

Do NOT begin until told to do so
Make sure that you have all pages before starting
You may not leave the room during the exam
No calculators, open book, 2 page notes

ACADEMIC INTEGRITY:

Students have the responsibility to know and observe the requirements of The UNCC Code of Student Academic Integrity (1997-99 Catalog page 336). This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.

Name: _____

Student Number: _____

Unless otherwise noted:

Show all work, even for multiple choice
 Multiple choice answers should be within 5% of correct value
 $x[n]$ is input, and $y[n]$ output of a system
 $\mathcal{F}\{\}$ denotes either continuous or discrete Fourier transform
 $\mathcal{F}^{-1}\{\}$ denotes inverse Fourier transform
 u, v denotes the frequency variable
 $*$ denotes linear convolution
 $x^*(t)$ denotes the conjugate of $x(t)$
 \oplus and \ominus denote dilation and erosion
 \circ and \bullet denote open and close
 $F(u, v) = \mathcal{F}\{f(x, y)\}$

Useful constants, etc:

$$\begin{array}{cccc}
 e \approx 2.72 & \pi \approx 3.14 & 1/e \approx 0.37 & \sqrt{2} \approx 1.41 \\
 \sqrt{3} \approx 1.73 & \sqrt{5} \approx 2.22 & \sqrt{7} \approx 2.64 & \sqrt{10} \approx 3.16 \\
 \log_{10}[2] \approx 0.30 & \log_{10}[3] \approx 0.48 & \log_{10}[5] \approx 0.70 & \log_{10}[10] \approx 1.0 \\
 \log_{10}[0.1] \approx -1.0 & \log_{10}[0.5] \approx -0.3 & \log_{10}[e] \approx 0.43 & \cos(\pi/4) \approx 0.79
 \end{array} \tag{1}$$

$$\begin{aligned}
 \cos(A)\cos(B) &= \frac{1}{2}\cos(A - B) + \frac{1}{2}\cos(A + B) \\
 \cos^2(A) &= \frac{1}{2} + \frac{1}{2}\cos(2A)
 \end{aligned}$$

$$e^{j\theta} = \cos(\theta) + j\sin(\theta)$$

5 Points Each (Circle the best answer)

1. A 4-neighbor of a pixel (x,y) is also an 8-neighbor of the same pixel.

(a) True

(b) False

2. $D(p_1,p_2) = 0$ is a valid distance metric, where p_1 and p_2 are pixels with coordinates (x_1,y_1) and (x_2,y_2) .

(a) True

(b) False

3. Rotation of an image produces a rotation in its frequency spectrum.

(a) True

(b) False

4. For a real image $f(x,y)$, and its Fourier transform $F(u,v)$, $F(u,v) = F(-u,-v)$.

(a) True

(b) False

5. $\mathcal{F}\{f(x,y) * h(x,y)\} = F(u,v)H(u,v)$ where $f(x,y)$ and $h(x,y)$ are continuous functions.

(a) True

(b) False

5 Points Each (Circle the best answer)

6. The D_4 distance between (0,0) and (2,2) is

- (a) 2 (b) $\sqrt{8}$ (c) 4 (d) None above

7. The D_8 distance between (0,0) and (2,2) is

- (a) 2 (b) $\sqrt{8}$ (c) 4 (d) None above

8. $\mathcal{F}\{f(x, y) * \delta(x - 1, y)\} =$

- (a) $F(u, v)e^{-j2\pi u}$ (b) $F(u, v)\delta(u - 1, v)$ (c) $F(u - 1, v)$ (d) None above

9. The number of complex multiplications required in the FFT of a 8x8 pixel image is

- (a) 64 (b) 192 (c) 4096 (d) None above

10. If image averaging is to be used to reduce the standard deviation of noise by a factor of 10, then the number of images to be averaged is

- (a) $\sqrt{10}$ (b) 10 (c) 100 (d) None above

5 Points Each (Circle the best answer)

11. The optimal single threshold for segmenting two regions with Gaussian pdf's $\sigma_1 = 3$, $\mu_1 = 2$, $\sigma_2 = 3$, $\mu_2 = 10$ and a priori probabilities $P_1 = 0.5$, $P_2 = 0.5$ is

- (a) 4 (b) 5 (c) 6 (d) None above

12. $A \oplus B = B \oplus A$

- (a) True (b) False

13. $A \ominus B = B \ominus A$

- (a) True (b) False

14. $(A \oplus B) \oplus B = B \oplus A$

- (a) True (b) False

15. $(A \circ B) \circ B = A \circ B$

- (a) True (b) False

The following questions refer to the image below.

