

## Written Assignment 2

Total Points: 110

Due: May 14

- 1) Supposed 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.
  - a. Find the equivalent frequency domain filter  $H(u,v)$ . [5]
  - b. Show that your result is again a low-pass filter. [5]
- 2) Any high pass filter has a strong spike at the origin. Explain the source of these spikes. [10]
- 3) You have an image of bandwidth 100Hz. What is the minimum resolution of a the display than 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]
- 4) Let  $f(x,y)$  denote an image and  $f_G(x,y)$  denote the image obtained by applying a Gaussian filter  $g(x,y)$  to  $f(x,y)$ . A high pass filtered image  $f_H(x,y) = f(x,y) - f_G(x,y)$ , is generated from this  $f_G(x,y)$ .
  - a. You are asked to achieve high pass filtering by using a single filter. Derive an expression,  $h(x,y)$ , for such a filter. [5]
  - b. How would the frequency response,  $H(u,v)$ , of this filter look like? [5]
- 5) 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]
- 6) You want to digitize an analog signal of bandwidth 120Hz. The sampling frequency of your display is 100 Hz. The bandwidth of your reconstruction kernel is 80 Hz.
  - c. Why won't you be able to sample and reconstruct this signal without artifacts using this display? [5]
  - d. How would you process the image to reconstruct it without any artifacts? [5]
  - e. What kind of artifacts would the reconstruction kernel generate? [5]
  - f. How would you change the reconstruction kernel to correct it? [5]
- 7) You would like to transmit text which have 10 characters,  $c_i : 1 \leq i \leq 10$ , with probability 0.01, 0.04, 0.025, 0.025, 0.025, 0.025, 0.3, 0.2, 0.25, 0.1 respectively. Construct a Huffman coding and generate the variable length binary encodings for these characters. [15]

- 8) To find transformations between quadrilateral images (specifying four corresponding or tie points) you use a bilinear function of the form  $c_1x+c_2y+c_3xy+c_4$  to define the functions relating  $(x, y)$  and  $(x', y')$ . If you were dealing with triangular images, what kind of equation would you use and why? **[10]**
- 9) 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]**
- 10) Consider a linear display whose red, green and blue primaries have chromaticity coordinates of  $(0.5, 0.4)$ ,  $(0.2, 0.6)$  and  $(0.1, 0.2)$  respectively. The maximum brightness of the red, green and blue channels is  $100$ ,  $200$  and  $80\text{cd/m}^2$  respectively. 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]**