Rensselaer Polytechnic Institute
Department of Electrical, Computer, and Systems Engineering
ECSE 4540: Introduction to Image Processing, Spring 2018

Homework #1: due Monday, Jan. 29th, at the beginning of class. Show all work for full credit! Submit your work as a single PDF on Gradescope, labeling each page with a problem number.

1. (30 points.) Create the following 500 × 500 8-bit images in Matlab; include a picture and the Matlab commands you used in your writeup. Note that each of these only requires 1-3 lines of Matlab code, no `for` loops, and no `if` statements! Use the image (not Cartesian) coordinate system; that is, x indexes the rows from top to bottom and y the columns from left to right. Use `imshow(im,[0 255])` for grayscale image display. Use `uint8(im)` for commands that don't produce an integer output. You will be penalized if your code is too complicated.

    (a) A grayscale image of constant intensity 60

    (b) A grayscale image with alternating black and white vertical stripes, each of which is 2 pixels wide

    (c) A grayscale image where the left half has intensity 32 and the right half has intensity 200

    (d) A grayscale image with a ramp intensity distribution, described by $I(x, y) = x/2$

    (e) A grayscale image with a Gaussian intensity distribution centered at (64, 64), described by
    $$I(x, y) = 255 \exp - \left(\frac{(x-64)^2 + (y-64)^2}{200^2} \right)$$

    (f) A color image where the upper left quadrant is white, the lower left quadrant is magenta, the upper right quadrant is cyan, and the lower right quadrant is blue

2. (20 points.)

    (a) A 4K HDR Netflix video stream transmits frames of size 4096×2160 at 30 frames per second with 10 bits per color channel. Compute the number of bits it would take to stream the season premiere of *Stranger Things 2*, a 48-minute episode.

    (b) Suppose your internet provider caps your download rate at 30 Mbps. Based on your answer in part (a), compute a lower bound on the compression ratio that must be achieved by Netflix's video compression algorithm in order to deliver the stream.

3. (20 points.) Consider the image in Problem 1e, which has 256 gray levels. Create quantized versions of this image with 128, 64, 32, and 16 gray levels (this involves the `round` command). At what point can you visually detect false contouring?

4. (15 points.) We model the camera in the iPhone 8 as a pinhole placed at (0 m, 0 m, 0 m) in world coordinates. Suppose the focal length is 28mm and a 6.29 × 5.21 mm CCD array that has 4608 pixels in the x direction and 2592 pixels in the y direction is placed at the focal plane. What image pixel does the world coordinate (-0.05 m, 0.1 m, 2.5 m) project to, assuming $(0,0)$ is at the upper left corner (not the center) of the array?

5. (15 points.) The color of Rey's lightsaber is given by the HTML RGB code `#A8D0E8`. Represent this color as:

    (a) An RGB triplet where each value is in the range [0,1].

    (b) A CMY triplet where each value is in the range [0,1].

    (c) An HSI (hue-saturation-intensity) triplet where each value is in the range [0,1]. See Gonzalez and Woods (Section 6.2 3rd ed., Section 7.2 4th ed.) for how to do the conversion and show your work! Note that Gonzalez and Woods define the intensity component slightly differently than Photoshop and other paint programs, and that HSI is not the same as HSV!

    (d) an interpretation of the HSI triplet in words (e.g., similar to "a deep, dark red".)