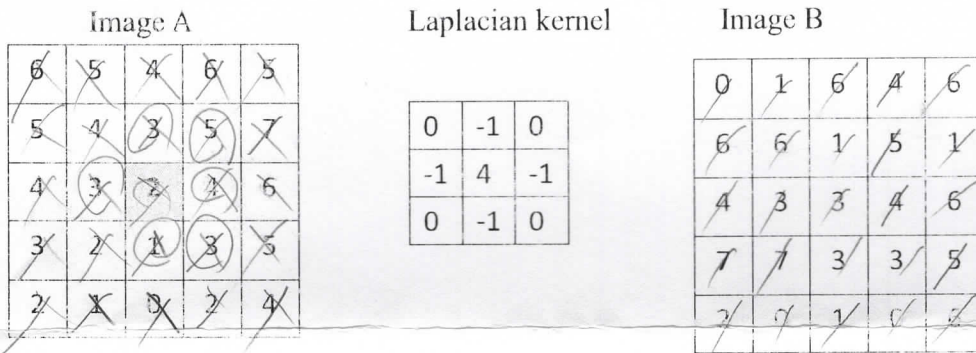


Midterm (100%)

Please remember to write down your name and student number.
The procedures leading to your answers are required to grade.

1. (5%) Which of the following cannot be used as an energy source for image sensing and acquisition?
 (1). gamma rays (2) radio waves (3) acoustic (4) electronic
2. (20%) Give two points p (3, 5) and q (6, 1)
 - (a) (10%) What is the chessboard distance of p and q?
 - (b) (10%) What is the Euclidean distance of p and q?
3. (50%) Consider the following intensity matrix of a 5x5 image A. The depth of a pixel is 3 bits.



- (a) (15%) For image A, what is the intensity matrix of the histogram-equalized image?
 - (b) (15%) For image A, what is the intensity matrix of the histogram-matched image such that the output image has a histogram of the shape similar to what image B has?
 - (c) (10%) What is the intensity of the pixel in the middle position (shaded one in the figure A) of the Laplacian-sharpened image, using the Laplacian kernel shown above?
 - (d) (10%) What is the intensity of the pixel in the middle position (shaded one in the figure A) of the sharpened image using highboost filtering? The blurred image is obtained using a 3x3 box kernel, and k=2 for highboost filtering.
4. (15%) Suppose that we have two classes c_1 and c_2 , with two patterns in the training set $x=[3 \ 5 \ 1]^T \in c_1$ and $x=[1 \ 2 \ 1]^T \in c_2$. Using the perceptron training algorithm to find the weight vector after two epoches. Note that the initial weight vector= $[0 \ 0 \ 0]^T$ and the learning rate is 2. Also, c_1 is on the positive side of the line (decision boundary) and c_2 is on the negative side.
5. (10%) When using bilinear interpolation, how many pixels are involved to interpolate one pixel, and why?

1. 4

2. (a) $\max\{13-6, 15-11\} = 4 \# 10$

(b) $\sqrt{(3-6)^2 + (5-1)^2} = 5 \# 10$

3. (a)

| \bar{i} | n_i | P_i |
|-----------|-------|----------------|
| 0 | 1 | $\frac{1}{25}$ |
| 1 | 2 | $\frac{2}{25}$ |
| 2 | 4 | $\frac{4}{25}$ |
| 3 | 4 | $\frac{4}{25}$ |
| 4 | 5 | $\frac{5}{25}$ |
| 5 | 5 | $\frac{5}{25}$ |
| 6 | 3 | $\frac{3}{25}$ |
| 7 | 1 | $\frac{1}{25}$ |

$S_0 = 7 \times \frac{1}{25} \approx 0$
 $S_1 = 7 \times (\frac{1}{25} + \frac{2}{25}) = \frac{21}{25} \approx 1$
 $S_2 = 7 \times (\frac{1}{25} + \frac{2}{25} + \frac{4}{25}) = \frac{49}{25} \approx 2$
 $S_3 = 7 \times (\frac{1}{25} + \frac{2}{25} + \frac{4}{25} + \frac{4}{25}) = \frac{77}{25} \approx 3$
 $S_4 = 7 \times (\frac{1}{25} + \frac{2}{25} + \frac{4}{25} + \frac{4}{25} + \frac{5}{25}) = \frac{112}{25} \approx 4$
 $S_5 = 7 \times (\frac{1}{25} + \frac{2}{25} + \frac{4}{25} + \frac{4}{25} + \frac{5}{25} + \frac{5}{25}) = \frac{147}{25} \approx 6$
 $S_6 = 7 \times (\frac{1}{25} + \frac{2}{25} + \frac{4}{25} + \frac{4}{25} + \frac{5}{25} + \frac{5}{25} + \frac{3}{25}) = \frac{168}{25} \approx 7$
 $S_7 = 7 \times 1 = 7$

| | | | | |
|---|---|---|---|---|
| 7 | 6 | 4 | 7 | 6 |
| 6 | 4 | 3 | 6 | 7 |
| 4 | 3 | 2 | 4 | 7 |
| 3 | 2 | 1 | 3 | 6 |
| 2 | 1 | 0 | 2 | 4 |

