HW #1 Solutions

ECE 178 WINTER 2004

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Problem 2.1

The diameter, x, of the retinal image corresponding to the dot is obtained from similar triangles, as shown in Fig. P2.1. That is,

$$\frac{(d/2)}{0.2} = \frac{(x/2)}{0.014}$$

which gives x = 0.07d. From the discussion in Section 2.1.1, and taking some liberties of interpretation, we can think of the fovea as a square sensor array having on the order of 337,000 elements, which translates into an array of size 580 X 580 elements. Assuming equal spacing between elements, this gives 580 elements and 579 spaces on a line 1.5 mm long. The size of each element and each space is then s = [(1.5mm)/1, 159] = 1.3×10^{-6} m. If the size (on the fovea) of the imaged dot is less than the size of a single resolution element, we assume that the dot will be invisible to the eye. In other words, the eye will not detect a dot if its diameter, d, is such that 0.07(d) < $1{:}3 \times 10^{-6}$ m, or d < 18.6×10^{-6} m.

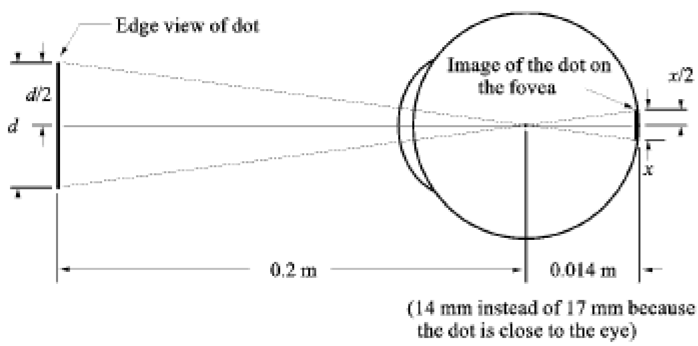

Figure P2.1

Problem 2.2

Brightness adaptation.

Problem 2.3

$\lambda = c/\nu = 2{:}998 \times 10^8$(m/s)=60(1/s) = 4.99×10^6m = 5000 Km.

λ: wavelength of the alternating current, c: velocity of light,

ν: frequency of the alternating current

Problem 2.4

(a) From the discussion on the electromagnetic spectrum in Section 2.2, the source of the illumination required to see an object must have wavelength the same size or smaller than the object. Because interest lies only on the boundary shape and not on other spectral characteristics of the specimens, a single illumination source in the far ultraviolet (wavelength of .001 microns or less) will be able to detect all objects. A far ultraviolet camera sensor would be needed to image the specimens. (b) No answer required since the answer to (a) is affirmative.

Problem 2.5

From the geometry of Fig. 2.3,

Height of image = height of the lens = 7 mm (given)
Focal length (distance of image from lens) = 35 mm (given)
Height of object = z mm (say)
Distance of object = 500 mm (given)

We know by theory of similar triangles applied to Fig. 2.3 that,
Height of image / Focal length = Height of object / Distance of object from lens

⇨ 7 mm / 35 mm = z = 500 mm, or z = 100 mm

So the target (object) height is 100 mm on the side. Now, for 1 line on the object we have 1024 elements on the CCD. So the resolution of 1 line is 1024 / 100 = 10 elements/mm.

⇨ For 1 linepair (lp) the resolution is 5 lp/mm.

Problem 2.6

One possible solution is to equip a monochrome camera with a mechanical device that sequentially places a red, a green, and a blue pass filter in front of the lens. The strongest camera response determines the color. If all three responses are approximately equal, the object is white. A faster system would utilize three different cameras, each equipped with an individual filter. The analysis would be then based on polling the response of each camera. This system would be a little more expensive, but it would be faster and more reliable. Note that both solutions assume that the field of view of the camera(s) is such that it is completely filled by a uniform color [i.e., the camera(s) is (are) focused on a part of the vehicle where only its color is seen. Otherwise further analysis would be required to isolate the region of uniform color, which is all that is of interest in solving this problem].

Problem 2.7

The image in question is given by

$$f(x, y) = i(x, y)r(x, y)$$
$$= 255 (\exp(-[(x-x_0)^2+(y-y_0)^2])) \quad (1.0)$$
$$= 255 (\exp(-[(x-x_0)^2+(y-y_0)^2]))$$

A cross section of the image is shown in Fig. P2.7(a). If the intensity is quantized using m bits, then we have the situation shown in Fig. P2.7(b), where $\Delta G = (255 + 1) = 2^m$. Since an abrupt change of 8 gray levels is assumed to be detectable by the eye, it follows that $\Delta G = 8 = 256 = 2^m$, or m = 5. In other words, 32, or fewer, gray levels will produce visible false contouring.

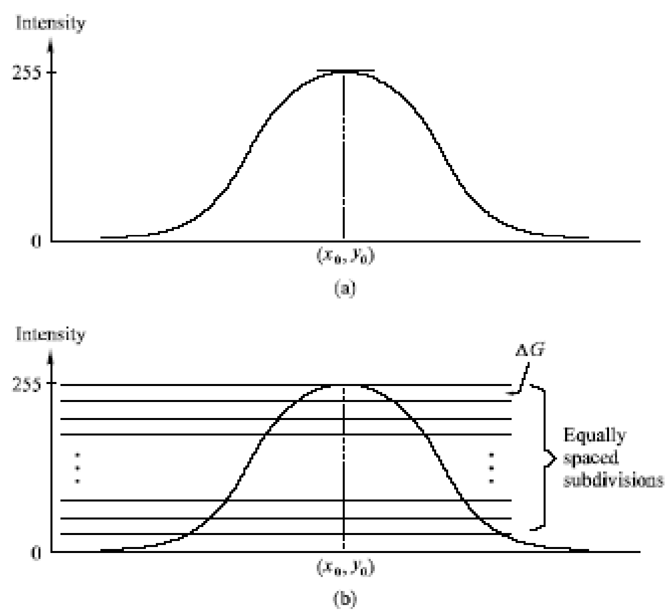

Figure P2.7

MATLAB Code: Brightness Adaptation Experiment

```
function hw1_04( )

%Description: Brightness Adaptation Experiment Program
%Author: Srivatsan PALLAVARAM
%Date: 01/29/2004
%Context: ECE 178 HW#1, winter 2004, UCSB

close all

%Creating matrixs x & y with its values representing the x & y coordinates of the
%corresponding pixels w.r.t the center of the matrix
[x, y]=meshgrid(-128:1:128,-128:1:128);

z=zeros(257); %actual image
radius_dec=10; %the number of pixels by which we plan to reduce the radius of the circle
intensity_inc=1; %the number of graylevels by which we plan to increase the intensity
radius=128; %initial radius for a 256X256 image
intensity=1; %initial intensity of the outermost circle

while (intensity<256 && radius>0)
   for i=1:257,
      for j=1:257,
         %Identifying the pixels that lie within the radius of the
         %current circle and setting their intensities using the user's
         %perception-based feedback
         if (sqrt(x(i,j)*x(i,j)+y(i,j)*y(i,j)) <= radius)
            z(i,j)=intensity;
         else
         end
      end
   end
   imshow(uint8(z));

   %Getting user feedback
   ButtonName=questdlg('Can you see the new circle?', 'Checking your perception', 'No', 'Yes', 'No');

   %Checking feedback
   if strcmp(ButtonName, 'Yes')
      radius=radius-radius_dec; %Decrement the radius by whatever step you choose
   else
   end

   intensity=intensity+intensity_inc; %Increment the intensity by whatever step you choose
end

close all
z=z(1:256,1:256);
imshow(uint8(z));
title('Final result');
```