Assignment 3: Pixels & Histograms

Harry Kim

Handed out: September 7, 2022
Due: 11:59pm, September 23, 2022
Handed in: 11:59pm, September 23, 2022

Important Notes:

- Feel free discuss the homework with the instructor or the TAs.
- Handwritten solutions will not be accepted.
- Turn in a PDF report and .m/.py files through Canvas as a compressed (.zip) file; turn in a hardcopy of PDF printout in class)

Question 1: Pixel-wise operations on images

(a) Write a function to blend two given images using their weighted combination (using the below equation). Display the input images and the blended results using different values of **a**. Comment on the resulting composite images. How the resulting image changes as we increase **a**. Do you observe blurry (smoothed out) features when blending each of the below pairs of images? Explain why or why not.

(i) toycars1.png and toycars2.png

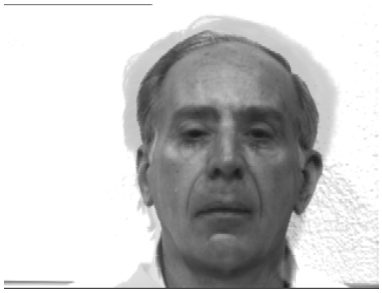
(a) Blended 25%

(b) Blended 50%

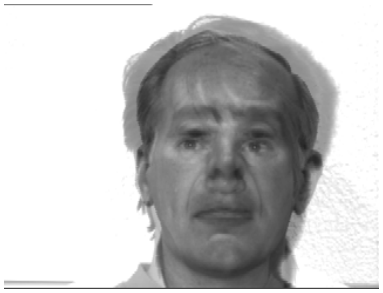
(c) Blended 75%

(d) Blended 90%

(ii) subject01.centerlight.png and subject05.noglasses.png



(a) Blended 25%



(b) Blended 50%

(c) Blended 75%

(d) Blended 90%

The resulting image seems to be a blend of the two images. The higher the weight, the more prominent the second image becomes over the first. I do not observe blurry (smoothed out) features when blending each of the below pairs of images. I think this is because there is no kind of smoothing going on. It is just one image on top of another.

(b) Write a function to threshold the below image to separate the pixels of the red car. What range of colors to use segment the red car? Write down the steps you used to determine the range to use for thresholding. Display the input image and its binarizedthresholded version. Did you perfectly separate the red car? Why or why not?

(a) carpark.png (b) Only red pixels

I chose the threshold value of 100. If the r value is above 100 while the g and the b values are less than 100, display the pixel. If not, make the pixel value 0. I don't think that I perfectly separated the red pixels from the image because some areas may be obviously red but the pixel may be below the threshold to be considered "red".

(c) Write a function to apply the logarithmic and exponential transforms on image pixels (see Eq. 3.4 and Eq. 3.7 in Chapter 3). Fix the output range to be 0 to 255. Display input and output/transformed images using different values for controlling the dynamic range compression (sigma for the logarithmic transform and alpha for the exponential transform). Discuss what specific details in the image are made more obvious in the transformed images and which details are made more or less clear as you change the values of sigma and alpha.

(a) sigma: 0.01 (b) sigma: 0.03 (c) sigma: 0.05

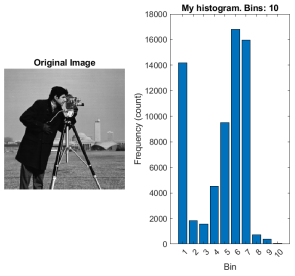
(a) alpha: 0.01 (b) alpha: 0.03 (c) alpha: 0.05

The details on the left side of the face (where the shadow is cast) is made more obvious in the transformed images. The background with the popcorn wall, however, becomes less clear.

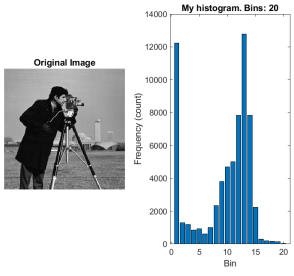
Question 2: Histograms

(a) Write your own function to compute the histogram of a given image given the number of bins. Plot the histogram that your function produced using 10, 20, 40, 80, and 100 bins. Compare this result with built-in histogram functions using the same number of bins. What happens when you increase the number of bins for the histogram? Report your observations.

