Digital Signal Processing I
Purdue University
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Lab 4 Report

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1 Histogram of an Image

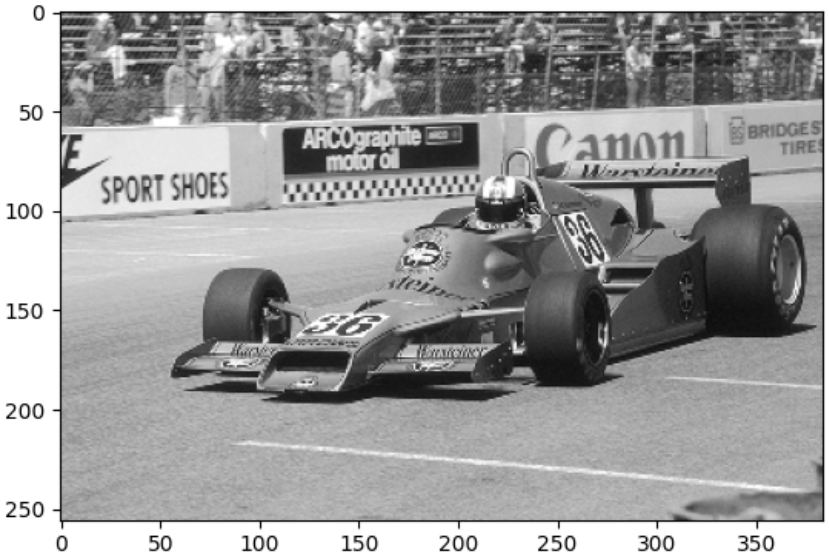

Figure 1: Original Image of race.tif

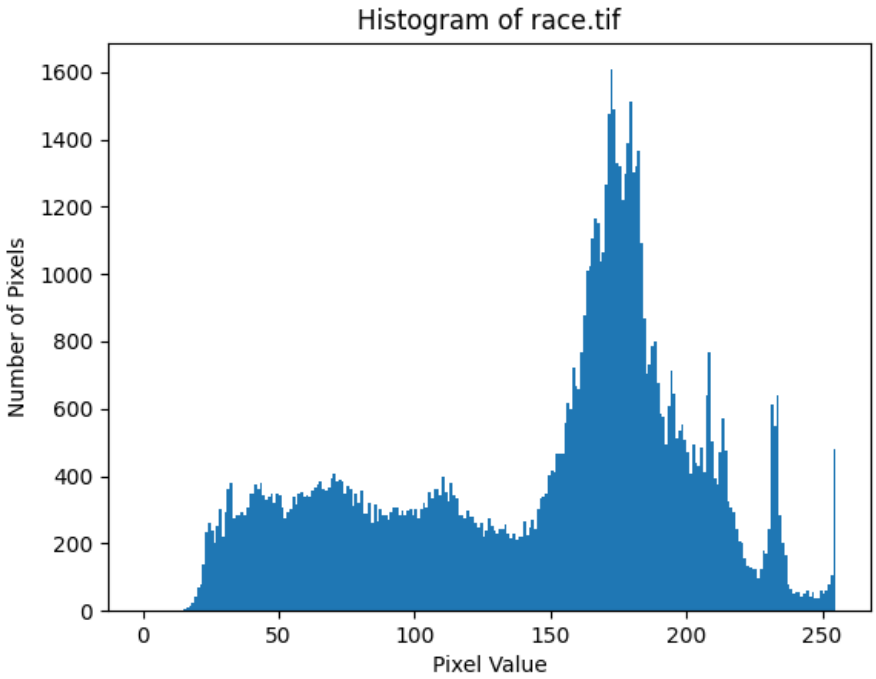

Figure 2: Histogram of race.tif

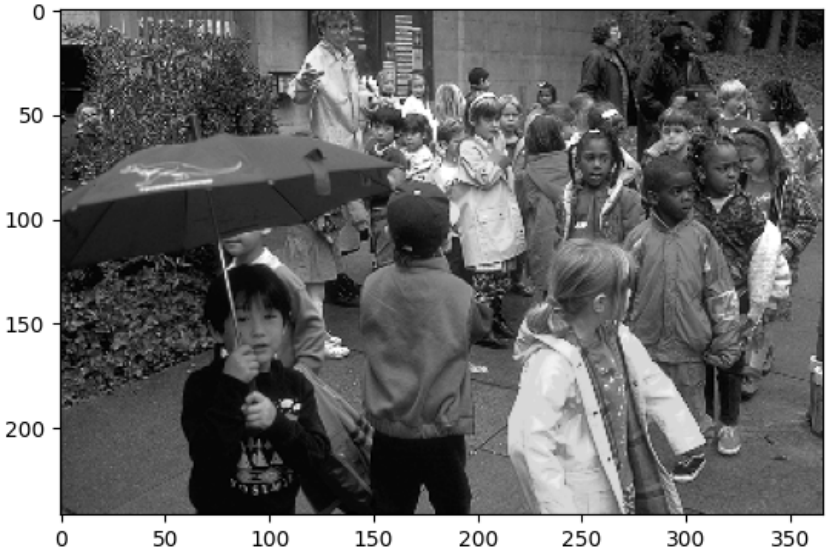

Figure 3: Original Image of kids.tif

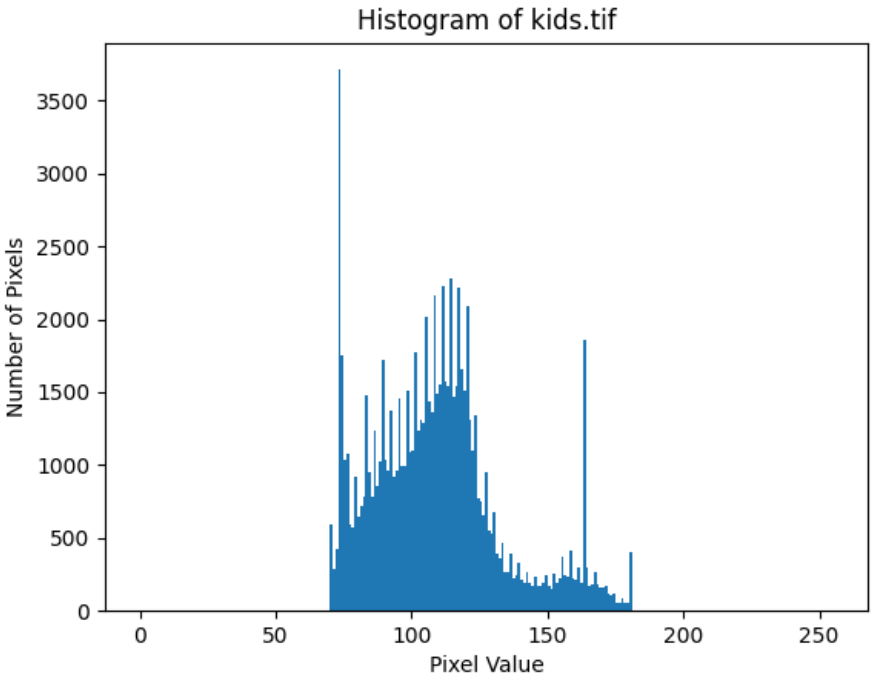

Figure 4: Histogram of kids.tif

2 Histogram Equalization

1. Hand in the function *equalize(x)*

```
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image
from matplotlib import cm

def equalize(x):
    # calculate histogram of x
    h,_ = np.histogram(x, bins=np.linspace(0,255,256))

    # calculate cumulative distribution of x
    F = np.zeros((256,))
    for i in range(256):
        F[i] = np.sum(h[0:i]) / np.sum(h)

    # equalize the image
    y = np.ones_like(x, dtype=float)
    for i in range(x.shape[0]):
        for j in range(x.shape[1]):
            x_temp = x[i,j]
            f_temp = F[x_temp]
            y[i,j] = F[x_temp]
    y_min = y.min()
    y_max = y.max()
    z = 255 * (y - y_min) / (y_max - y_min)
    z = z.astype(dtype=int)
    return z, F
```

