Computer Graphics	Prof. Brian Curless
CSE 457	Spring 2000

Homework #1

Visual Perception, Color, Image Processing, Affine Transformations

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Assigned: Wednesday, April 5th
Due: Friday, April 21th

Directions: Please provide short written answers to the questions in the space provided. If you require extra space, you may staple additional pages to the back of your assignment. Feel free to talk over the problems with classmates, but please *answer the questions on your own*.

Name:_____

1. **True or False – *Justify Your Answer***
   12 points (1 each)

   a. To keep an object in focus as it moves closer the ciliary muscles will contract.

   b. The density of rods is greatest outside the fovea.

   c. Our peripheral vision has low acuity because we have relatively few cones in the periphery.

   d. Rods are mainly used to detect color.

   e. Two colors with identical RGB values will always have the same spectra.

   f. Two colors that produce identical cone responses will always have the same spectra.

   g. Two colors with identical HSV values will always have the same spectra.

   h. The colors produced on a CRT display can be reproduced on a color printer, and vice versa.

   i. If a computer's video card is set to "Truecolor" mode, i.e. 24 bits per pixel, its monitor can produce every color perceptible by the human eye.

   j. A median filter is a convolution filter.

   k. A Gaussian filter is a convolution filter.

2. Image Processing
27 points

a. (5 points) In class, we discussed salt and pepper, impulse, and Gaussian noise and some filters you could use to help remove this noise. Which filters work best to eliminate each kind? Why?

b. (10 points) Describe the effect of each of the following filters. In addition, indicate which filter will cause the most blurring and which will produce the brightest image. Justify your answers.

0.1	0.1	0.1
0.1	0.1	0.1
0.1	0.1	0.1

0	-1	0
-1	5	-1
0	-1	0

0	0.2	0
0.2	0.4	0.2
0	0.2	0

0	0	0
-1	3	-1
0	0	0

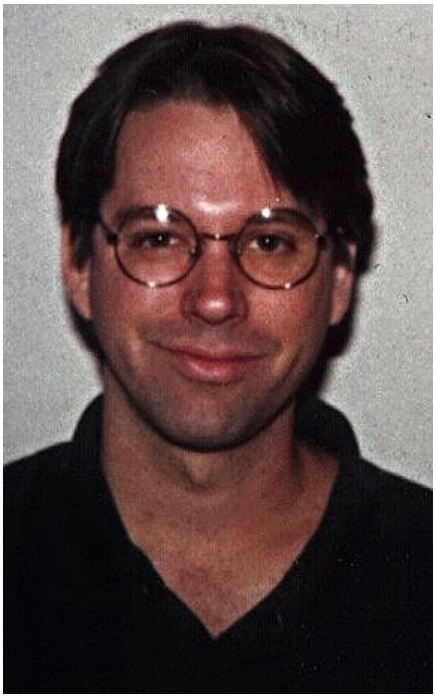
Problem 2 (cont'd.)

c. (12 points, 2 points each) Match the following image processing functions to their respective image pairs, where each pair is of the form f(x,y) → f(X(x,y), Y(x,y)) or f(r, theta) → f(R, THETA) where (r, theta) is polar coordinates:

1.	R = r*r / 100.0	THETA = theta
2.	R = r	THETA = theta + r/60.0
3.	R = r + 200.0*theta/(PI*2.0)	THETA = theta
4.	R = r	THETA = (double)((int)(13.0 * theta)) / 13.0
5.	X = 2.0*x	Y = 2.0* (y + x/2.0)
6.	X = 50.0 * cos(x/40.0)	Y = 50.0 * sin(y/40.0)

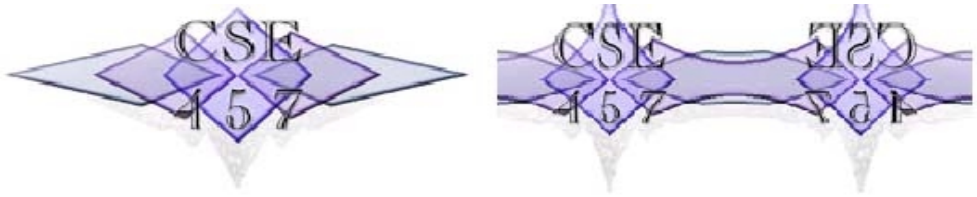
I.

II.



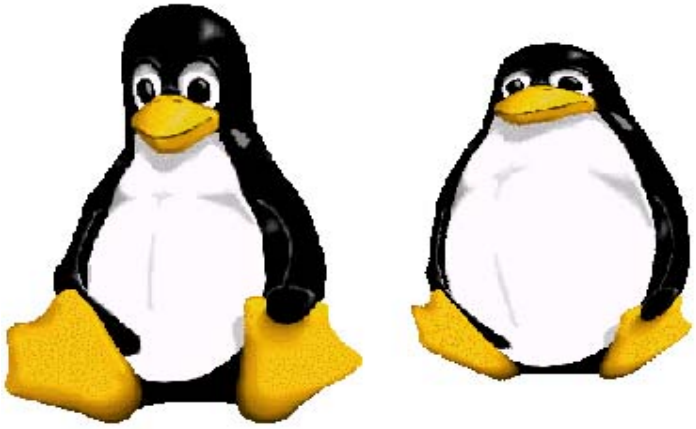
Problem 2 (cont'd.)

