Written Assignment W1

Computer Graphics 2 (15-463)
13 Feb. 1996

Due noon Friday, 16 Feb. 1996 at my office (DH 4301A).

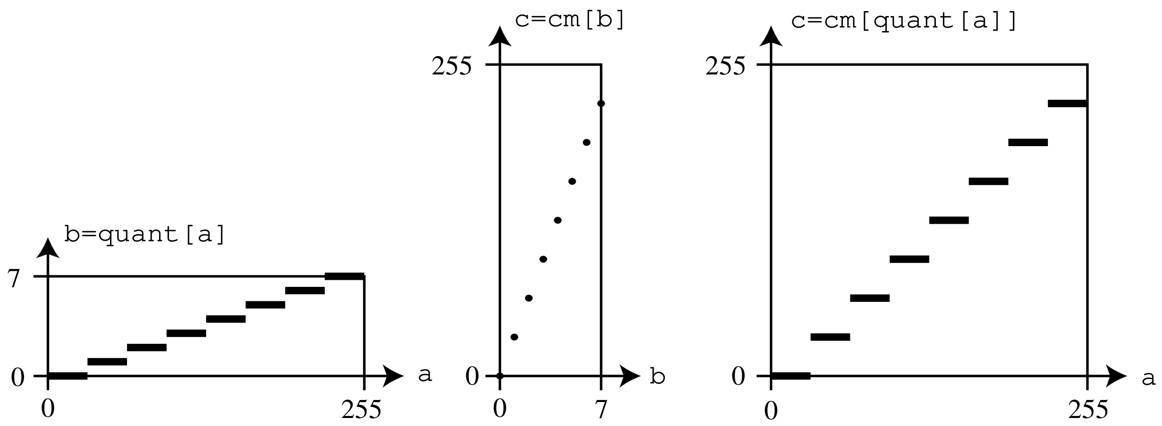
1. [10 pts.] An affine warp from picture A to picture B has been defined in terms of three points (u_i, v_i), $i = 1, 2, 3$ in A and their corresponding points (x_i, y_i), $i = 1, 2, 3$ in B. Write out the formulas and pseudocode for transforming an arbitrary point (x, y) of picture B to its corresponding point (u, v) of picture A. Your answer may make use of determinants or linear systems solvers for 3×3 or smaller matrices.

2. [20 pts.] Find the continuous Fourier transform of $f(x) = K \sin(\alpha x + \phi)$. Also plot the magnitude of $F(\omega)$. Hint: first find the inverse Fourier transforms of $B\delta(\omega - \alpha)$ and $C\delta(\omega + \alpha)$, using the sifting property of delta functions given in Notes 7.

3. [20 pts.] Given an image that has been blurred, and the filter with which it was blurred, how can we "unblur" to recover the original image? That is, given a filter g, and the blurred image h, where $h = f \circledast g$ for some input image f, how can we compute f? What can go wrong? Hints (use either): $h = f \circledast g \quad \leftrightarrow \quad H = F \cdot G$, or write convolution as a matrix multiply. Extra credit: try it, and print a picture of g, h, and the recovered f.

4. [20 pts.] You are given an intensity-linear (gamma=1), 3-bit per pixel, grayscale display device and asked to display some 8-bit grayscale images on it so that they **look as similar to the originals as possible** given limited information about the pictures to be displayed. Dithering is not allowed. To display each 8-bit picture, you'll map input pixel value `a` through a quantization table `b = quant[a]` that maps 8 bits to 3 bit pixel values `b` that you write into the display memory, and then the hardware will display the intensity `c = cm[b]` at each pixel, where `cm` is a colormap that you can set, which maps 3 bits to 8 bits.

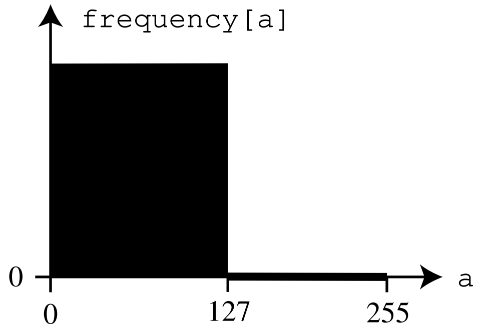
Uniform quantization would use `quant[a]=a/32, a=0..255` and `cm[b]=b*32, b=0..7` or something very similar. Plots of `quant`, `cm`, and their composition for uniform quantization are below.



quantization table colormap composite table

a) Given no knowledge about the character of the pictures to be displayed, what colormap and quantization table would you use to improve on uniform quantization? Hint: think about sensitivity to intensity differences. Graph the quantization table, colormap, and their composition in a manner similar to the above, labeling the axes. Your pictures should be qualitatively correct (relative spacing and number of plateaus) but need not be exact.

b) For a set of pictures that each has the histogram shown below, sketch the best quantization table, colormap, and their composition. Remember that the goal here is perceptually accurate reproduction of intensities, not histogram equalization.



c) If you're given a similar display device that has a gamma greater than 1, how would answer "a)" change? Draw new curves.