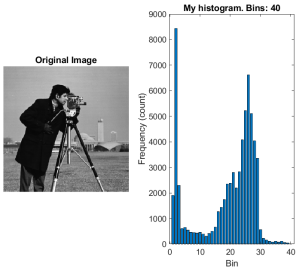
My histograms:



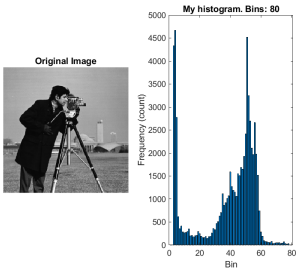
(a) Original image



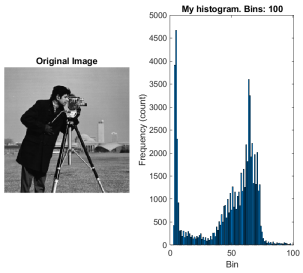
(b) Known points: 50%



(c) Known points: 10%

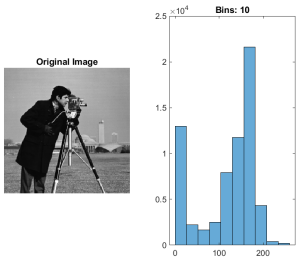


(a) Original image

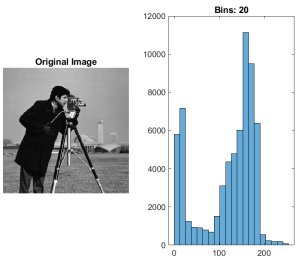


(b) Known points: 50%

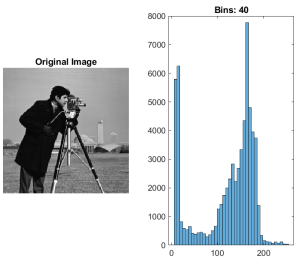
Matlab histograms:



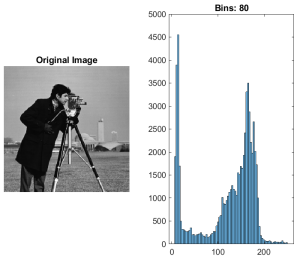
(a) Original image



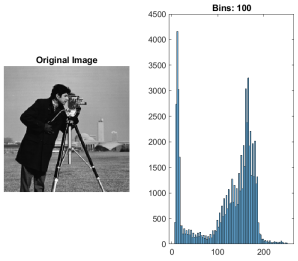
(b) Known points: 50%



(c) Known points: 10%



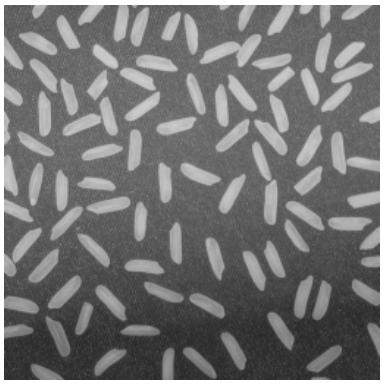
(a) Original image



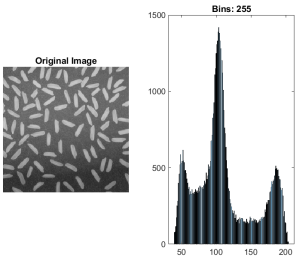
(b) Known points: 50%

When I increase the number of bins for the histogram, the histogram graph becomes more crowded with more precise data.

(b) Using the histogram function from (a), determine by visual inspection that best threshold(s) to use to separate foreground objects. Write a function to threshold the images and show the input and the thresholded images. Comment on the impact of the number of bins on the determined threshold and the quality of thresholded images in separating the objects of interest.



