ECE 5273
Test 1

Wednesday, March 26, 2008
4:30 PM - 5:45 PM

Spring 2008 Name: SOLUTION

Dr. Havlicek Student Num: ____________

Directions: This is an open book, open notes test. 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	
	✓	(a) **2 pts**. A main reason that digital image processing has become popular recently is that image sensing is free from any reduction in dimensionality.
✓		(b) **2 pts**. Just like in the pinhole camera, images in the human vision system appear physically "upside down" on the retina.
✓		(c) **2 pts**. While any image is generally multidimensional, the image histogram function $H_{\mathbb{I}}$ is a 1-D function.
	✓	(d) **2 pts**. The main problem that prohibits good histogram-based segmentation algorithms is that the histogram is always bimodal.
	✓	(e) **2 pts**. Run-length coding always reduces the amount of memory needed to store a ditial image.
	✓	(f) **2 pts**. Medical CAT scans are an example of reflection imaging.
	✓	(g) **2 pts**. For viewing the DFT of an image $\mathbb{I}$ with real-valued pixels, it is usually most useful to display the logarithm of the DFT phase.
✓		(h) **2 pts**. Binary morphological dilation is an operation that removes holes of sufficiently small size.
✓		(i) **2 pts**. Binary morphological dilation is an operation that removes gaps or bays of insufficient width.
	✓	(j) **2 pts**. An image $\mathbb{J}$ is formed by applying the histogram matching algorithm to match the histogram of image $\mathbb{I}_1$ to the histgram of another image $\mathbb{I}_2$. Then, even though the two images $\mathbb{J}$ and $\mathbb{I}_2$ might look quite different from one another, their histograms $H_{\mathbb{J}}(k)$ and $H_{\mathbb{I}_2}(k)$ will be identical.
	✓	(k) **2 pts**. The most efficient way to implement a medial axis transform is by using DFT's.
	✓	(l) **3 pts**. The main reason that *Lena* is famous is because she once had an affair with the instructor.

2. **25 pts**. The connected components labeling algorithm (blob coloring algorithm) given in the notes is a *4-connected* algorithm. This means that any two LOGIC ONE pixels that are 4-neighbors will always become part of the same connected component (blob).

It is also possible to define an 8-connected algorithm, so that any two LOGIC ONE pixels that are 8-neighbors will always end up in the same blob.

Consider the application of connected components labeling with minor region removal. Use the blank 10×10 grid below to construct an image $\mathbb{I}$ such that the results will be different depending on whether a 4-connected or an 8-connected blob coloring algorithm is used.

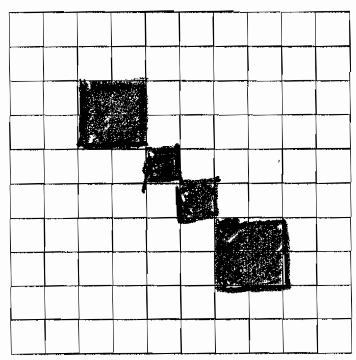
Indicate LOGIC ONE pixels with the numeral "1" or by "coloring in" (shading). Indicate LOGIC ZERO pixels with the numeral "0" or by "not coloring in."

Explain your answer in the space provided below the image.

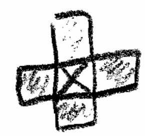
4-connected: 4 blobs.

8-connected: 1 blob.

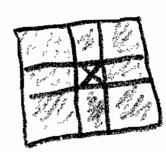
$\mathbb{I}$ =



A 4-connected neighborhood looks like this:



