## Computer Science 4422.03

## Test #1
Feb. 9 2000

## Answer all questions in the space provided

## Make sure that you have 9 pages

Student Last Name: _____

Student Given Name: _____

Student Id. No: _____

| Question | Value | Score |
|----------|-------|-------|
| 1 | 42 | |
| 2 | 30 | |
| 3 | 28/38 | |

**Question 1.** [42 points]

1. [3 points] What is the simplest way to reduce the amount of aberration in a given lens.

2. [3 points] Name four things that will be affected by a change in the diameter of the lens.

3. [3 points] What is the name and the size of the matrix that relates an image point in camera coordinates to an image point in image coordinates.

4. [3 points] We have a gray scale image and we want to reduce the amount of detail. Give an example of a template to convolve it with (just the name *or* a brief description).

5. [3 points] What is the problem with 4- or 8-connectedness?

6. [3 points] Define *Boundary* of an object.

7. [3 points] We dilate and then erode a binary image. Is the number of pixels that belong to the object bound to increase, decrease or stay the same?

8. [3 points] What is a histogram?

9. [3 points] Name 4 properties of the gaussian.

10. [3 points] What is the gradient of an image?

11. [3 points] What is the Laplacian of an image.

12. [3 points] Simplify
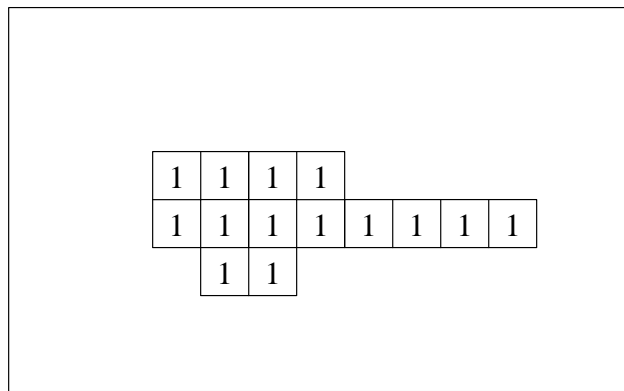
$$(\cos \theta + i \sin \theta)^n$$

13. [3 points] Name the four types of ideal edges.

14. [3 points] Name two methods to chose thresholds.

## Question 2.
[30 points]

1. [10 points] Name the three definitions of perimeter and calculate the perimeter of the following object.

| 1 | 1 | 1 | 1 |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|   | 1 | 1 |   |   |   |   |   |

2. [10 points] Convolve the image and template below and show the result on the empty "image". Pixels not marked otherwise are zero. The origin of the template is indicated by the arrows.

Image (values):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | 1 | 2 | | | |
| | | | | 1 | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Template:

| | 1 | |
|---|---|---|
| 1 | 1 | 1 |

(origin indicated by arrows at the lower-left "1")

Result image:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | . | . | | | |
| | | | | . | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

3. [10 points] Erode the following image with the template below and show the result on the empty "image". Pixels not marked otherwise are zero. The origin of the template is indicated by the arrows.
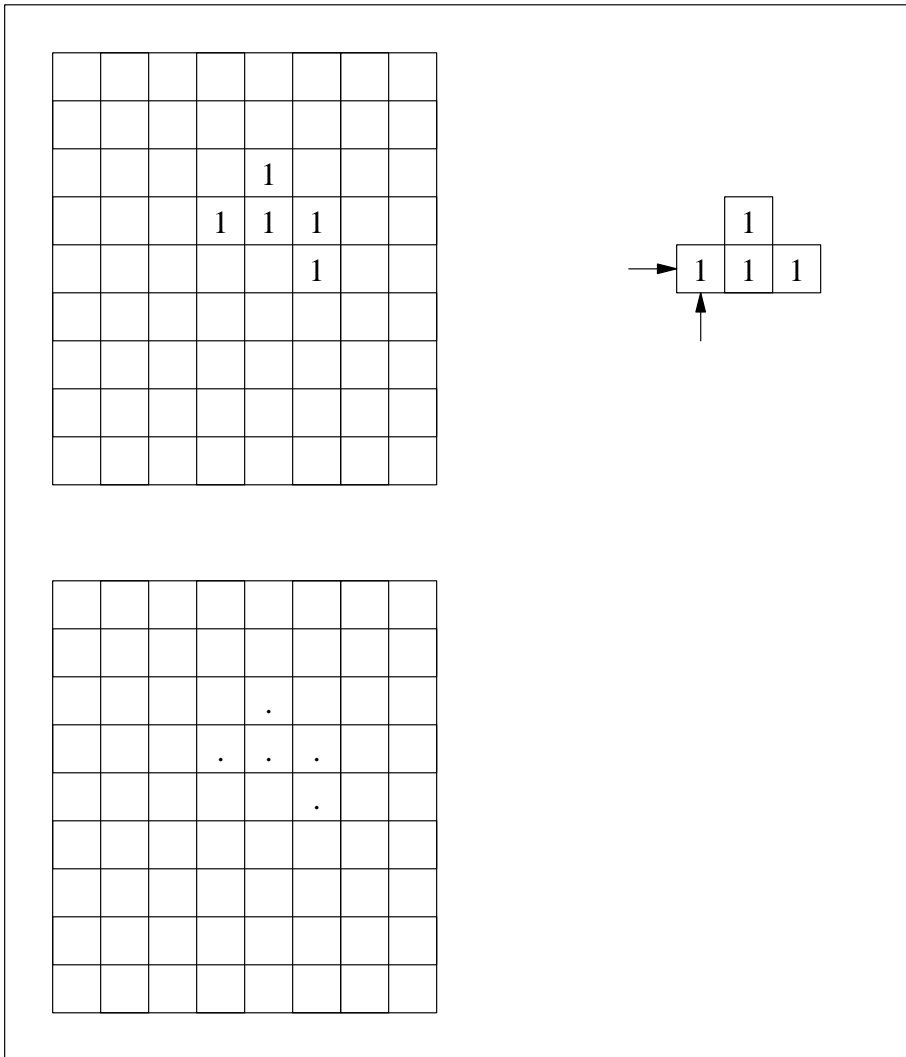
**Question 3.**

[28/38 points]

1. [14 points] What do we get if we convolve a (one dimensional) complex exponential

$$I[k] = e^{j\omega k}$$

with a template $t$ of length 5 that contains the binomial of order 4

$$t[k] = \begin{pmatrix} 4 \\ k+2 \end{pmatrix}$$

and the template goes from $k = -2 \cdots 2$.

2. [14 points] Are the templates of the Sobel operator separable? If yes, what are the components and if no, why? (The three rows of the first template are [-1, -2, -1], [ 0, 0, 0] and [1, 2, 1]).

3. [10 points, GRAD] Show that the convolution of two binomials of order $N$ and $M$ is a binomial. (Hint: start from the definition of the binomial as the expansion of $(1 + x)^N$)

**Formula Table**

The convolution of an image $I[k] = e^{j\omega k}$ with a template $w$ is

$$I_r[k_0] = W(e^{j\omega})e^{j\omega k_0}$$

where

$$W(e^{j\omega}) = \sum_k w[k]e^{-j\omega k}$$

The convolution in one dimension is

$$I_r[k_0] = \sum_k w[k]I[k_0 - k]$$