THE UNIVERSITY OF WESTERN AUSTRALIA

FIRST SEMESTER EXAMINATIONS

June 2000

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 candidates should attempt SIX questions.

1.

(a) State the Jordan Curve Theorem.
Explain its significance in the processing of discrete binary images.

(2)

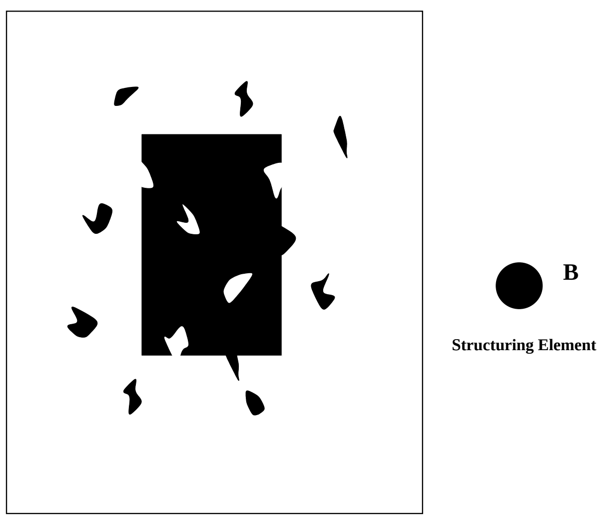
(b) What happens when the morphological dilation operation is applied to a binary image twice?

(1)

(c) What happens when the morphological opening operation is applied to a binary image twice?

(1)

(d) Consider the binary image shown below



What will the morphological operations of opening followed by closing, using the structuring element B, do to this image? Sketch the results of each successive dilation/erosion step in performing this opening and closing. Note: consider the black regions as object regions.

(6)

2.

(a) What are the two factors that dictate the brightness at a point in an image?

(1)

(b) Define Hue, Saturation, and Brightness.

(3)

(c) What are the differences between specular reflection and diffuse reflection? Illustrate with a diagram.

(1)

(d) Describe in detail the steps involved in performing homomorphic filtering for image enhancement. Explain the purpose of each step. What assumptions does homomorphic filtering make about the nature of the image structure?

(4)

(e) How would you apply homomorphic filtering to a RGB colour image?

(1)

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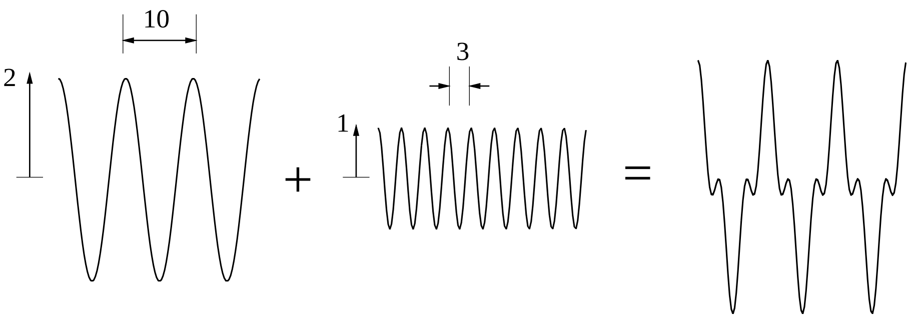
3. A 1D signal is formed from the sum of two cosine waves with amplitudes and wavelengths as shown below



(a) Plot the amplitude of the Fourier transform of this 1D signal. Label the axes and coordinates of your plot clearly.

(3)

(b) What is the highest frequency that can be represented in a discrete valued signal?

(1)

(c) Plot the form of a low-pass filter having a fairly sharp cutoff frequency of 0.2 .

(1)

(d) Apply this low-pass filter to the signal above. Plot the Fourier transform of the result. In the spatial domain how will the two components that make up this signal be affected?

(2)

(e) Plot the form of a high-boost filter having a fairly sharp cutoff frequency of 0.2 . At low frequencies the filter takes on a value of 0.5 and at high frequencies the filter takes on a value of 1.5 .

(1)

(f) Apply this high-boost filter to the signal above. Plot the Fourier transform of the result. In the spatial domain how will the two components that make up this signal be affected?

(2)

4.

