Computational Photography

Assignment 1 - Pixel Operations
Summer 2023

Introduction

In this first assignment we want to get you comfortable with importing and exporting images as well applying basic point-processing algorithms.

Subsequent assignments will likely be far more involved, but we want to you getting your "hands dirty" as soon as possible!

In this assignment, as with all of our assignments, you shouldn't be using built-in functions that violate the "spirit" of the assignment. For instance, in part 3, you can't use a function like *rgb2gray*, for part 5 you can't use any functions that do gamma correction for you.

In this assignment you will demonstrate your ability to:

- Obtain images and import them into Matlab
- Demonstrate the application of several pixel-processing algorithms.
- Render histograms and images

Grading

Theory Questions	20pts
RGB $\rightarrow$ Grayscale	20pts
RGB $\rightarrow$ Binary	20pts
Gamma Correction	20pts
Histograms	20pts
TOTAL	100pts

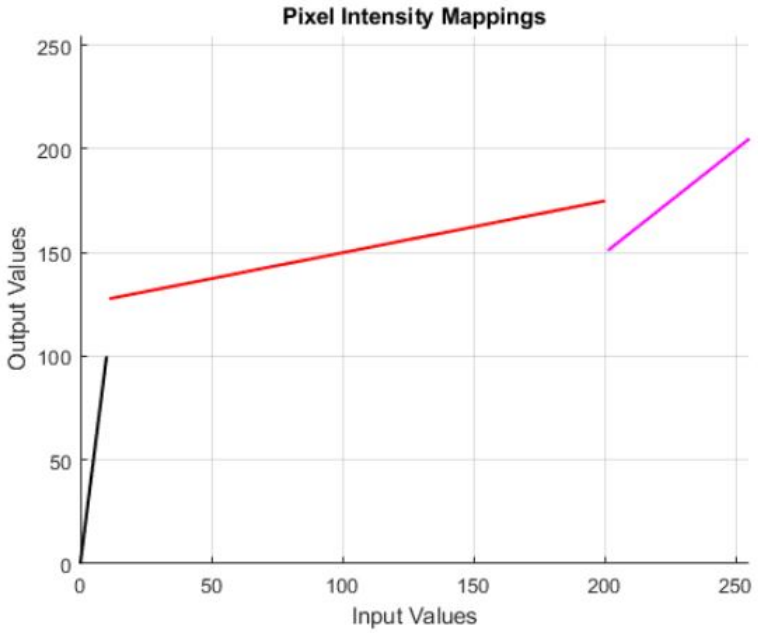
Table 1: Grading Rubric

1 (20pts) Theory Questions

1. Based on observing a histogram perhaps we decided to create the following pixel intensity mappings in order to stretch the values of a particularly compressed area (you may assume the full range is [0,255]):

$$[0,10] \rightarrow [0,100]$$
$$(10,200] \rightarrow (100,150]$$
$$(200,255] \rightarrow (150,255]$$

   (a) (5pts) Draw a 2D graph showing these mappings. The x-axis will be the input values and the y-axis will be the output values.



   (b) (10pts) What are the equations for these mappings?

$$Y = \begin{cases} 10x, & 0 < x < 10 \\ \frac{1}{4}x, & 10 < x < 200 \\ x - 50, & 200 < x < 255 \end{cases} \tag{1}$$

   (c) (2pt) Given a value of 50, what will this value be mapped to?

$$y = \frac{1}{4}(50) + 125 = \mathbf{137.5}$$

   (d) (3pts) In your own words, describe the effect of this mapping.

   These mappings will help to stretch the image through positive slope maniuplations of the pixels within the given range of 0:255. This will increase the "brightness"/contrast of the image, making the RBG pixels brighter, as the intensity from 0 to 255 is increased for each channel.

2 Dataset

For the programming component of this assignment, you may use a *color* image of your choosing. Make sure that you include your image with your submission so that we can recreate your results. In each of the following sections you'll be asked to output images. The images will also be included in your report.

3 (15pts) RGB → Grayscale

The first point-processing thing we want to be able to do is to convert an image from color to grayscale.