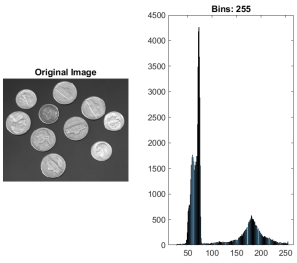
(a) rice.png



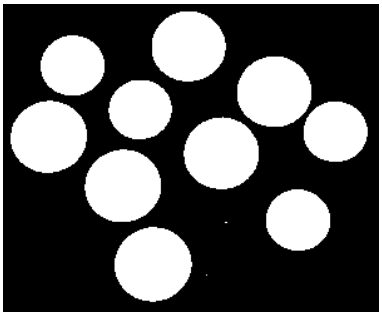
(b) rice.png histogram

(c) Threshold Value: 130

(d) coins.png



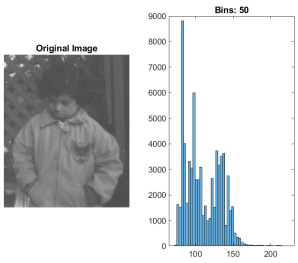
(e) coins.png histogram



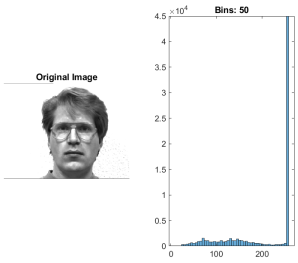
(f) Threshold Value: 130

Picking higher number of bins makes it easier to determine a sharper cut-off for the threshold to separate foreground objects. The quality is pretty good, though for the rice, the grains toward the bottom are lost because of the changing contrast between the top and the bottom.

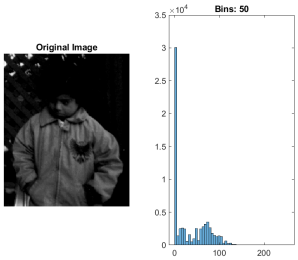
(c) Write a function to stretch the contrast of a given image using Eq. 3.10 in Chapter 2. The contrast of the output image should span the full range of grayscale intensities, i.e., a = 255 and b = 0. Experiment on low and high contrast images. Display input and output images and their histograms. Comment on the impact of this operation on the images' histogram. Does it make a difference to run a contrast stretching step on a high contrast image?



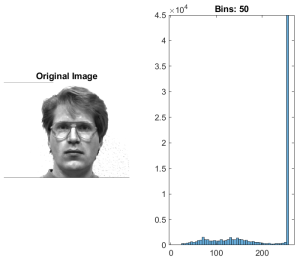
(a) pout.png



(b) subject01.glasses.png



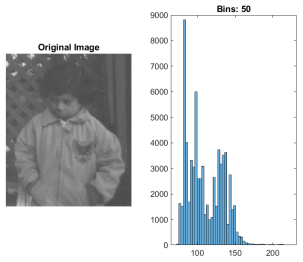
(a) pout.png contrast stretch



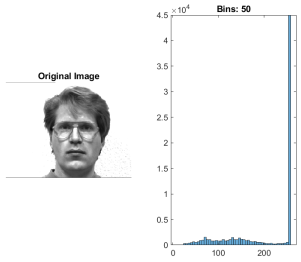
(b) subject01.glasses.png contrast stretch

The contrast stretching with the the equation Eq. 3.10 from chapter 3 made the dark regions in pout.png darker and didn't really change subject01.glasses.png much at all. The histograms show that the values became more prominent toward the extremes. Again, a larger change is observed with pout.png but not much at all with subject01.glasses.png.

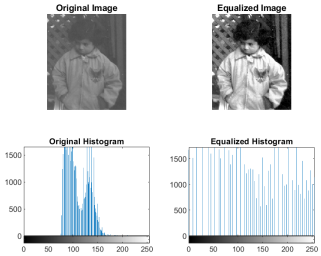
(d) Write a function to equalize the histogram of a given image using builtin functions for histogram equalization. Plot the histogram of input and output images. Comment on the output image and its histogram.



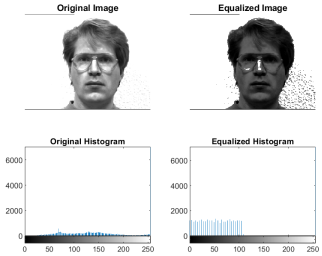
(a) pout.png



(b) subject01.glasses.png



(a) pout.png equalized



(b) subject01.glasses.png equalized

The resulting image for pout.png after being equalized is much more balanced and has a higher contrast than the original. The histogram also shows that the more prominent values are spread out throughout the range of pixel values. For subject01.glasses.png, the resulting image only became darker and the histogram shows that the equalization function tried to balance out the values, but resulted in a worse image over all.