Digital Image Processing Laboratory:

Pointwise Operations and Gamma

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1. Histogram of an Image

1.1 Hand in the two images and their labeled histograms.

Fig 1: Image race.tif

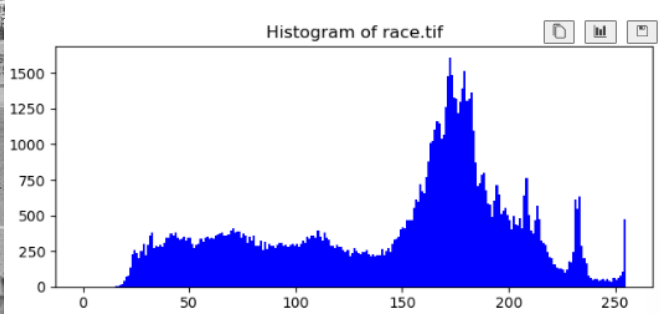

Fig 2: Histogram of race.tif

Fig 3: Image kids.tif

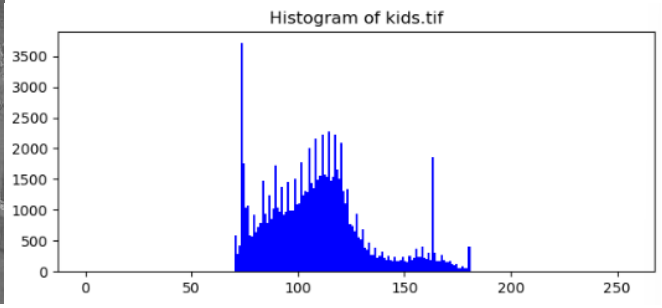

Fig 4: Histogram of kids.tif

2. Histogram Equalization

2.1 Hand in the function equalize.m

```
3  def equalize(X):
4      # Compute histogram
5      h, bins = np.histogram(X, bins=256, range=[0, 255])
6
7      # Cumulative sum of histogram
8      Y = np.cumsum(h) / np.sum(h)
```

```
9
10      # Normalize values to [0, 1]
11      Ymax = Y[X.max()]
12      Ymin = Y[X.min()]
13
14      Z = np.uint8(255 * ((Y[X] - Ymin) / (Ymax - Ymin)))
15
16      plt.figure(figsize=(8, 4))
17
18      # Display CDF
19      plt.subplot(1, 2, 1)
20      plt.plot(range(256), Y, color='blue')
21      plt.xlabel('Pixel Intensity')
22      plt.ylabel('Cumulative Distribution Function (CDF)')
23      plt.title('Cumulative Distribution Function')
24
25      # Display histogram of equalized image
26      plt.subplot(1, 2, 2)
27      plt.hist(Z.flatten(), bins=256, range=[0, 255], color='blue')
28      plt.xlabel('Pixel Intensity')
29      plt.ylabel('Number of Pixels')
30      plt.title('Histogram of Equalized Image')
31
32      plt.tight_layout()
33      plt.show()
```