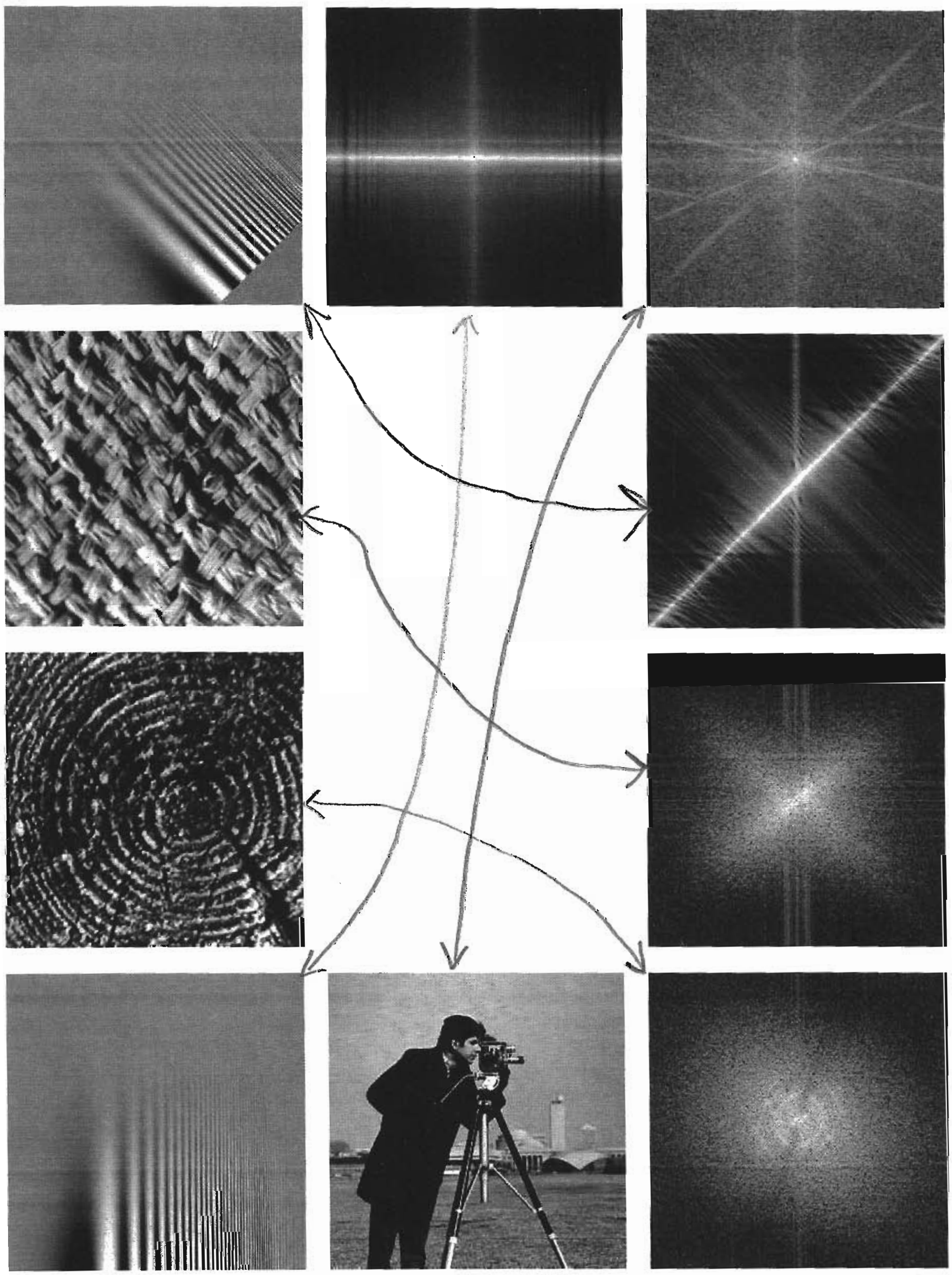
An 8-connected neighborhood looks like this:



The key to this problem is to construct two main blobs that are connected by one or more diagonal neighbors only.

Then the two main blobs will be connected (i.e., part of the same blob) with the 8-connected topology, but will be separate blobs with the 4-connected topology.

3. **25 pts.** Draw lines to match the images with their log-magnitude DFT spectra.



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

$\mathbb{I}$ =

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

$\mathbb{I}'$ =

14	**11**	**5**	**8**
14	**2**	**8**	**8**
14	**5**	**14**	**11**
14	**14**	**11**	**11**

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.

$\mathbb{J}$ =

14	11	8	5
14	11	8	14
11	14	14	14
8	5	14	14

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

The work is shown on the next page.

Workspace for Problem 4...

Work Space:

$J_1 =$

16/16	8/16	5/16	2/16
11/16	8/16	5/16	16/16
8/16	11/16	14/16	14/16
5/16	2/16	11/16	14/16

14	11	8	5
14	11	8	14
11	14	14	14
8	5	14	14

$= J$

Histogram of I:

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

Histogram of I':

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

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

$$J_1(i,j) = \sum_{k=0}^{I(i,j)} p(k) \; ; \qquad J(i,j) = \arg\min_n \{P'(n) \geq J_1(i,j)\}$$

$I(i,j)$	$J_1(i,j)$	$\arg\min_{P'(n)} \{P'(n) \geq J_1(i,j)\}$	$J(i,j) = \arg\min_n \{P'(n) \geq J_1(i,j)\}$
1 2	2/16 5/16	3/16 6/16	5 8
3 4	8/16 11/16	10/16 16/16	11 14
9 10	14/16 16/16	16/16 16/16	14 14