2. Hand in a labeled plot of $\hat{F}_x(i)$ for the image *kids.tif*

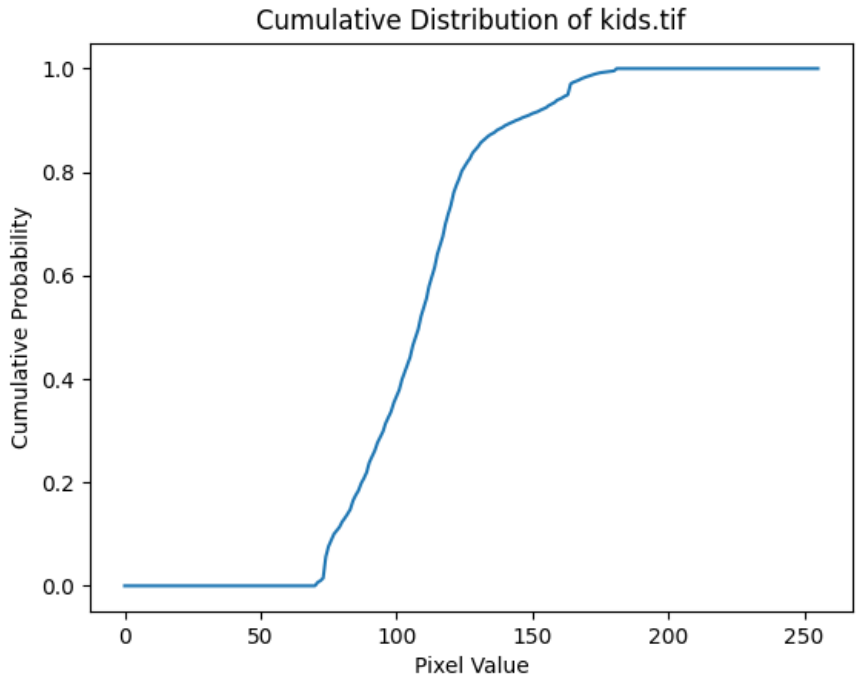

Figure 5: Cumulative Distribution of pixels in kids.tif

3. Hand in a labeled plot of the equalized image's histogram.

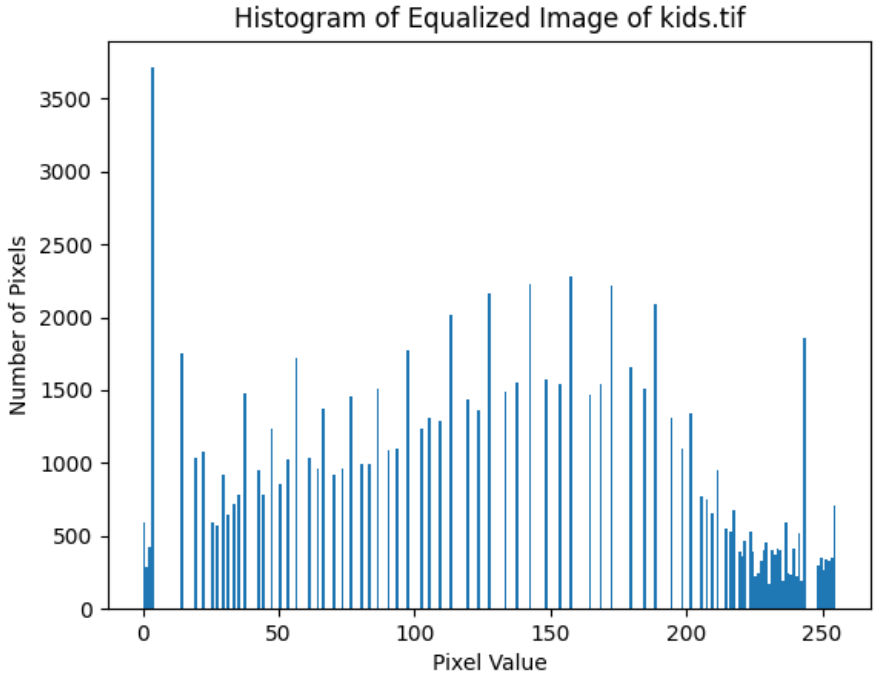

Figure 6: Histogram of the equalized image kids.tif

4. Hand in the equalized image

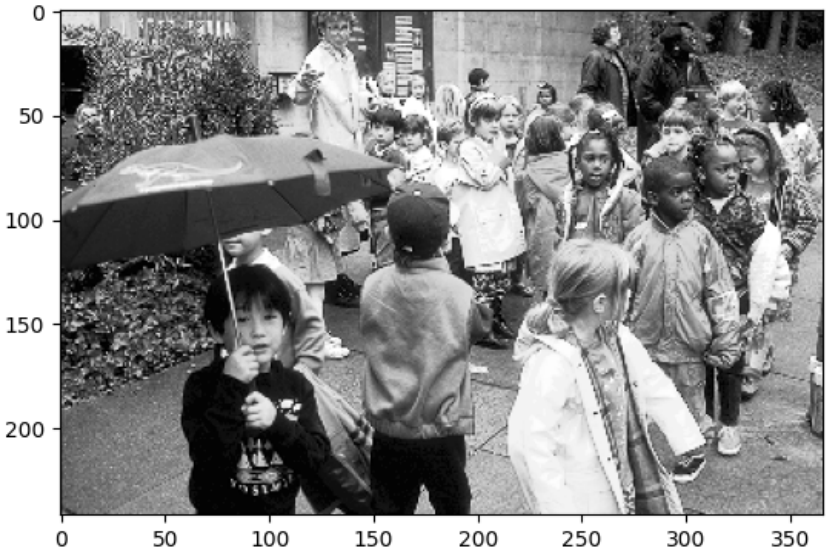

Figure 7: Equalized image of kids.tif

3 Contrast Stretching

1. Hand in your code for *stretch*

```
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image
