ECE 5273
Test 1

Wednesday, March 24, 2010
4:30 PM - 5:45 PM

Spring 2010 Name: SOLUTION

Dr. Havlicek Student Num:________________

Directions: This is an open notes test. You may use the official course notes pack. Other materials are not allowed. You have 75 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (25) ________

2. (25) ________

3. (25) ________

4. (25) ________

TOTAL (100):

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this test.

Name:________________ Date:________________

1. **25 pts**. True or False. Mark *True* only if the statement is **always** true.

TRUE FALSE

____ X (a) **2 pt**. Medical ultrasound images are an example of emission imaging. Reflection

X ____ (b) **2 pt**. A digital image $\mathbb{I}$ can be exactly recovered from its DFT $\tilde{\mathbb{I}}$.

____ X (c) **2 pt**. Any digital image $\mathbb{I}$ can be exactly recovered from its histogram $H_{\mathbb{I}}(k)$.

____ X (d) **2 pt**. A pinhole camera is used to image a 3-D real-world scene $I(X,Y,Z)$, resulting in an optical image $\mathbb{I}_C(x,y)$ at the camera focal plane. A digital camera chip samples $\mathbb{I}_C(x,y)$ to produce the digital image $\mathbb{I}(i,j)$.

If the pixel spacings X and Y are small enough to prevent spatial aliasing, then the 3-D scene $I(X,Y,Z)$ can be exactly recovered from $\mathbb{I}(i,j)$. $I_C(x,y)$ can be, but not $I(X,Y,Z)$

____ X (e) **2 pt**. When using thresholding to make a binary image from a gray scale image, the threshold selection is usually simplified if the gray scale image has a ~~flat~~ Bimodal histogram.

X ____ (f) **2 pt**. A binary median filter removes both gaps and peninsulas of insufficient width.

____ X (g) **2 pt**. A binary CLOSE-OPEN filter tends to link neighboring ~~holes~~ objects together.

X ____ (h) **2 pt**. The most basic geometric image transformations are translation, rotation, and scaling.

____ X (i) **2 pt**. For any continuous optical image $\mathbb{I}_C(x,y)$, the Fourier transform $\tilde{\mathbb{I}}_C(\omega_x,\omega_y)$ is periodic.

____ X (j) **2 pt**. For any continuous optical image $\mathbb{I}_C(x,y)$, the DFT $\tilde{\mathbb{I}}_C(u,v)$ is periodic. does not have a DFT.

____ X (k) **2 pts**. Any real-valued digital image $\mathbb{I}$ has a DFT $\tilde{\mathbb{I}}$ that is real-valued and conjugate symmetric. Not necessarily real.

____ X (l) **3 pts**. The famous *Lena* image originally appeared in the magazine *Better Homes and Gardens*.

2. **25 pts**. The gray scale image $\mathbb{I}_1$ shown below has 8-bit pixels. This image was thresholded to obtain the binary image $\mathbb{I}_2$, which is also shown below. In $\mathbb{I}_2$, the pixel value 255 (WHITE) represents LOGIC_ONE and the pixel value zero (BLACK) represents LOGIC_ZERO.

$\mathbb{I}_1$

$\mathbb{I}_2$

Binary morphological OPEN and CLOSE operations where performed on the image $\mathbb{I}_2$ using a 5×5 diamond-shaped structuring element. The resulting images are shown as $\mathbb{J}_1$ and $\mathbb{J}_2$ below.

$\mathbb{J}_1$

OPEN

$\mathbb{J}_2$

CLOSE

Determine which image is the result of the OPEN operation and which is the result of the CLOSE operation. Explain your answer.

Workspace for Problem 2...

In $\mathbb{J}_1$, the mouth remains but fine LOGIC-ONE structure of the hair is lost. This is because OPEN performs erosian first, which enlarges the mouth but eradicates the fine LOGIC-ONE structure of the hair. In OPEN, the dilation is performed second; it restores the mouth to its original size but cannot recover the lost LOGIC-ONE structure of the hair.

In $\mathbb{J}_2$, the dilatian is done first. This enlarges the fine LOGIC-ONE structure of the hair but the mouth is lost. The subsequent erosian operatian returns the structure of the hair to approximately its original size but cannot recover the mouth.

3. **25 pts**. Consider the 4×4 images $\mathbb{I}$ and $\mathbb{I}'$ shown below, where the allowable range of gray levels is $0 \leq I(i,j), I'(i,j) \leq 15$:

$\mathbb{I} =$

11	**8**	**3**	**0**
9	**7**	**1**	**0**
7	**5**	**5**	**1**
3	**11**	**13**	**13**

$\mathbb{I}' =$

10	**3**	**2**	**1**
4	**3**	**2**	**10**
3	**4**	**9**	**9**
2	**1**	**4**	**9**

Construct a new image $\mathbb{J}$ by applying the histogram matching algorithm to shape the histogram of image $\mathbb{I}$, where the desired shape is given by the histogram of the image $\mathbb{I}'$. Show the new image $\mathbb{J}$ and its histogram $H_{\mathbb{J}}$ in the spaces provided below. Work space is given on the next page.

$\mathbb{J} =$

9	4	3	1
9	4	2	1
4	3	3	2
3	9	10	10

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H_{\mathbb{J}}(k)$	0	2	2	4	3	0	0	0	0	3	2	0	0	0	0	0

See work on page 6.

Workspace for Problem 3. . .

$\mathbb{J}$

Work Space:

$\mathbb{J}_1 =$

14/16	11/16	6/16	2/16
12/16	10/16	4/16	2/16
10/16	8/16	8/16	4/16
6/16	14/16	16/16	16/16

9	4	3	1
9	4	2	1
4	3	3	2
3	9	10	10

for II:

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H(k)$	2	2	0	2	0	2	0	2	1	1	0	2	0	2	0	0
$p(k)$	2/16	2/16	0/16	2/16	0/16	2/16	0/16	2/16	1/16	1/16	0/16	2/16	0/16	2/16	0/16	0/16

for II′:

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H(k)$	0	2	3	3	3	0	0	0	0	3	2	0	0	0	0	0
$p(k)$	0/16	2/16	3/16	3/16	3/16	0/16	0/16	0/16	0/16	3/16	2/16	0/16	0/16	0/16	0/16	0/16

n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$P'(n)$	0/16	2/16	5/16	8/16	11/16	11/16	11/16	11/16	11/16	14/16	16/16	16/16	16/16	16/16	16/16	16/16

4. **25 pts.** Draw lines to match the images with their log-magnitude DFT spectra.