THE UNIVERSITY OF WESTERN AUSTRALIA

FIRST SEMESTER EXAMINATIONS

June 1998

Computer Vision 412

233.412
This paper contains:
7 questions;
6 pages.

Time allowed: 2 hours

Reading time: 10 minutes

Each question is worth 10 marks.
All third year candidates should attempt SIX questions.
All fourth year candidates must attempt ALL Questions.

1.

(a) Explain the difference between 4-connectedness and 8-connectedness.

(2)

(b) State the Jordan Curve Theorem.

(1)

(c) Give an example of a simple binary image that violates the Jordan Curve Theorem under both 4-connectedness and 8-connectedness. Explain the violations.

(3)

(d) Outline the sequential scan labelling algorithm for labelling connected components in a binary image. Assume 6-connectedness.

(4)

2.

(a) A mean filter is a linear filter, but a median filter is not. Why?

(2)

(b) Compare the characteristics of mean and median filters and identify the situations where you would use them.

(2)

(c) An 8×8 image $f(i,j)$ has grey levels given by the following equation:

$$f(i,j) = \mid i - j \mid, \text{ for } i,j = 0,\ldots,7.$$

Find the output image obtained by applying a 3×3 median filter on the image $f(i,j)$; note that the border pixels remain unchanged.

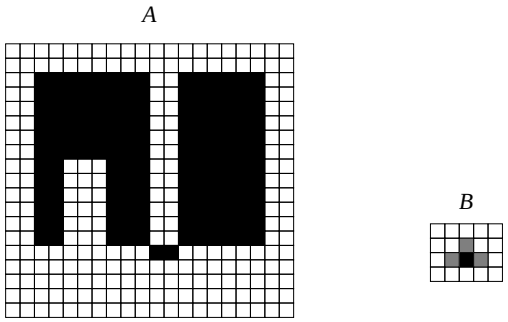
(6)

3.

(a) Define the *dilation* and *erosion* of an object A by a structuring element B.

(2)

(b) Sketch the dilation and erosion of the object labelled A in the figure below, using the structuring element shown. Note that the centre of the binary structuring element B is given by the darker pixel.



(4)

(c) What does it mean to say that "dilation and erosion are duals to each other with respect to set complementation and reflection"? Express this mathematically.

(2)

(d) Define the *opening* of A by B, and the *closing* of A by B.

(2)

4.

(a) Explain what a difference-of-Gaussians filter is and why one would convolve an image with such a filter.

(3)

(b) State the Convolution Theorem for Fourier transforms.

(2)

(c) Sketch the shape of the Fourier transform of a difference-of-Gaussians filter, and explain how you derived this shape. Is it a low-pass, band-pass, or high-pass filter?

(5)

5.

(a) Explain the difference between the image motion field and the optical flow. Give an example where these two differ.

(2)

(b) Consider a point object located at *world* coordinates $(10, 0, 10)$ at time $t = 0$. A camera system with a focal length of 2 is located such that its *lens centre* is at the origin of the world coordinate system and its optical axis is looking directly at the object at time $t = 0$. The object is moving with a uniform velocity of $(5, 0, 0)$.

(i) What are the coordinates of the point object in the image plane at time $t = 0$?

(ii) Find the image coordinates of the point at time $t = 1$ if

A. The camera is stationary.

B. The camera translates with a uniform velocity of $(0, 0, 5)$.

(8)

6.

(a) Draw a diagram showing a single world point $W = (X, Y, Z)$ imaged by two perfectly aligned identical cameras, with focal length f, and lens centres separated by a distance b. Assume the world coordinates (X, Y, Z) are measured with respect to a coordinate frame attached to the focal point of the left camera.

(2)

(b) Write down the relationships between X and the image x-coordinates, x_l and x_r in the left and right images.

(2)

(c) Show how these expressions may be used to solve for Z given the coordinates of the image of W in each camera.

(2)

(d) Draw a diagram showing the geometry of a structured lighting arrangement, where the camera and the projector are offset by a baseline distance b, and the projector is at an angle θ with respect to the optical axis of the camera.

(2)

(e) What is the equation that relates the world point coordinates (X, Y, Z) to the image coordinates (x, y)?

(2)

7.

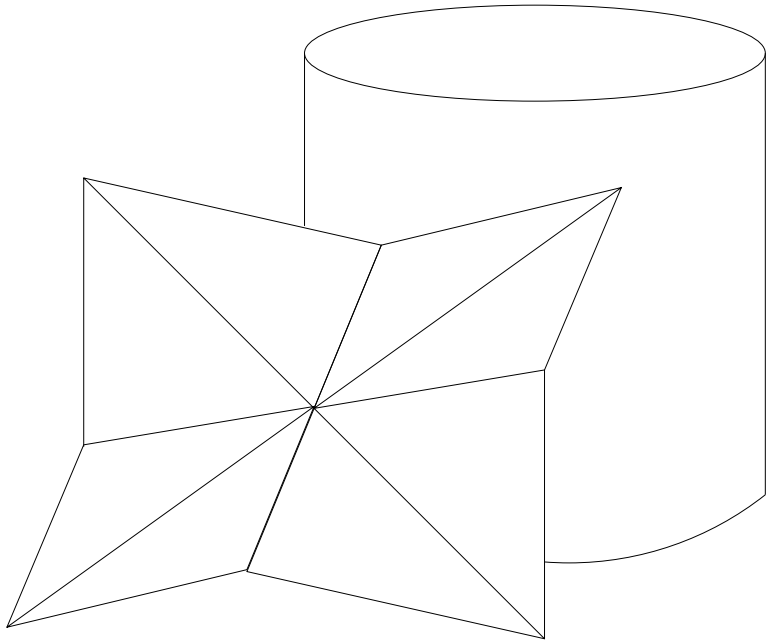
(a) Explain the difference between an illumination discontinuity, an orientation discontinuity, a depth discontinuity, and a surface reflectance discontinuity. Draw a diagram illustrating each of these discontinuities.

(5)

(b) List the six possible edge labels and the four possible junction types.

(2)

(c) Provide a valid labelling the following edge drawing:



(2)

(d) What geometrical event does a T-junction signify?

(1)