Read in your color image and use the following formula to convert it to a grayscale image. You **may not** use a built-in function to do this (i.e rgb2gray).

$$Gray = 0.2989R + 0.5870 * G + 0.1140B \tag{2}$$

Color Image

GrayScale Image

4 (15pts) RGB → Binary

In this part, we want to be able to convert your color image into a binary image, where each pixel is either black or white.

To do this, first convert your image to grayscale (using what you did in the previous part), then produce three binary images, one for each of the following thresholds (as percentages of maximum possible intensity value):

- t=25%
- t=50%
- t=75%

Figure 1: Color

Figure 2: 25% Threshold

Figure 3: 50% Threshold

Figure 4: 75% Threshold

5 (20pts) Gamma Correction

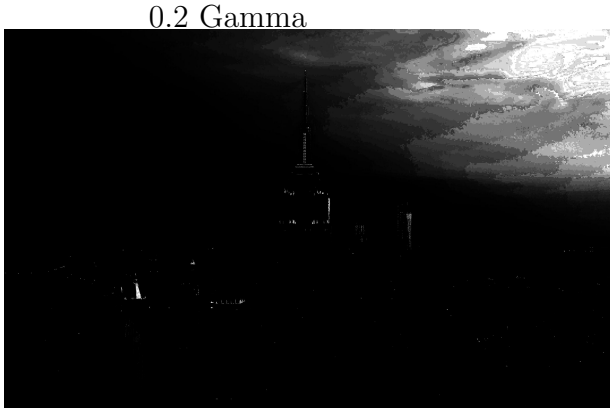
In this part, we want to apply some gamma correction to your image. Making sure that your RGB values are in the range $[0, 1]$, apply gamma correction to each channel (independently) via the formula $s = r^\gamma$ (we'll let $c = 1$). Do this for each of the following values of gamma (producing three images):

