ECE 5273
Test 1

Monday, March 6, 2017
4:30 PM - 5:45 PM

Spring 2017

Dr. Havlicek

Name: SOLUTION

Student Num: __________

Directions: This is an open notes test. You may use the official course lecture notes and a calculator. 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. (20) ________

2. (20) ________

3. (20) ________

4. (20) ________

5. (20) ________

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

TRUE	FALSE	
X		(a) **2 pts**. Magnetic Resonance Imaging (MRI) is a type of emission imaging. Notes p. 1.24
X		(b) **2 pts**. In the "pinhole" camera model we have used, straight lines in the 3D world always project to straight lines on the 2D focal plane. Notes p. 1.47 – 1.48
	X	(c) **2 pts**. The binary dilation filter and binary median filter are dual operations with respect to complementation. Notes p. 2.77, 2.81.
	X	(d) **2 pts**. The binary majority filter generally removes small objects more effectively than the binary median filter. They are the same. Notes p. 2.80
X		(e) **2 pts**. The binary CLOSE filter removes small holes better than the binary median filter. Notes p. 2.88
X		(f) **2 pts**. The binary OPEN-CLOSE filter tends to link neighboring objects together. Notes p. 2.91
	X	(g) **2 pts**. Run-length coding always reduces the amount of memory needed to store a binary digital image. Notes p. 2.103
	X	(h) **2 pts**. For histogram flattening (equalization), it is important to define the reference point to be the center of the filter window so that the output image is not shifted. It is a point operation. There is no window.
	X	(i) **2 pt**. Histogram flattening (equalization) always results in an image with a perfectly flat histogram. Notes p. 3.40
OH	MY!	(j) **2 pt**. Every international student should take ECE 5273 so that they can avoid being affected by the Presidential travel ban.

2. **20 pts.** Consider the 4×4 image **I** shown below, where the allowable range of gray levels is $0 \le I(i,j) \le 15$:

$$\mathbf{I} = \begin{array}{|c|c|c|c|} \hline \mathbf{4} & \mathbf{5} & \mathbf{9} & \mathbf{7} \\ \hline \mathbf{6} & \mathbf{10} & \mathbf{8} & \mathbf{9} \\ \hline \mathbf{7} & \mathbf{10} & \mathbf{11} & \mathbf{8} \\ \hline \mathbf{4} & \mathbf{6} & \mathbf{5} & \mathbf{11} \\ \hline \end{array}$$

Construct a new image **K** by applying the histogram shaping algorithm to make the histogram more "V-like." The **desired** histogram shape is given by:

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

Show the new image **K** and its histogram H_K in the spaces provided below.

$$\mathbf{K} = \begin{array}{|c|c|c|c|} \hline 0 & 2 & 12 & 9 \\ \hline 4 & 15 & 12 & 12 \\ \hline 9 & 15 & 15 & 12 \\ \hline 0 & 4 & 2 & 15 \\ \hline \end{array}$$

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

Work space is provided on the next page.

Workspace for Problem 2:

$$J = \begin{array}{|c|c|c|c|}\hline 2/16 & 4/16 & 12/16 & 8/16 \\ \hline 6/16 & 14/16 & 10/16 & 12/16 \\ \hline 8/16 & 14/16 & 16/16 & 10/16 \\ \hline 2/16 & 6/16 & 4/16 & 16/16 \\ \hline \end{array} = P_I(I(m,n))$$

For I :

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

DESIRED:

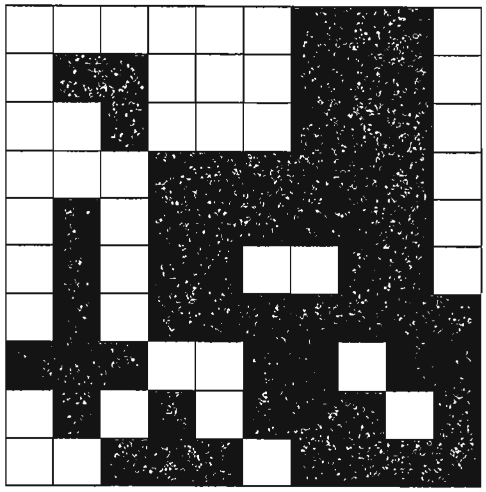
k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H(k)	3	0	2	0	1	0	1	0	0	2	0	0	3	0	0	4
p(k)	3/16	0/16	2/16	0/16	1/16	0/16	1/16	0/16	0/16	2/16	0/16	0/16	3/16	0/16	0/16	4/16
P(k)	3/16	3/16	5/16	5/16	6/16	6/16	7/16	7/16	7/16	9/16	9/16	9/16	12/16	12/16	12/16	16/16

$$K = \arg\min_{r} \{ P_k(r) \geq J(m,n) \} = \begin{array}{|c|c|c|c|}\hline 0 & 2 & 12 & 9 \\ \hline 4 & 15 & 12 & 12 \\ \hline 9 & 15 & 15 & 12 \\ \hline 0 & 4 & 2 & 15 \\ \hline \end{array}$$

3. **20 pts.** Consider the 10×10 binary image $\mathbf{I}$ shown below, where BLACK = LOGIC ONE and WHITE = LOGIC ZERO.

Blob coloring, blob counting, and minor region removal will retain the largest blob... without filling in the holes.

