

CS 111: Digital Image Processing (Fall 2016)

Written Assignment 2

Total Points: 111

Due: Monday, 7 November 2016, 3:30pm

- 1) Consider a box filter in *spatial domain* for a low pass filter. [2+3+4+2+3+3+4=21]
 - a. What is its frequency domain response?
 - b. Is the box filter an ideal low pass filter? Justify your answer.
 - c. Is a box filter in the *frequency domain* an ideal low pass filter? Justify your answer.
 - d. What is the frequency domain response of a Gaussian filter in the *spatial domain*?
 - e. How does it compare to box filter in *spatial domain* for low pass filtering? Justify your answer.
 - f. A multiplication of Gaussian and Sinc in the *spatial domain* is considered an ideal low pass filter. Express analytically the frequency domain response of this filter.
 - g. How does this filter compare with the Gaussian filter in the spatial domain? Justify your answer. (Hint: Use pictures of the frequency domain response to identify pros and cons)
- 2) Suppose that you form a low-pass spatial filter $h(x, y)$ that averages all the eight immediate neighbors of a pixel (x, y) but excludes itself. [5+5=10]
 - a. Find the equivalent frequency domain filter $H(u, v)$.
 - b. Show that your result is again a low-pass filter.
- 3) Any high pass filter has a strong spike at the origin. Explain the source of these spikes. [10]
- 4) You have an image of bandwidth 100 (LW/PH)¹. What is the minimum resolution of the display that can display this image free of artifacts? How will you process this image to make this suitable to display on a 50x50 resolution display? Justify your answers. [5+5=10]
- 5) You want to digitize an analog signal of bandwidth 120 (LW/PH). The sampling frequency of your display is 100 (LW/PH). The bandwidth of your reconstruction kernel is 80 (LW/PH). [5x4=20]
 - a. Why won't you be able to sample and reconstruct this signal without artifacts using this display?
 - b. How would you process the image to reconstruct it without any artifacts?
 - c. What kind of artifacts would the reconstruction kernel generate?
 - d. How would you change the reconstruction kernel to correct it?
- 6) When we mix blue paint with yellow paint we get green. But when we project blue light on yellow light, we get brown. How do you explain this contradiction? [5]
- 7) Consider a linear display whose red, green and blue primaries have chromaticity coordinates of $(0.5, 0.4)$, $(0.2, 0.5)$ and $(0.1, 0.1)$ respectively. The maximum intensity (defined by $X+Y+Z$) of white is 1000cd/m^2 respectively. The white point of the display is $(0.33, 0.37)$ Generate the matrix that converts the RGB coordinates for this device to the XYZ coordinates. What is the XYZ coordinates of the color generated by the RGB input $(0.5, 0.75, 0.2)$ on this device? [10]

¹ Line Width per Picture Height (LW/PH) is a common unit for measuring spatial frequency in image and video processing. It tells us in an imaging or display system how many lines (pairs of black and white lines) can be fitted in a picture. In this assignment you can consider this unit similar to that of cycles per second or Hertz (Hz).

- 8) The spectrum of color $C_1 = (X_1, Y_1, Z_1)$ and $C_2 = (X_2, Y_2, Z_2)$ are given by $s_1(\lambda)$ and $s_2(\lambda)$ respectively. Let the color formed by multiplications of the spectrums s_1 and s_2 be s_3 , i.e. $s_3(\lambda) = s_1(\lambda) * s_2(\lambda)$. Is it true that the XYZ coordinate corresponding to s_3 , denoted by C_3 , is (X_1X_2, Y_1Y_2, Z_1Z_2) ? Justify your answer with calculations. **[5]**
- 9) An image has a probability density function (PDF) of $p(r) = 2(1-r)$. We want to transform this image so that its PDF becomes $p(z) = 2z$. Assume continuous images and find the transformation (in terms of r and z) that would achieve this goal. **[10]**
- 10) C_1 and C_2 are colors with chromaticity coordinates $(0.33, 0.12)$ and $(0.66, 0.66)$ respectively. In what proportions, should these colors be mixed to generate a color C_3 of chromaticity coordinates $(0.55, 0.48)$? If the brightness of C_3 is 90, what are the brightness of C_1 and C_2 ? **[10]**