function of intensity (PDF). The integral of a PDF is known as the cumulative distributive function (CDF). For a flatten PDF, it would have a linearized CDF across the value range. Hence we can derive the following histogram equalization formula:

$$s_k = \sum_{j=0}^{k} \frac{n_j}{n} \times (L-1) = CDF(k) \times (L-1)$$

$k: 0, 1, 2, \dots, L-1$

$L: number\ of\ grey\ levels\ in\ image\ (in\ this\ case\ 256)$

$n_j: number\ of\ times\ j-th\ grey\ level\ appears\ in\ image$

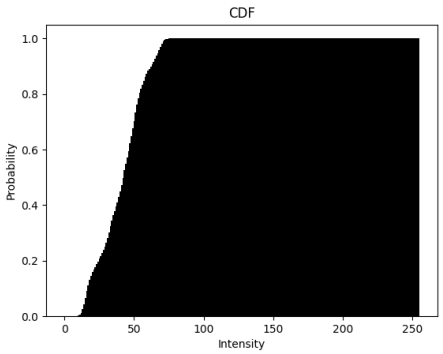
$n: total\ number\ of\ pixels\ in\ the\ image$

$cdf: cummulative\ distributive\ function$

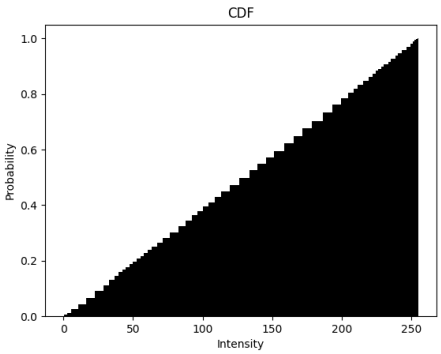
For each intensity value k within 0-255, we calculate its cdf value with the input histogram, and scale by 255 to get the transformed intensity value s_k. Finally, we process each pixel in the input image and reassign its intensity with the transformed value.

The picture shown below are the CDF before and after equalization. We can see that the CDF has be linearized across 0-255 after equalization as mentioned earlier.

Darken image



Equalized image



1.2 Result

The result image and histogram are saved as `equalized_image.bmp` and `equalized_histogram.png` as shown below.