UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering

ECE 418 Image Processing

Problem Set 5

Spring 2008

Issued: Thursday, February 14, 2008 **Due:** Thursday, February 21, 2008

Problem 5.1

An image $x_a(t_1, t_2)$ is scanned using a vidicon camera with horizontal and vertical periods $T_1 = 2$mm and $T_2 = 1$mm. Two cameras are considered. The sampling aperture of each camera is modeled by

$$w(t_1, t_2) = e^{-\frac{(t_1/T_1)^2 + (t_2/T_2)^2}{2R^2}}$$

The first camera uses $R = 0.5$, and the second uses $R = 4$. For each camera, sketch the output digitized image when

(a) $x_a(t_1, t_2) = 5$

(b) $x_a(t_1, t_2) = 1 + \cos\left(\frac{\pi t_1}{2} + \pi t_2\right)$

For each image, determine which camera produces the better results.

Problem 5.2

The image display performance of two CRT monitors is evaluated. The display spot of the each monitor is modeled by

$$s(t_1, t_2) = e^{-\frac{(t_1/T_1)^2 + (t_2/T_2)^2}{2R^2}}$$

The first monitor uses $R = 0.5$, and the second uses $R = 4$. Here $T_1 = T_2 = 2$. For each camera, sketch the displayed image when the input digital image is given by

(a) $x[n_1, n_2] = 3$

(b) $x[n_1, n_2] = 1 + (-1)^{n_1 - n_2}$

For each image, determine which monitor produces the better results.

Problem 5.3

A 512×512 image with uniform intensity level $x[n_1, n_2] = 57$ is to be printed on a laser printer. The dither matrix

$$D = \begin{bmatrix} 8 & 136 & 40 & 168 \\ 200 & 72 & 232 & 104 \\ 56 & 184 & 24 & 152 \\ 248 & 120 & 216 & 88 \end{bmatrix}$$

is used for halftoning.

(a) Compute the halftone image $y[n_1, n_2]$. Assume that Black= 0 and White= 255.

(b) Compute the mean-squared error

$$\text{MSE} = \frac{1}{512^2} \sum_{n_1} \sum_{n_2} |y[n_1, n_2] - x[n_1, n_2]|^2$$

(c) It is assumed that the halftone image will be viewed from a known distance. Evaluate the error

$$\text{MSE}' = \frac{1}{512^2} \sum_{n_1} \sum_{n_2} |z[n_1, n_2] - x[n_1, n_2]|^2$$

where $z[n_1, n_2]$ models the image as it is encoded by the ganglion cells in the retina,

$$Z(\omega_1, \omega_2) = H(\omega_1, \omega_2) Y(\omega_1, \omega_2),$$

and $H(\omega_1, \omega_2)$ is the following simple model of the spatial response of the eye:

$$h[n_1, n_2] = \frac{1}{4} \left(\delta[n_1, n_2] + \delta[n_1 - 1, n_2] + \delta[n_1, n_2 - 1] + \delta[n_1 - 1, n_2 - 1] \right)$$