HW1:Histogram and Spatial Filtering

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1 Exercises

1.1 Histogram Equalization

Let n = MN be the total number of pixels and let n_{r_j} be the number of pixels in the input image with intensity value r_j . Then, the histogram equalization transformation is

$$s_k = T(r_k) = \Sigma_{j=0}^{k} n_{rj}/n = \frac{1}{n}\Sigma_{j=0}^{k} n_{r_j}$$

. So it follows that $n_{sk} = n_{rk}$. A second pass of histogram equalization would produce value v_k according to the transformation

$$v_k = T(s_k) = \frac{1}{n}\Sigma_{j=0}^{k} n_{sk}$$

. But, $n_{sj} = n_{rj}$, so

$$v_k = T(s_k) = \frac{1}{n}\Sigma_{j=0}^{k} n_{r_j} = s_k$$

. This shows that a second pass of histogram would yield the same result as the first pass.

1.2 Spatial Filtering

1. My result is

$$\begin{bmatrix} -177 & -420 & -279 & -271 \\ -74 & -72 & -90 & 52 \\ 61 & 131 & 2 & 19 \\ 172 & 199 & 215 & 60 \end{bmatrix}$$

2. The positive values and negative values means the difference of the gray level among the upper pixels and the under pixels around the orginal pixel.
3. Since it seems like a sobel filter, it reserves the edge part and filters the smooth part.

2 Programming Tasks

2.1 Pre-requirement

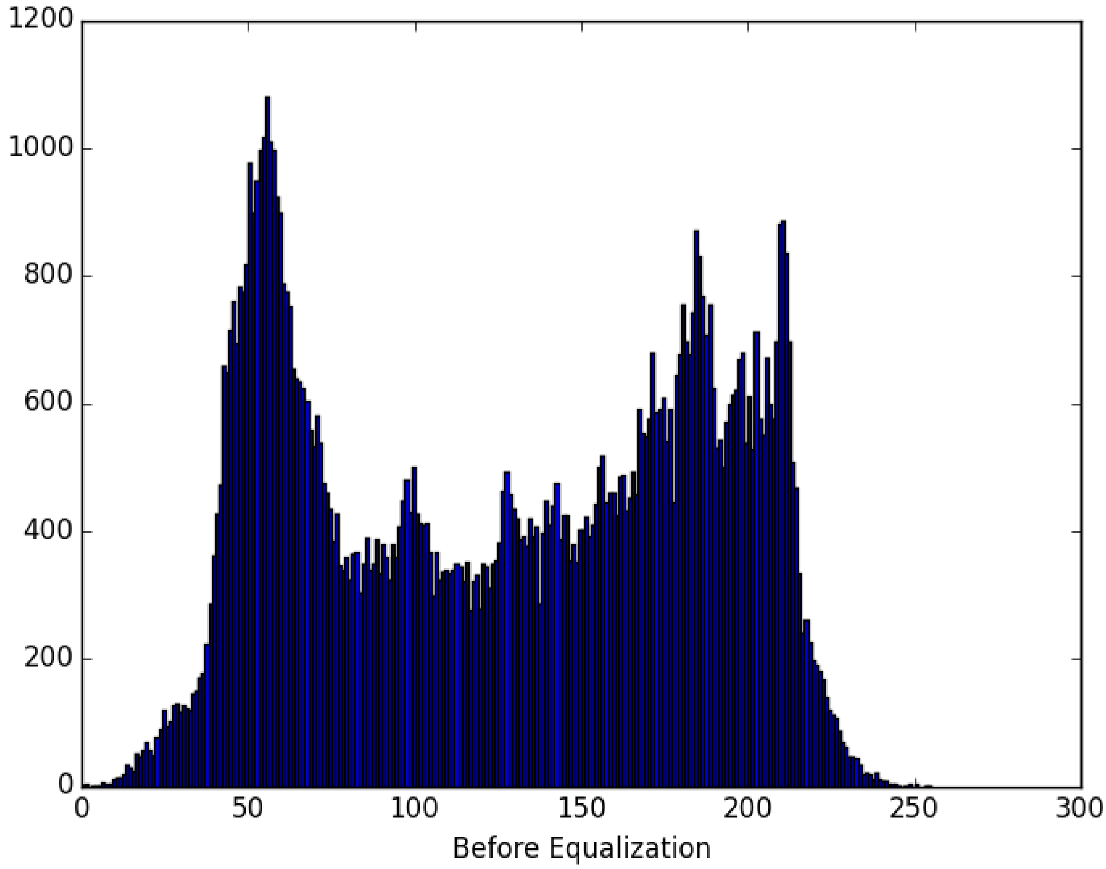
Input My student ID is "13331158", so my picture is "**58.png**".

Language The language I choose is **Python**, and the library I choose is **PIL**, **Numpy** and **Pylab**.