III.



IV.

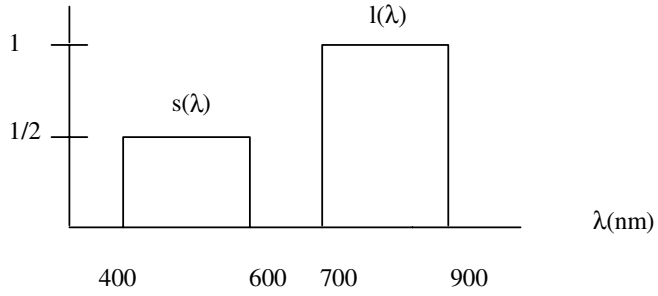
V.



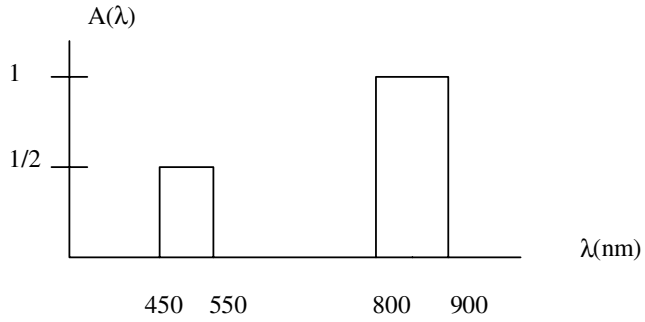
VI.

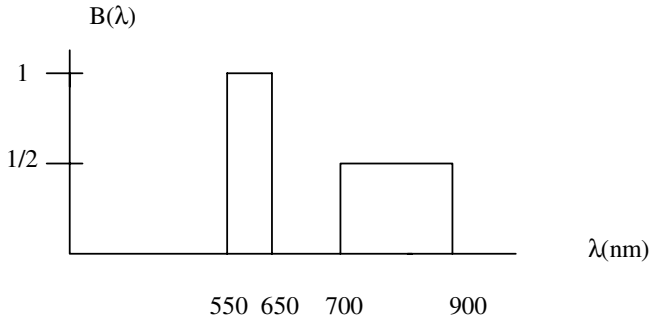
3. Color Perception
20 Points

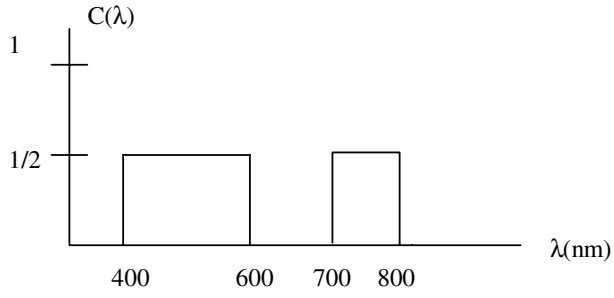
A recently discovered breed of pot-bellied pig has two types of cones, labeled s(λ) and l(λ), with spectral sensitivities as shown below.



a. (10 points) We perform the color matching experiment with this rather intelligent pig using the three lights shown below. Determine which, if any of these lights, are metamers for the pig. Show your work in the column next to the spectral plots.

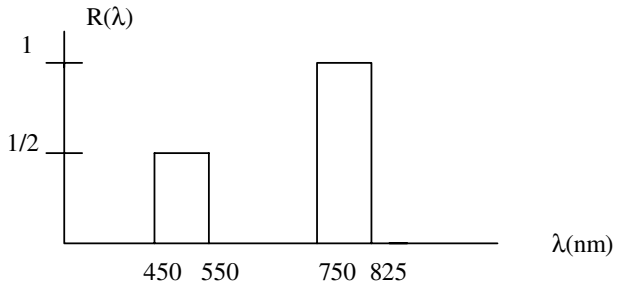






Problem 3 (cont'd.)

b. (10 points) We now repeat the experiment by shining the lights from (a) onto a piece of paper with surface reflectance R(λ) shown below. Determine under which, if any, of the lights the surface will yield subtractive metamers for the pig. Show your work.



4. Affine Transformations
27 points

a. (2 points each) As discussed in class, any two-dimensional affine transformation can be represented as a 3X3 matrix. Here are some useful matrices:

$$A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad B(a,b) = \begin{pmatrix} 1 & 0 & a \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} \qquad C(a,b) = \begin{pmatrix} \cos a & \sin a & 0 \\ -\sin a & \cos a & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$D(a,b) = \begin{pmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad E = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad F(a) = \begin{pmatrix} 1 & a & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Which of the matrices above implements each of the following transformations?

Rotation about the origin

Reflection through the line y=x

Translation

Shearing

Differential (Non-Uniform) Scaling

Reflection through the x-axis

Problem 4 (cont'd.)

b. (15 points) Consider a line that passes through a point $\mathbf{p} = (p_x, p_y, p_z)$ in the direction $\mathbf{v} = (\cos\alpha, 0, \sin\alpha)$. Write out the product of matrices that would perform a rotation by θ about this line. You should **not** multiply these matrices out, but you do need to list all of the elements in these matrices.