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

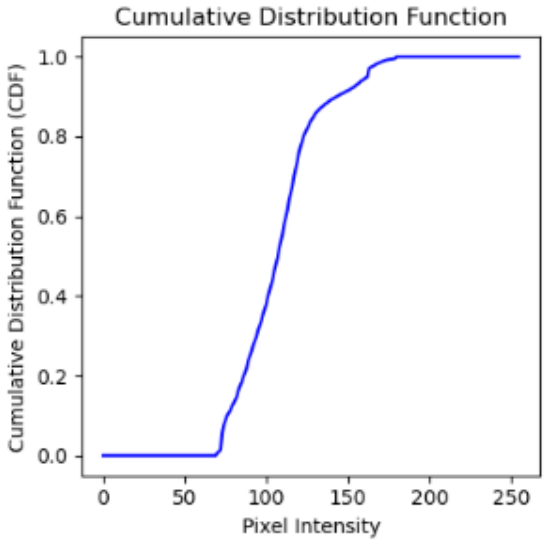

Fig 5: Plot of $\hat{F}_x(i)$ for the image kids.tif

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

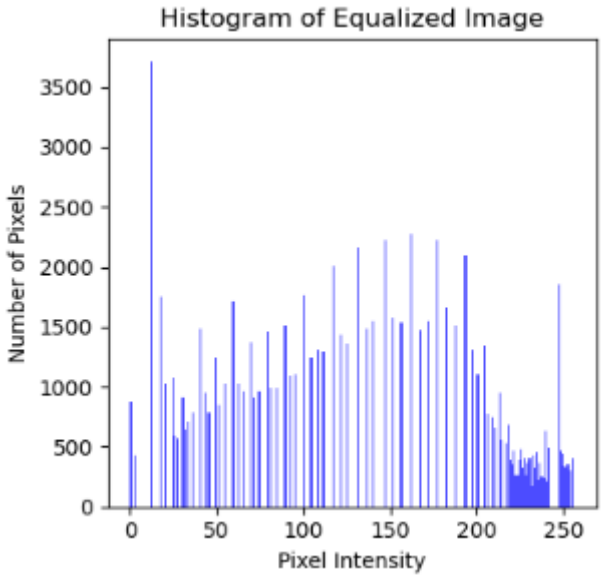

Fig 6: Histogram of the equalized image

2.4 Hand in the equalized image.

Fig 7: Equalized image

3. Contrast Stretching

3.1 Hand in your code for stretch.

```
4  def stretch(input, T1, T2):
5      rol, col = input.shape
6      output = np.zeros((rol, col), dtype=np.uint8)
7
8      for i in range(rol):
9          for j in range(col):
10             if input[i, j] > T2:
11                 output[i, j] = 255
12             elif T1 < input[i, j] < T2:
```

```
13                 output[i, j] = np.uint8((input[i, j] - T1) * (255 /
   (T2 - T1)))
14
15     return output
```

3.2 Hand in the transformed image and its histogram

Fig 8: Transformed image

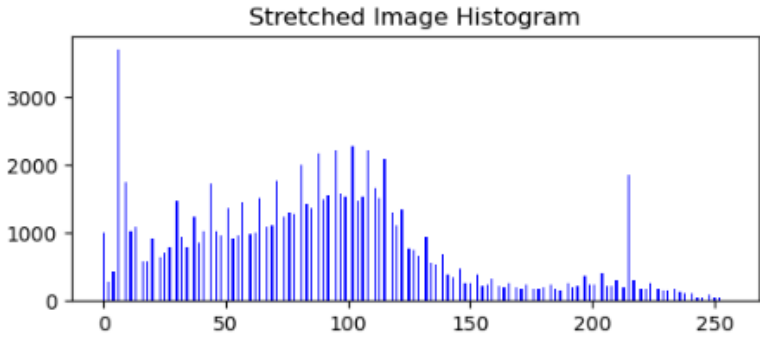

Fig 9: Histogram of the transformed image

4. Gamma

4.1 Setting the Black Level and Picture of Your Monitor

4.2 Determining the Gamma of Your Computer Monitor

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

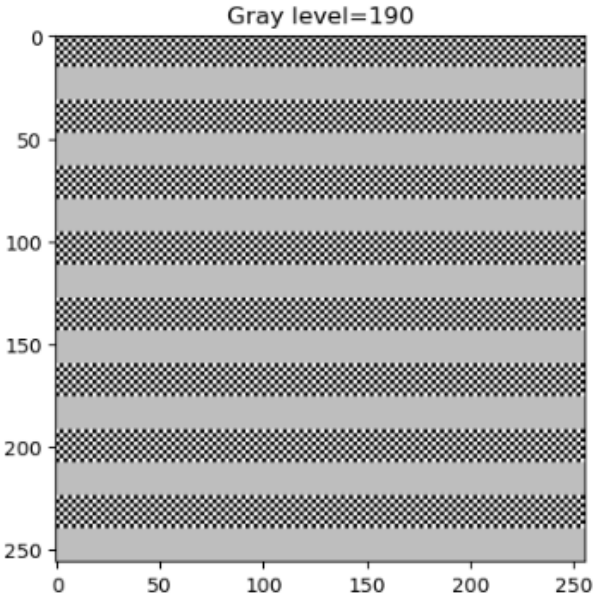

Fig 10: Image with matching gray level 190

4.2.2 Hand in a derivation of the expression which relates the matching gray level to the value of γ.

$$\frac{I_{255}}{2} = I_{255}\left(\frac{g}{255}\right)^{\gamma}$$

$$\log\left(\frac{1}{2}\right) = \gamma \log\left(\frac{g}{255}\right)$$

$$\gamma = \frac{\log(1/2)}{\log(g/255)}$$

$$\gamma = -\frac{\log(2)}{\log(g/255)}$$

4.2.3 Hand in the values of the measured gray level and the measured γ.

$$g = 190$$

$$\gamma = -\frac{\log(2)}{\log\left(\frac{190}{225}\right)} = 2.3557$$

4.3 Gamma Correction

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

Fig 11: Original image

Fig 12: Corrected image with γ = 2.3557

4.3.2 Hand in the formula you used to transform the original image.

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

$$g^{\gamma} = \frac{I_g \cdot 255^{\gamma}}{I_{255}}$$

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

4.3.3 Hand in the corrected image. Be sure it is labeled in the report.

Fig 13: Corrected image of gamma15.tif with γ = 1.5/2.3557

4.3.4 Document the procedure you used to change the gamma correction of the original image.

The given image has already suffered a gamma correction with γ_1

$$g = 255 \left(\frac{I_g}{I_{255}}\right)^{\frac{1}{\gamma_1}}$$

And we want to correct it with $\gamma_2 = 2.3557$

$$g = 255 \left(\frac{I_g}{I_{255}}\right)^{\frac{\gamma_1}{\gamma_2}}$$

We combine both so that γ is:

$$\gamma = \frac{\gamma_1}{\gamma_2} = \frac{1.5}{2.3557}$$