

EECS 203A: HOMEWORK #1

Due: April 11, 2019. Submit written questions during class and images to class dropbox.

1. Suppose that a continuous ramp image is defined by

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

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

$$x = 0, \frac{1}{N}, \frac{2}{N}, \dots, \frac{N-1}{N} \quad y = 0, \frac{1}{N}, \frac{2}{N}, \dots, \frac{N-1}{N}$$

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. 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 units is considered objectionable for this ramp image. For what combinations of values of N and b will the digital image $f(X, Y)$ not be considered objectionable? 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 $b(1.5, 1.5)$.

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 sent out by email. 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 emailed example. The emailed C program `rw.c` that was written for another purpose 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`. When you finish, the following displayable images should be put in the class dropbox: `triangles4.jpg`, `triangles16.jpg`, `trianglei4.jpg`, `trianglei16.jpg`, `cats4.jpg`, `cats16.jpg`, `cati4.jpg`, `cati16.jpg`.