

EECS 203A: HOMEWORK #1

Due: April 12, 2018. 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) Let H be an operator that maps an input image $I(x, y)$ to the output image $3I(x, y) + 6$. Is H a linear operator? Prove your answer.

b) Is an operator that replaces every pixel in an image with the median of all of the pixels in the image linear? Prove your answer.

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

$$f(1, 1) = 8 \quad f(1, 2) = 12 \quad f(2, 1) = 11 \quad f(2, 2) = 16$$

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:

Notes: Software and images for EECS203A are in the directory

`/ecelib/ece234a/shared`

on the computer `zuma.eecs.uci.edu`. Zuma can be accessed using `putty`. You can copy files under the shared directory to your own directory as you need them. The image `triangle` (`/ecelib/ece234a/shared/img/triangle`) is 480 rows x 640 columns stored row-by-row with 8 bits per pixel in raw format. Images in raw format can be converted to raster format for display using `rawtoras` (`/ecelib/ece234a/shared/bin/rawtoras`) with a command like

```
rawtoras -c 640 -r 480 image image.ras
```

Images in raster format can be viewed using the command

```
xv image.ras
```

The C program `rw.c` (`/ecelib/ece234a/shared/src/rw.c`) that was written for another purpose might be helpful in showing you how to read and write 8 bit per pixel raw images. Information on `putty` is available at

<http://the.earth.li/~sgtatham/putty/0.67/htmldoc>

Tasks: Write a program that subsamples the image `triangle` by 4 to 120×160 to generate an image named `triangles4` and also subsample by 16 to generate a 30×40 image named `triangles16`. Then use nearest neighbor interpolation to transform `triangles4` to a 480×640 image named `trianglei4` and also to transform `triangles16` to a 480×640 image named `trianglei16`. Repeat for the image `cat`. When you finish, the following displayable images should be put in the class dropbox: `triangles4.ras`, `triangles16.ras`, `trianglei4.ras`, `trianglei16.ras`, `cats4.ras`, `cats16.ras`, `cati4.ras`, `cati16.ras`.