Introduction to Digital Image Processing HW #1 (Due 03/21/2024)

(Gonzalez 3rd edition)

1. Problem 2.1 (10%)

Using the background information provided in Section 2.1, and thinking purely in geometric terms, estimate the diameter of the smallest printed dot that the eye can discern if the page on which the dot is printed is 0.2 m away from the eyes. Assume for simplicity that the visual system ceases to detect the dot when the image of the dot on the fovea becomes smaller than the diameter of one receptor (cone) in that area of the retina. Assume further that the fovea can be modeled as a square array of dimensions 1.5 mm × 1.5 mm, and that the cones and spaces between the cones are distributed uniformly throughout this array.

2. Problem 2.7 (10%)

Suppose that a flat area with center at (x_0, y_0) is illuminated by a light source with intensity distribution

$$i(x, y) = Ke^{-[(x-x_0)^2+(y-y_0)^2]}$$

Assume for simplicity that the reflectance of the area is constant and equal to 1.0, and let $K = 255$. If the resulting image is digitized with k bits of intensity resolution, and the eye can detect an abrupt change of eight shades of intensity between adjacent pixels, what value of k will cause visible false contouring?

3. Problem 2.10 (10%)

High-definition television (HDTV) generates images with 1125 horizontal TV lines interlaced (where every other line is painted on the tube face in each of two fields, each field being 1/60th of a second in duration). The width-to-height aspect ratio of the images is 16:9. The fact that the number of horizontal lines is fixed determines the vertical resolution of the images. A company has designed an image capture system that generates digital images from HDTV images. The resolution of each TV (horizontal) line in their system is in proportion to vertical resolution, with the proportion being the width-to-height ratio of the images. Each pixel in the color image has 24 bits of intensity resolution, 8 bits each for a red, a green, and a blue image. These three "primary" images form a color image. How many bits would it take to store a 2-hour HDTV movie?

4. Problem 2.11 (10%)

Consider the two image subsets, S_1 and S_2, shown in the following figure. For $V = \{1\}$, determine whether these two subsets are (a) 4-adjacent, (b) 8-adjacent, or (c) m-adjacent.

		S_1				S_2			
0	0	0	0	0	0	0	1	1	0
1	0	0	1	0	0	1	0	0	1
1	0	0	1	0	1	1	0	0	0
0	0	1	1	1	0	0	0	0	0
0	0	1	1	1	0	0	1	1	1

5. Problem 2.15 (10%)

Consider the image segment shown.

★**(a)** Let $V = \{0, 1\}$ and compute the lengths of the shortest 4-, 8-, and m-path between p and q. If a particular path does not exist between these two points, explain why.

(b) Repeat for $V = \{1, 2\}$.

	3	1	2	1 (q)
	2	2	0	2
	1	2	1	1
(p)	1	0	1	2

6. Problem 2.19 (10%)

The median, ζ, of a set of numbers is such that half the values in the set are below ζ and the other half are above it. For example, the median of the set of values $\{2, 3, 8, 20, 21, 25, 31\}$ is 20. Show that an operator that computes the median of a subimage area, S, is nonlinear.

7. Problem 2.25 (10%)

Prove that the Fourier kernels in Eqs. (2.6-34) and (2.6-35) are separable and symmetric.

$$r(x, y, u, v) = e^{-j2\pi(ux/M+vy/N)} \tag{2.6-34}$$

$$s(x, y, u, v) = \frac{1}{MN}e^{j2\pi(ux/M+vy/N)} \tag{2.6-35}$$

Please print out the simulation code along with your results for the problems below.

8. **Reducing the Number of Intensity Levels in an Image** (10%)

(a) Write a computer program capable of reducing the number of intensity levels in an image from 256 to 2, in integer powers of 2. The desired number of intensity levels needs to be a variable input to your program.

(b) Download Fig. 2.21(a) from the course web site and duplicate the results shown in Fig. 2.21 of the book.

9. **Zooming and Shrinking Images by Pixel Replication** (10%)

(a) Write a computer program capable of zooming and shrinking an image by pixel replication. Assume that the desired zoom/shrink factors are integers.

(b) Download Fig. 2.20(a) from the course web site and use your program to shrink the image by a factor of 12.

(c) Use your program to zoom the image in (b) back to the resolution of the original. Explain the reasons for their differences.

10. **Image Rotation, Scaling, Translation and Intensity Interpolation** (10%)

(a) Write a computer program capable of rotating, scaling, and translating an image by specified degree, ratio, and pixels. The rotation degree, scaling ratio, and translating pixels need to be variable inputs to your program.

(b) Download Fig. 2.36 (a) from the course web site and rotate the image 23° clockwise, scale it to 2/3 of original size, and shift it by 18 and 22 pixels in x and y directions, respectively. Show the results using three interpolation approaches mentioned in the textbook. Please also zoom in the results to compare the differences as shown in Figs. 2.36 (b) – (d).