THE UNIVERSITY OF WESTERN AUSTRALIA

FIRST SEMESTER EXAMINATIONS

June 1999

Computer Vision 412

233.412
This paper contains:
7 questions;
7 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) Draw a figure illustrating the principles of the pinhole camera model. Annotate your figure carefully.

(2)

(b) Write down the equations that relate the image coordinates to the real world coordinates of a point.

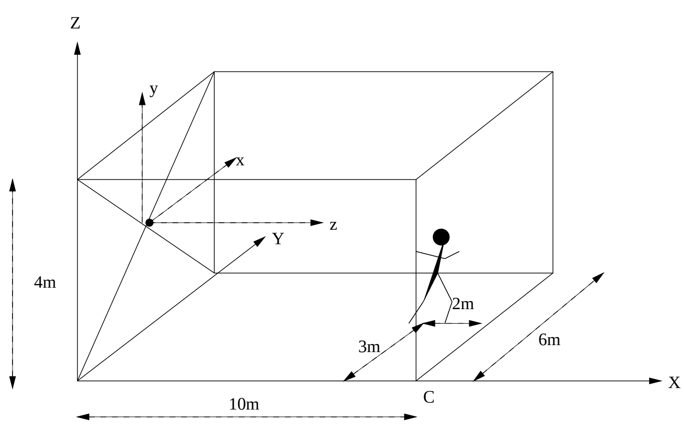
(1)

(c) Using homogeneous coordinates, explain how these equations become linear in projective space.

(2)

(d) A surveillence camera is embedded in the centre of one of the walls of a room, as shown in the figure below. The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is 0.05 metres. The **x**–**z** plane of the camera is parallel to the **X**–**Y** plane of the world coordinate system. The image plane is behind the wall. Find the image plane coordinates of the head of a person 2 meters tall standing at a distance of 3m × 2m from the corner C. What are the coordinates of the head if the person stands in the corner C?

(5)



2.

(a) Define 4-connectedness for a discrete raster grid.

(1)

(b) Define 8-connectedness for a discrete raster grid.

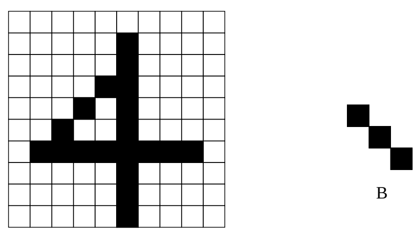
(1)

(c) Define how the Euler number is computed for a discrete binary image.

(1)

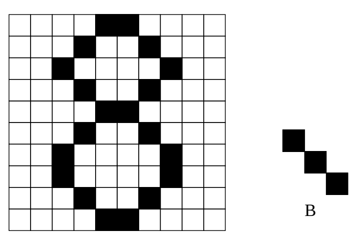
(d) Assuming 4-connectedness, compute the Euler number for the following image of the digit '4'.

(1)



(e) Assuming 8-connectedness, compute the Euler number for the following image of the digit '8'.

(1)



(f) Using the 3-pixel diagonal structuring element B shown beside both the images above, sketch the dilation and erosion of the images in (d) and (e).

(5)

3.

(a) Define the horizontal and vertical Sobel operators.

(2)

(b) Given a 10×10 binary image whose central 4×4 pixels are all 1 and whose other pixels are all 0, sketch the gradient of this image obtained by using the Sobel operators. Give the values of all the pixels in the image.

(4)

(c) Explain the difference between low-pass filtering and high-pass filtering.

(2)

(d) Sketch the results of low-pass filtering and high-pass filtering on the one-dimensional signal obtained by taking a horizontal slice through the middle of the image described in question (b).

(2)

4.

(a) Define Hue, Saturation, and Brightness. Which of these is important in characterising colour at a point?

(4)

(b) Explain the additive and subtractive models of colour. Which one is more suitable for printers?

(3)

(c) What is the HSI solid? Draw a diagram illustrating the three axes and carefully label the relevant parts of your diagram.

(3)

5.

(a) What does histogram equalisation do and how does it work?

(4)

(b) Imagine a 64×64 image with 4 grey levels. The normalised grey levels are 0, 1/3, 2/3 and 1. Suppose the image distribution is given by

Grey level	Number of pixels	Probablility of occurence
0	1813	0.44
1/3	1506	0.37
2/3	574	0.14
1	303	0.05

(i) Draw the histogram of the image, mapping the normalised grey level against the probability of occurence.

(1)

(ii) Apply the histogram equalisation transformation to determine the equalised histogram.

(3)

(iii) Draw the equalised histogram.

(1)

(c) What happens if you apply histogram equalisation *twice* to the same image?

(1)

6.

(a) Define the term *disparity* used in stereo vision.

(2)

(b) Illustrate the basic geometry of stereo vision and label your illustration.

(2)

(c) Give the equation that determines the distance of a point in terms of the disparity in a pair of stereo images.

(1)

(d) Write down the *optical flow constraint equation*.

(1)

(e) Define the *focus of expansion* of a motion field and give an illustration.

(2)

(f) Give an example where the motion field and the optical flow are orthogonal.

(2)

7.

(a) Find the quad tree representation for the following image:

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

(3)

(b) Give an example of an object whose wire-frame representation and skeleton representation are different.

(2)

(c) How do you tell the difference between a knife, a fork, and a spoon? Imagine your job is to design a simple object recognition system. The input consists of images of knives, forks, and spoons at any scale, but the objects do not overlap or touch. A sample input image is given below. Design an algorithm that will label the objects correctly.

(5)