#

| | | | | |
|---|---|---|---|---|
| 7 | 6 | 4 | 7 | 6 |
| 6 | 4 | 3 | 6 | 7 |
| 4 | 3 | 2 | 4 | 7 |
| 3 | 2 | 1 | 3 | 6 |
| 2 | 1 | 0 | 2 | 4 |

(b) image B

| i | n _i |
|---|----------------|
| 0 | 3 |
| 1 | 4 |
| 2 | 1 |
| 3 | 4 |
| 4 | 3 |
| 5 | 2 |
| 6 | 6 |
| 7 | 2 |

$$S = T(r) = (L-1) \sum_{i=0}^{L-1} p_i$$

$$G(z) = (L-1) \sum_{i=0}^{L-1} P_z(i) = S$$

$$z = G^{-1}(S)$$

$$G_0 = 7 \cdot \frac{3}{25} \approx 1$$

$$G_1 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} \right) \approx 2$$

$$G_2 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} + \frac{1}{25} \right) \approx 2$$

$$G_3 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} + \frac{1}{25} + \frac{4}{25} \right) \approx 3$$

$$G_4 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} + \frac{1}{25} + \frac{4}{25} + \frac{3}{25} \right) \approx 4$$

$$G_5 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} + \frac{1}{25} + \frac{4}{25} + \frac{3}{25} + \frac{2}{25} \right) \approx 5$$

$$G_6 = 7 \cdot \left(\frac{3}{25} + \frac{4}{25} + \frac{1}{25} + \frac{4}{25} + \frac{3}{25} + \frac{2}{25} + \frac{6}{25} \right) \approx 6$$

$$G_7 = 7$$

$$z = G^{-1}(S) \Rightarrow$$

S =

| | | | | |
|---|---|---|---|---|
| 7 | 6 | 4 | 7 | 6 |
| 6 | 4 | 3 | 6 | 7 |
| 4 | 3 | 2 | 4 | 7 |
| 3 | 2 | 1 | 3 | 6 |
| 2 | 1 | 0 | 2 | 4 |

| | | | | |
|---|---|---|---|---|
| 7 | 6 | 4 | 7 | 6 |
| 6 | 4 | 3 | 6 | 7 |
| 4 | 3 | 1 | 4 | 7 |
| 3 | 1 | 0 | 3 | 6 |
| 1 | 0 | 0 | 1 | 4 |

#

(c) g

+9.

(d)

+7.

4. ep

epo

(c) $g(x, y) = f(x, y) + \Delta f$
 $= 2 + (-3 - 3 - 4 - 1 + 8)$
 $= 7$
 $\rightarrow 0$ #

(d) $g(x, y) = f(x, y) + K \cdot \text{mask}(x, y) = f(x, y) - \bar{f}(x, y)$
 $= 2 + 2 \left(\frac{4+3+5+3+2+4+2+1+3}{9} \right)$
 $= 2 + 6 = 8$ #

4. epoch 1 =

for $x_1 = [0 \ 0 \ 0] \begin{bmatrix} 3 \\ 5 \\ 1 \end{bmatrix} = 0 \leq 0$

$W_1^T = [0 \ 0 \ 0] + 2[3 \ 5 \ 1] = [6 \ 10 \ 2]$

for $x_2 = [6 \ 10 \ 2] \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} = 6 + 20 + 2 = 28 > 0$

$W_2^T = [6 \ 10 \ 2] - 2[1 \ 2 \ 1] = [4 \ 6 \ 0]$

epoch 2 =

for $x_1 = [4 \ 6 \ 0] \begin{bmatrix} 3 \\ 5 \\ 1 \end{bmatrix} = 12 + 30 = 42 > 0$

for $x_2 = [4 \ 6 \ 0] \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} = 4 + 12 = 16 > 0$

$W_3^T = [4 \ 6 \ 0] - 2[1 \ 2 \ 1] = [2 \ 2 \ -2]$

weight vector = $[2 \ 2 \ -2]^T$ #

5. $g(x,y) = ax + by + cxy + d$ 4 pixel

4 pixels are involved #

part 1

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} = \begin{pmatrix} g(0,0) \\ g(0,1) \\ g(1,0) \\ g(1,1) \end{pmatrix}$$

$$W_1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} = \begin{bmatrix} g(0,0) \\ g(0,1) \\ g(1,0) \\ g(1,1) \end{bmatrix}$$

$$W_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} = \begin{bmatrix} g(0,0) \\ g(0,1) \\ g(1,0) \\ g(1,1) \end{bmatrix}$$

Weight vector $W = [a \ b \ c \ d]^T$

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