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	1	1	2	0	0
0	0	1	1	1	2	0	0
0	0	1	1	1	2	0	0
0	0	1	1	1	3	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

25 points

16. Show the resulting images if the sobel operators are applied.

x	x	x	x	x	x	x	x
x							x
x							x
x							x
x							x
x							x
x							x
x	x	x	x	x	x	x	x

x	x	x	x	x	x	x	x
x							x
x							x
x							x
x							x
x							x
x							x
x	x	x	x	x	x	x	x

The following questions refer to the image below.

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	1	0	1	1	0
0	0	1	1	0	1	0	0
0	0	1	1	0	0	0	0
0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

25 points

17. Show the resulting images $A \oplus B$ and $A \bullet B$ if B is a 3×3 structuring element.

$A \oplus B$

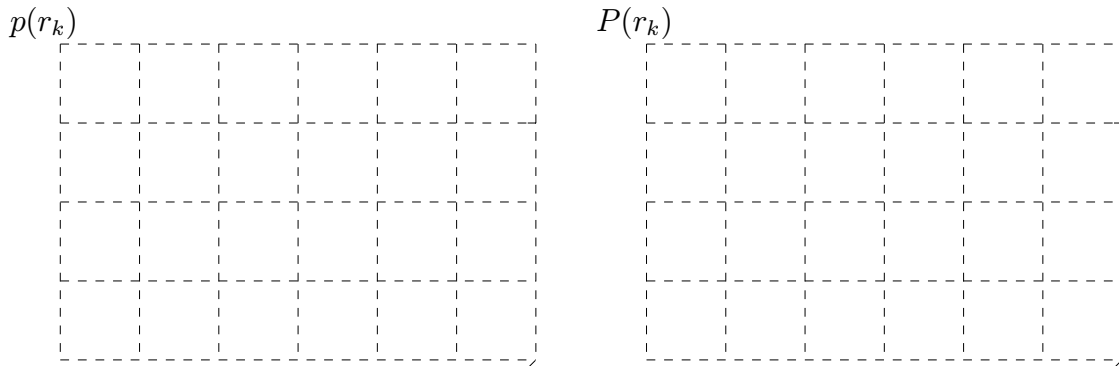
$A \circ B$

The following questions refer to the image below.

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5

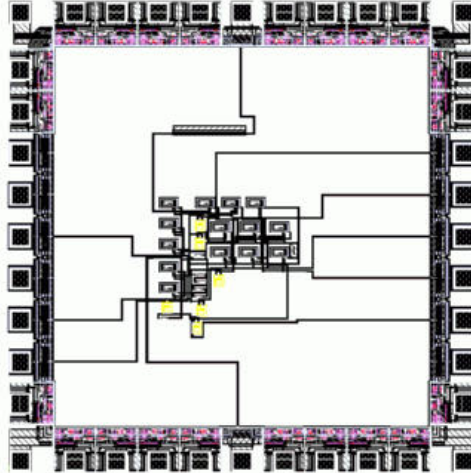
25 points

18. Plot the probability density $p(r_k)$, cumulative distribution $P(r_k)$, and show the histogram equalized image $f_e(x, y)$. Make sure that you label the axes.



25 points

19. Show the histogram equalized image $f_e(x, y)$. Assume that the equalized image gray levels are from 0 - 255.



25 points

20. An image processing system is to be designed to segment the above image for a robotic wire bonder that attaches wires to the chip. You are to segment the image such that the output image is to be a binary image consisting only of the bonding pads at the periphery of the chip. Draw a block diagram and write a short description of the processing steps in the image processing system. Explain the rationale of your approach.