$\mathbf{I}$ =



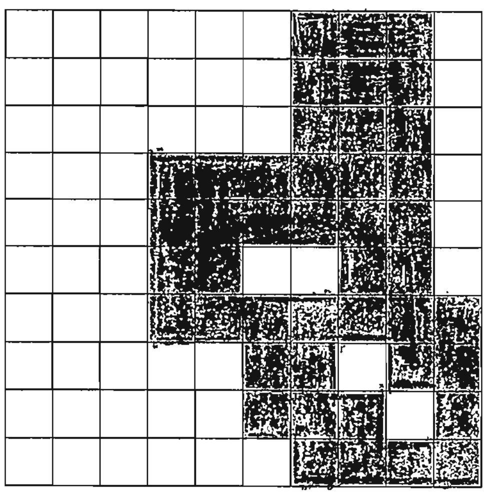
Apply 4-connected blob coloring (connected components labeling), blob counting, and minor region removal to form a new binary image $\mathbf{J}$.

Note: here, you are ***not*** being asked to apply blob coloring a second time to the inverted image.

Note: intermediate results are ***not*** required; however, they may be helpful for awarding partial credit in case you make a mistake.

Show the new image $\mathbf{J}$ in the space provided below:

$\mathbf{J}$ =



There is work space on the next page if you need it.

Workspace for Problem 3:

4. **20 pts.**

(a) **14 pts**. Consider the 256×256 binary image **I** shown below, where WHITE = LOGIC ONE (object) and BLACK = LOGIC ZERO (background).

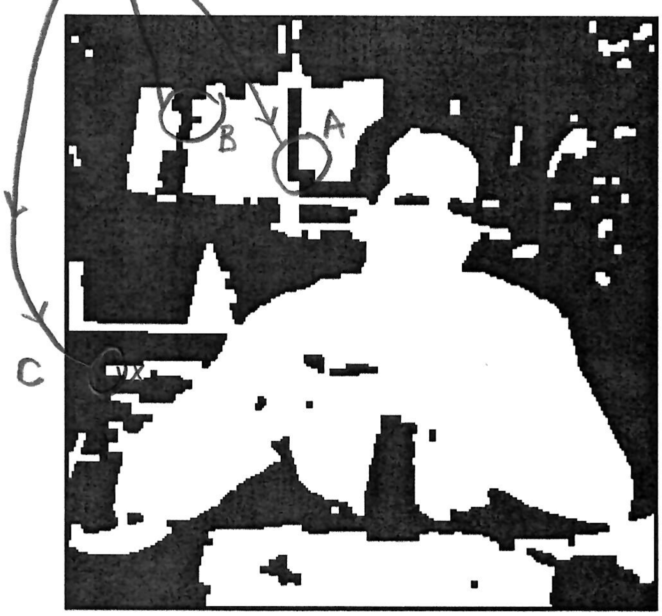
I

Tends to link neighboring holes

Binary OPEN-CLOSE and CLOSE-OPEN filters were applied to this image with the structuring element SQUARE(9) shown on page 2.54 of the course notes. The resulting binary images $\mathbf{J}_1$ and $\mathbf{J}_2$ are shown below.

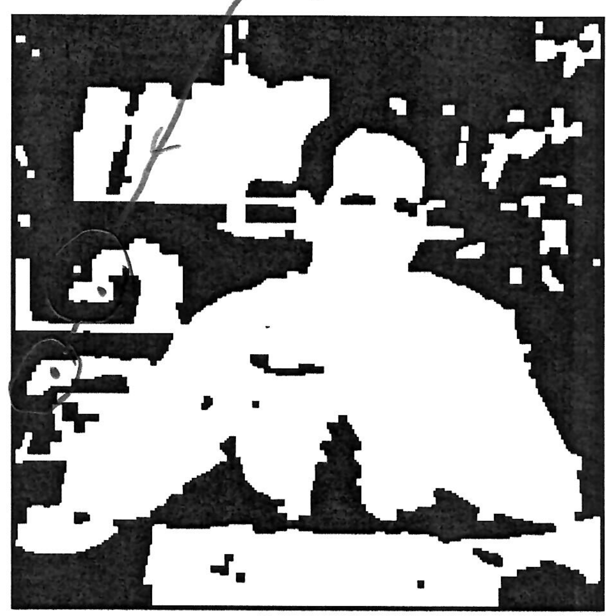
Tends to link neighboring objects

$\mathbf{J}_1$



CLOSE-OPEN

$\mathbf{J}_2$



OPEN-CLOSE

Problem 4 cont...

Determine which output image resulted from each filtering operation. Briefly explain and justify your answer.

J_1 = CLOSE-OPEN (I, B)

J_2 = OPEN-CLOSE (I, B)

As explained on page 2.91 of the course notes, OPEN-CLOSE tends to link neighboring objects (WHITE).

→ In J_2, we see this with the small white blobs that are located to the left of the triangular object near the salesman's shoulder in the original image... and also with the white dots below and to the left of that.

CLOSE-OPEN tends to link neighboring holes (BLACK).

→ In J_1, we see this with the small black dots just to the right of the vertical break between the bookshelves and some of the breaks between books near the spot marked "A" in the J_1 image, as well as near the spots marked "B" and "C".

Problem 4 cont...

(b) **6 pts.** Show that binary OPEN and CLOSE are dual operations with respect to complementation.

Hint: it is stated on page 2.77 of the course notes that ERODE and DILATE are dual operations with respect to complementation. Use this fact to show that CLOSE[NOT(**I**)] = NOT[OPEN(**I**)].

CLOSE [NOT (I)] = ERODE {DILATE [NOT(I)]}

= ERODE { NOT [ERODE (I)]}

= NOT {DILATE [ERODE (I)]}

= NOT [OPEN(I)] ✓

This follows because ERODE and DILATE are dual with respect to complementation, which means that

ERODE [NOT (I)] = NOT [DILATE(I)]

and

DILATE [NOT(I)] = NOT [ERODE (I)],

as may be deduced from the figures on pages 2.77 and 2.78 of the course notes.

5. **20 pts.** Draw lines to match the images with their log-magnitude DFT spectra.