from matplotlib import cm

def stretch(input, T1, T2):
    slope = 255.0 / (T2 - T1)
    output = np.zeros_like(input)
    for i in range(input.shape[0]):
        for j in range(input.shape[1]):
            if (input[i,j] > T1 and input[i,j] <= T2):
                output[i,j] = int((input[i,j] - T1) * slope)
            elif (input[i,j] > T2):
                output[i,j] = 255
    return output
```

2. Hand in the transformed image and its histogram

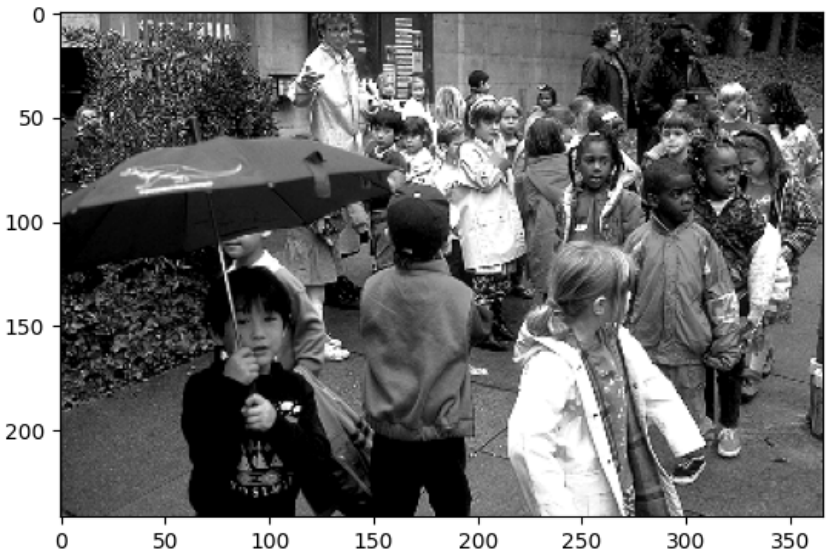

Figure 8: The transformed image of *kids.tif* ($T_1 = 80, T_2 = 160$)