2.2 Histogram Equalization

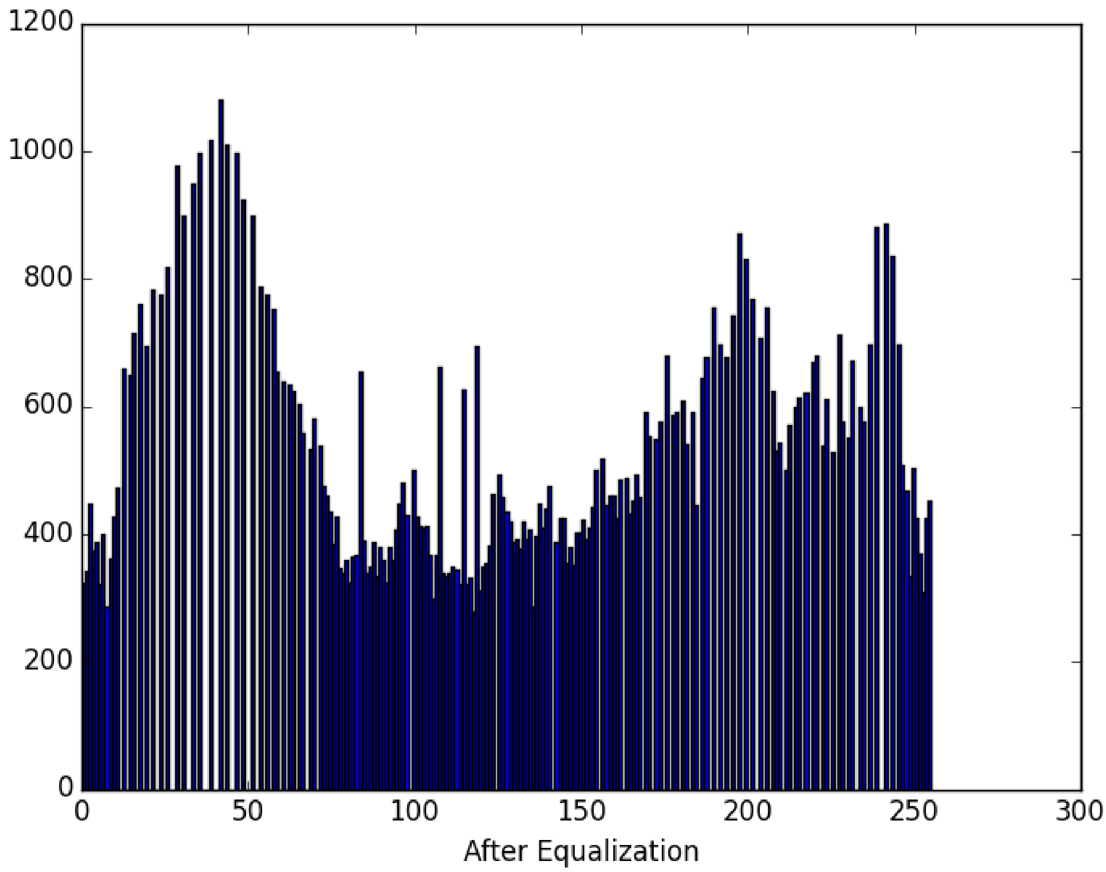
1. The **original** picture is:

The histogram is:



2. The **histogram-equalized** result is:

The corresponding histogram is:



3. As we can see from the original picture and the histogram-equalized result, the **contrast** has been improved very high. So you can **catch more details** and the "fog" in the original picture has disappeared. The result looks very **comfortable**.
4. First, new a array called "numOfGray", traverse the input picture to **capture the quantity of pixels** that lay on grey levels from 0 to 255.

```
numOfGray = [0 for i in range(256)]
for i in range(original_height):
    for j in range(original_width):
        numOfGray[resource[i * original_width + j]] += 1
```

Second, new a array called "Equalize_mapping" to make a **mapping** table from original grey value to result grey level after equalizing. That is, for original grey level from 0 to 255, **calculate the sum** of the quantity of pixels those grey level is not larger, multiply by 255 andn divide by the quantity of all pixels, then comes up with a result.

```
Equalize_mapping = [0 for i in range(256)]
sum = 0
for i in range(256):
    sum += numOfGray[i]
    Equalize_mapping[i] = int(sum * 255 / (original_height * original_width))
```

Then, new a array called "result", **transform the grey value** from the pixels in the original picture, and put into the new array, store into a new image.

```
result = []
for i in range(original_height):
    for j in range(original_width):
        result.append(Equalize_mapping[resource[i * original_width + j]])
output_img.putdata(tuple(result))
```

2.3 Spatial Filtering

1. The **3*3 averaging filter** result is:

The **7*7 averaging filter** result is:

The **11*11 averaging filter** result is:

2. The **variant of Laplacian** I pick is:

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

And the result is:

Digital images are often similar to transition ramp on the gray edge, thus leading to a first-order differential image produced thicker edge , because the differential along the slopes is not zero. On the other hand , second-order differential generated a one-pixel-width double-edge separated from zero. Second differential is much better than the first-order differential in enhancing detail , this is an ideal characteristic for sharpening images.

3. The weight k I select is **3**. Thus the result is:

4. The **filter2d** function, can be used to perform averaging filtering, Laplacian filtering and high-boost filtering.

First, ensure the width and the height of the input image and the filter.

```
original_width = input_img.width
original_height = input_img.height
filter_width = len(filter[0])
filter_height = len(filter)
diff_width = int(filter_width / 2)
diff_height = int(filter_height / 2)
```

Second, calculate the sum of the weights from the filter. If the sum **is not 0**, then it means the **averaging filtering model**, else it means the other models.

```
weight_sum = 0
for i in range(filter_height):
    for j in range(filter_width):
        weight_sum += filter[i][j]
```

Finally, traverse the input image, use the filter to come up with a result and put into the result image.

```
sum = 0
for k in range(i - diff_height, i + diff_height + 1):
    if k >= 0 and k < original_height:
        for l in range(j - diff_width, j + diff_width + 1):
            if l >= 0 and l < original_width:
                sum += resource[k * original_width + l] *
```

```
                filter[k - i + diff_height][l - j + diff_width]
if weight_sum:
    sum /= weight_sum
result[i * original_width + j] = int(sum)
```