- $\gamma = 0.2$
- $\gamma = 1$
- $\gamma = 50$

Color

0.2 Gamma

1 Gamma

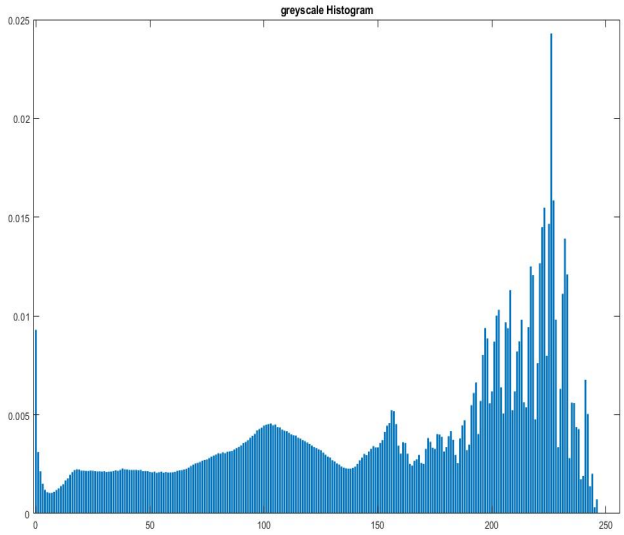


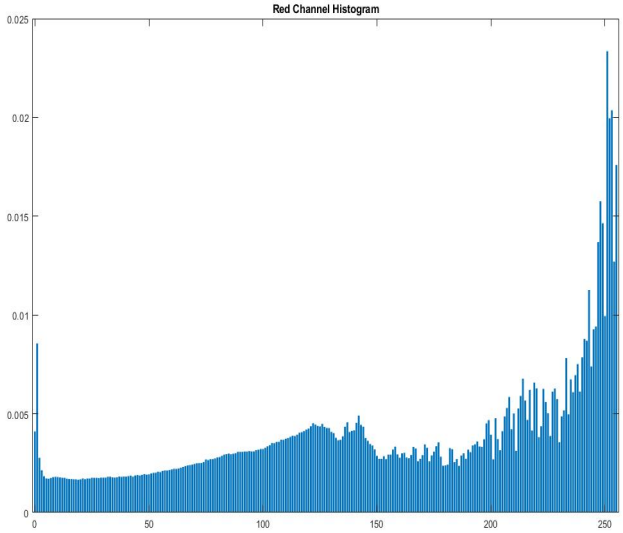
50 Gamma

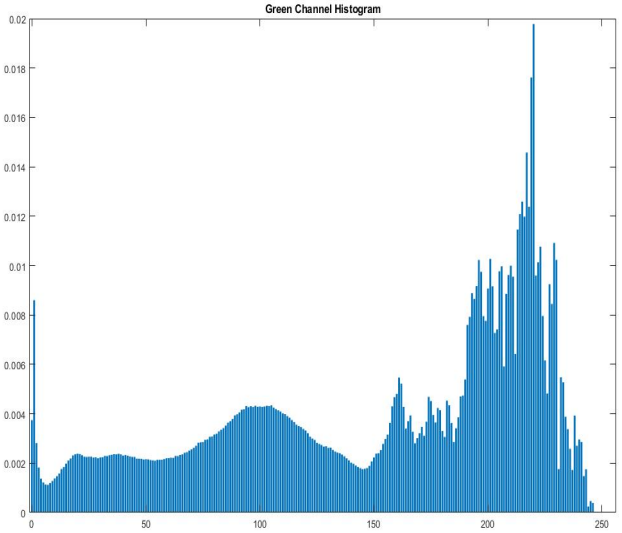
6 (20 points) Histograms

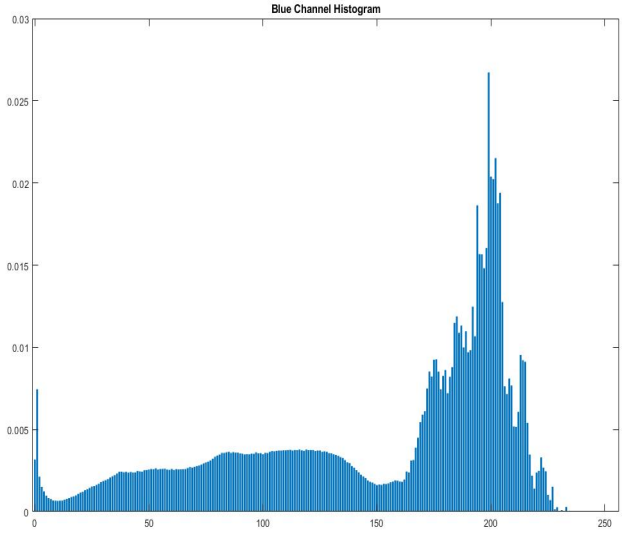
Histograms are a critical analysis tool use for many computer vision problems. Display four histograms for your image, each of which have 256 bins. **You may not use a built-in function to obtain the histogram**. To plot your histogram, use the *bar* function of Matlab.

- Grayscale histogram
- Histogram of the red channel
- Histogram of the green channel
- Histogram of the blue channel.


greyscale Histogram
0.025
0.02
0.015
0.01
0.005
0
0
50
100
150
200
250


Red Channel Histogram
0.025
0.02
0.015
0.01
0.005
0
0
50
100
150
200
250


Green Channel Histogram
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250


Blue Channel Histogram
0.03
0.025
0.02
0.015
0.01
0.005
0
0
50
100
150
200
250

Submission

For your submission, upload to Blackboard a single zip file containing:

1. PDF writeup that includes:
   (a) Your answer to the theory question(s).
   (b) The RGB and Gray images for Part 3.
   (c) The RGB and Binary images for Part 4 (so 4 images total).
   (d) The RGB and Gamma Corrected images for Part 5 (so 4 images total).
   (e) The histograms for Part 6 (4 total)
2. A README text file (**not** Word or PDF) that explains:
   (a) Any unique features of your program (if applicable).
   (b) Any instructions on how to run your script to reproduce your results.
3. Your source file(s).
4. The chosen image(s) that you processed.