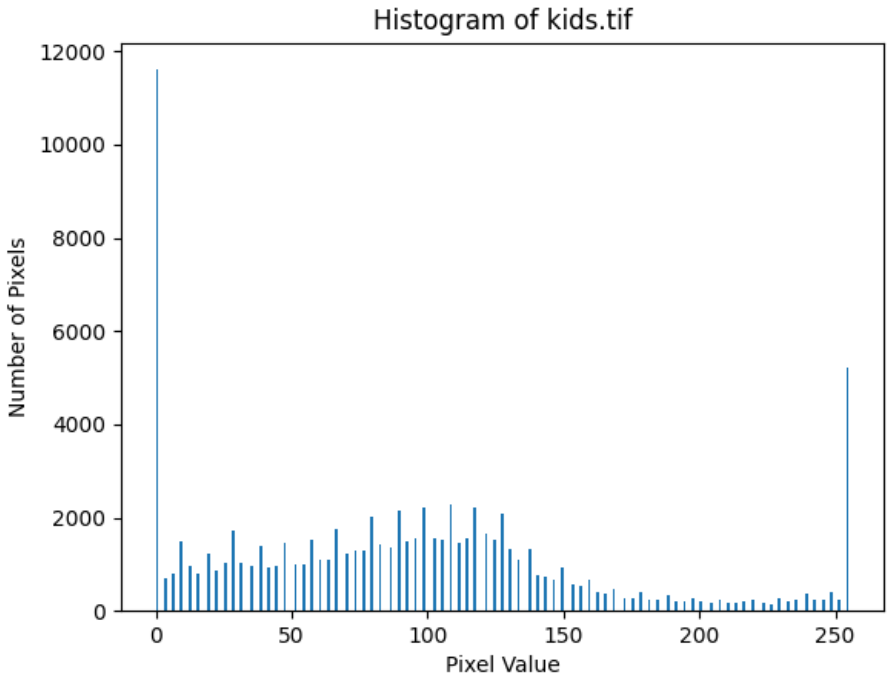

Figure 9: Histogram of the transformed image of *kids.tif* ($T_1 = 80, T_2 = 160$)

4 Gamma

4.1 Setting the Black Level and Picture of Your Monitor

The Black Level and Picture has been set.

4.2 Determining the Gamma of Your Computer Monitor

1. Hand in your image corresponding to the matching gray level.

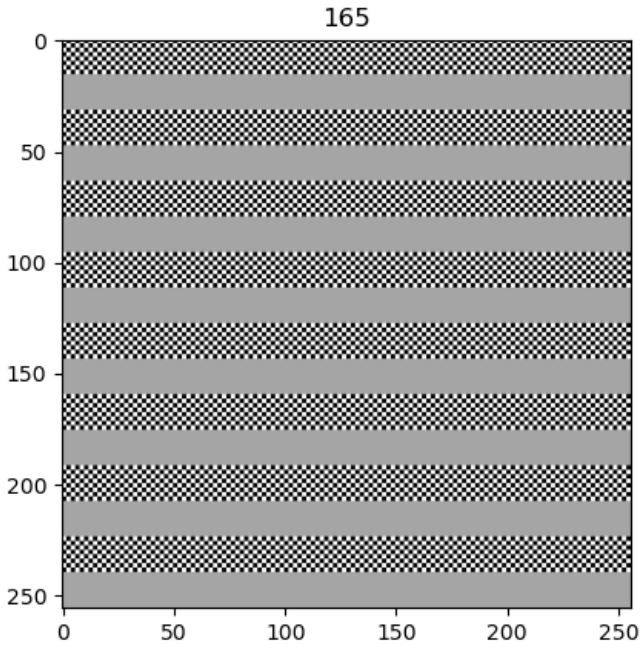

Figure 10: Image that has matching grey level

2. Derivation for calculate the value of γ

$$I_g = I_{255}(\frac{g}{255})^\gamma$$
$$\frac{I_g}{I_{255}} = (\frac{g}{255})^\gamma$$
$$\log\left(\frac{I_g}{I_{255}}\right) = \gamma \log\left(\frac{g}{255}\right)$$
$$\gamma = \log\left(\frac{I_g}{I_{255}}\right) / \log\left(\frac{g}{255}\right)$$

3. Calculate gamma value of my monitor

$$I_g = Ic = (I_{255} + 0)/2 = 127.5$$

$$\gamma = \log\left(\frac{I_g}{I_{255}}\right) / \log\left(\frac{g}{255}\right) = \log\left(\frac{127.5}{255}\right) / \log\left(\frac{165}{255}\right) = 1.59$$

4.3 Gamma Correction

1. Hand in the original and corrected images. Label them and indicate the value of gamma that was used to correct the image.

