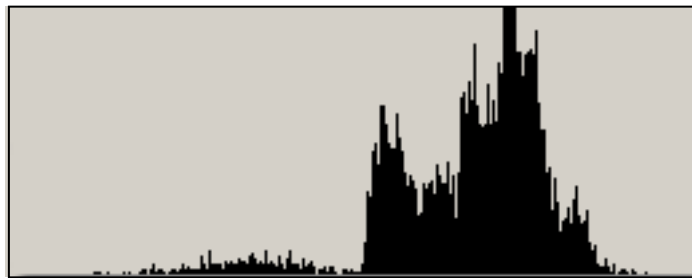


Supplement to Chapter 3 of *The Science of Digital Media* – Digital Image Processing

Worksheet – Digital Imaging > Histograms¹

Before completing this worksheet, you should view the on-line interactive tutorial "Histograms." This tutorial can be accessed at the website for *The Science of Digital Media*.

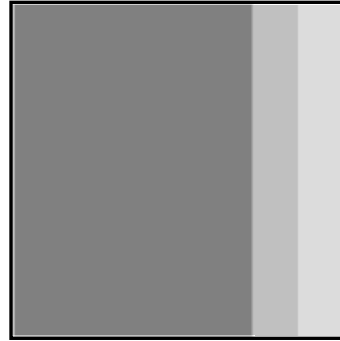
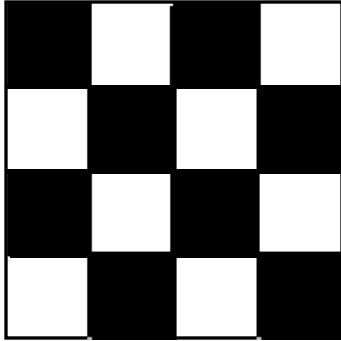
1. Assume that the histogram below represents a grayscale image in which each pixel is stored in eight bits. Describe what the horizontal and vertical axes represent and what the domain of values is for the x-axis.



2. Explain the difference between pixel point processing and spatial filtering. Why does adjusting the histogram represent a form of pixel point processing? Give an example of spatial filtering.

¹This material is based on work supported by the National Science Foundation under Grant No. DUE-0340969. This worksheet was written by Todd Martin and Jennifer Burg.

3. The histogram statistics are an important aspect of image processing tools. In the tutorial, several statistical terms were discussed. For the following pair of eight-bit grayscale images, compare and contrast what the statistics would be. Discuss the statistics in the spaces given below.

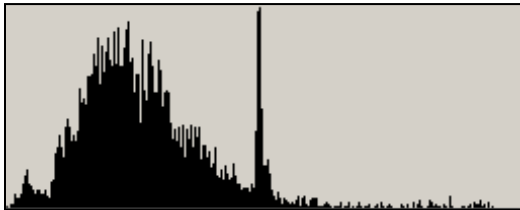
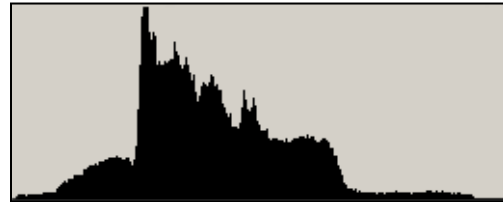


Mean:

Standard Deviation:

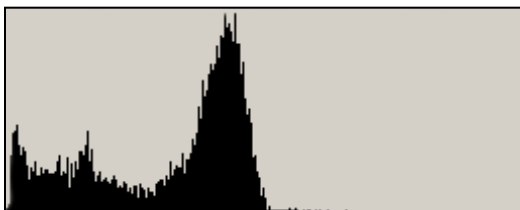
Median:

4. You should understand that there is a fundamental difference between local and global histograms. For the following grayscale image, the global histogram is shown. Below are four local histograms. Beside each, write "TRUE" or "FALSE" to indicate whether this local histogram could have come from some subsection of the image. (HINT: Look at the luminosity values present across the image to determine those that could be present in a local histogram.)

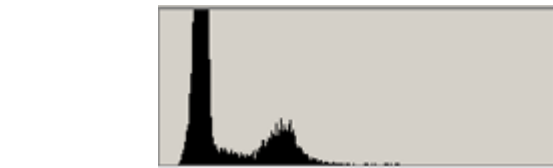








5. In the following eight-bit grayscale image, three local areas are highlighted by rectangles. Below the image are three histograms that have been calculated from the pixels in the three highlighted areas. Using what you know about histograms, label each histogram with the correct area in the image that the histogram represents. Remember that the horizontal axis of the histograms goes from black (0) on the left to white (255) on the right.



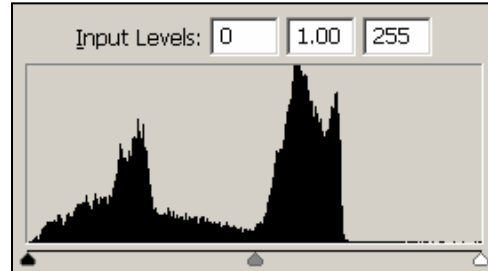
6. Explain the difference between RGB histograms and luminosity histograms as alternatives for representing the pixel data of RGB color images. Which of these two histograms is best for representing human perception?

7. The grayscale image below has the histogram given. To the right of the image is the inversion of the same image, where every pixel value p is replaced by $255 - p$. Explain how the histogram of this image would be different from the original histogram.



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8. You have learned that the histogram can be used as an adjustment tool in order to maximize the contrast of an image. Below is a grayscale image and its histogram, as seen in the level adjustment window. Describe what you would do in order to adjust the image to maximize contrast.



9. You have learned about the difference between RGB and luminosity histograms for color images and why luminosity offers a better representation of how the image is perceived by the human eye. Suppose that the matrix below represents a set of RGB pixel values for a subsection of an image (the RGB values are given as (RED, GREEN, BLUE) triples). Using the formula given in the tutorial, calculate the luminosity value for each of these pixels and fill in the matrix below. Truncate any decimal answers to obtain integer luminosity values.

RGB Matrix:

(100,130,56)	(98,134,76)	(93,121,83)
(105,140,45)	(101,130,67)	(94,123,86)
(109,141,49)	(104,123,60)	(86,130,74)

Luminosity Matrix:
