EECS 203A: HOMEWORK #1

Due: April 8, 2021

1. Suppose that a continuous ramp image is defined by

$$c(x, y) = 256x \qquad 0 \leq x \leq 1 \quad 0 \leq y \leq 1$$

An $N \times N$ digital image $f(X, Y)$ is formed by sampling $c(x, y)$ at the spatial locations

$$x = 0, \frac{1}{N}, \frac{2}{N}, \ldots, \frac{N-1}{N} \qquad y = 0, \frac{1}{N}, \frac{2}{N}, \ldots, \frac{N-1}{N}$$

where N is a power of 2. The value at each pixel is represented using 8 bits where only the b most significant bits are allowed to be nonzero. For example, in 11100000 (= 224 decimal) the three most significant bits are nonzero. If a sampled value of $c(x, y)$ is larger than the largest representable value, then it is represented by the largest representable value. A pixel-to-pixel difference of 6 or more is considered jagged for this ramp image. For what combinations of values of N and b will the digital image $f(X, Y)$ not be jagged? Explain your answer. The values of N and b should be large enough so that $f(X, Y)$ is not a constant image.

2. a) Is an operator that replaces every pixel in an image with the average of the pixel itself and its eight neighbors a linear operator? Ignore boundary effects. Prove your answer.

b) Is an operator that replaces every pixel in an image with the median of the pixel itself and its eight neighbors a linear operator? Ignore boundary effects. Prove your answer.

3. Consider an image $f(x, y)$ with the pixel values

$$f(1, 1) = 16 \quad f(1, 2) = 24 \quad f(2, 1) = 22 \quad f(2, 2) = 32$$

a) Find the continuous bilinear function $b(x, y)$ such that $b(x, y) = f(x, y)$ at these four points.

b) Find $b(1.2, 1.6)$.

4. Consider a television standard with 1125 horizontal lines and a width-to-height aspect ratio of 16:9 with full images displayed every 1/30 of a second. Suppose that we create a digital image by sampling each horizontal line so that the horizontal and vertical sample spacing are the same (i.e. the digital image also has a 16:9 aspect ratio). Each pixel is represented using 24 bits. How many bits would it take to store all of the digital images without compression for a 2-hour movie in this format?

Computer Problems:

The images triangle.raw and cat.raw have been uploaded to the Files directory on Canvas. These images are 480 rows x 640 columns stored row-by-row with 8 bits per pixel in raw format. Images in raw format can be viewed using the IrfanView software for Windows as shown in the Canvas examples (IrfanviewGUI.PNG, SettingIrfanView.PNG). Gimp is a similar tool that can be used on the Mac. The C program rw.c on Canvas was written for another purpose but might be helpful for reading and writing 8 bit per pixel raw images. You may use any computer tools that you like to solve the computer problems.

Tasks: Write a program that subsamples the image triangle.raw by 4 to 120×160 to generate an image named triangles4.raw and also subsample by 16 to generate a 30×40 image named triangles16.raw. Then use nearest neighbor interpolation to transform triangles4.raw to a 480×640 image named trianglei4.raw and also to transform triangles16.raw to a 480×640 image named trianglei16.raw. Repeat for the image cat.raw. Submit your code and the following displayable images to Canvas: triangles4.jpg, triangles16.jpg, trianglei4.jpg, trianglei16.jpg, cats4.jpg, cats16.jpg, cati4.jpg, cati16.jpg.