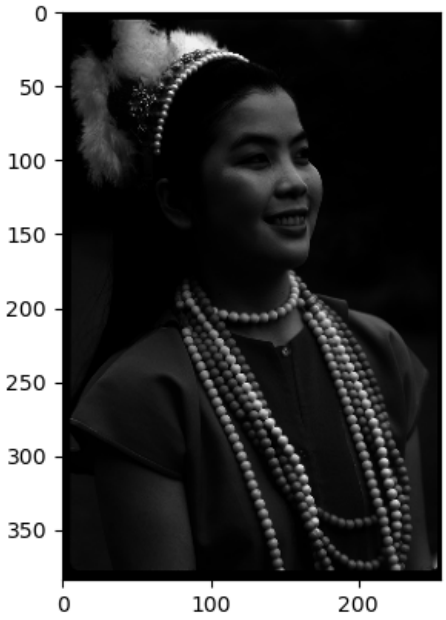

Figure 11: The original linear image

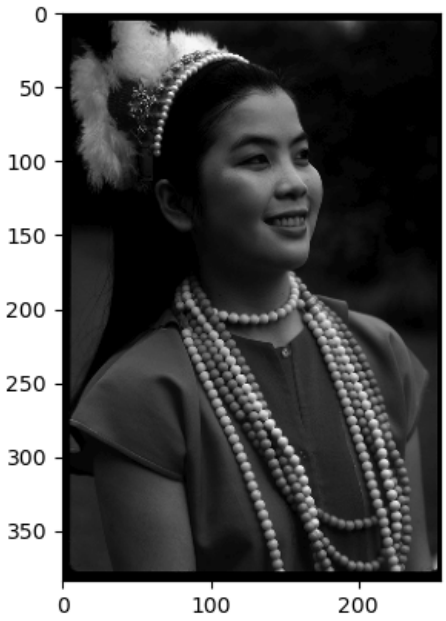

Figure 12: The gamma corrected image ($\gamma = 1.59$)

2. Hand in the formula used to transform the original image.

$$\text{corrected} = 255 \left(\frac{\text{linear}}{255} \right)^{1/\gamma}$$

3. Hand in the correct image.

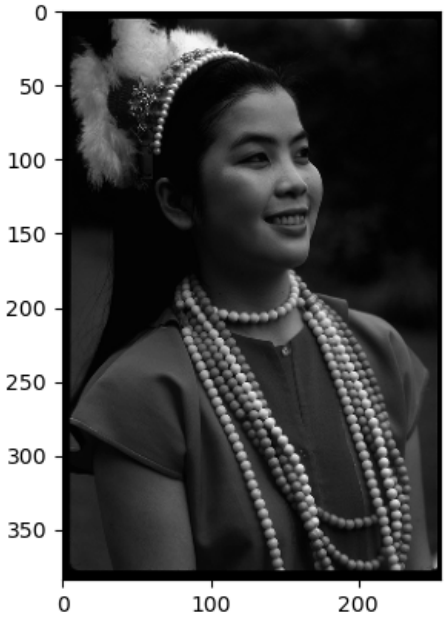

Figure 13: The gamma corrected image from *gamma15.tif* ($\gamma = 1.59$)

4. Document the procedure you used to change the gamma correction of the original image.
   (a) The *gamma15.tif* image was converted to a linear scaling using Equation 5 in the lab manual.
   (b) The new image with the linear scale was then corrected to the monitor gamma value of 1.59 using the inverse of Equation 5.