(a) List the three main criteria that Canny used to design his edge operator. Explain what each of the criteria aim to achieve, and explain where they might conflict with each other.

(3)

(b) Describe the convolution masks used in the Sobel edge detector. What does each mask attempt to do and how is the edge strength calculated? What properties about a point in the image does the operator attempt to calculate? What assumptions does it make about edges?

(3)

(c) A mask and 1D signal are defined below. Convolve the signal with the mask, assume the signal values are zero outside of the range defined below.

Signal:

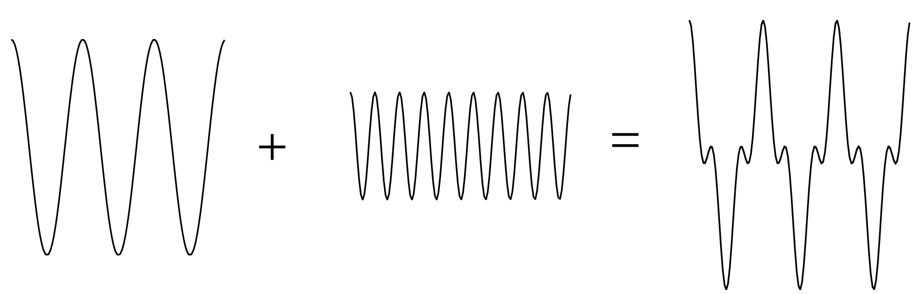
1	1	1	4	0	0	1	2	3	4

Mask:

-2	1	3

(2)

(d) A 1D signal is formed from the sum of two cosine waves as shown below



Where would a feature detector based on phase congruency mark features in this signal? Explain your answer.

(2)

5.

(a) In order to apply the Hough Transform the geometric features to be detected must be parameterised in some way. What property must the parameterisation satisfy?

(2)

(b) Describe in detail how you could use the Hough Transform to detect squares in an image. Assume you have an edge map marking the outlines of the squares. Also assume the squares are of a fixed size of 10 pixels by 10 pixels, and are aligned with the vertical/horizontal axes of the image. (Hint: What are the parameters of the Hough space?)

(8)

6.

(a) Explain what is meant by the terms motion field and optical flow. How do they differ?

(2)

(b) Explain the aperture problem in motion.

(2)

(c) Describe how one can consider the problem of deducing camera motion and 3D world information from a sequence of images as a stereo problem. Explain the derivation for the minimum amount of information needed to solve for the motion of the camera.

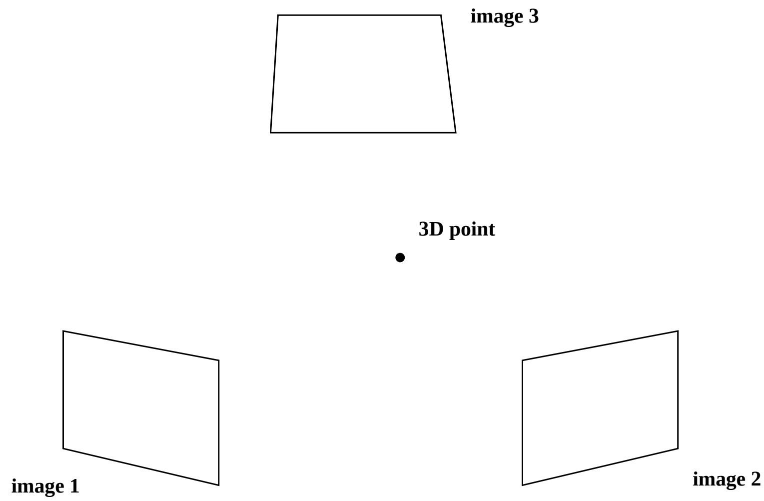
(4)

(d) Explain how the speed/scale ambiguity arises in the analysis of motion sequences.

(2)

7.

(a) Assume you have images of a scene from *three* calibrated cameras, one on the left, one on the right and one in the middle and slightly above. as shown below



Draw a clear diagram illustrating the construction of all the epipolar lines corresponding to the three images of the 3D point in the world. Mark the centres of projection, the epipoles and the epipolar planes. (Give yourself plenty of room to draw the diagram).

(5)

(b) Describe all the possible advantages of having three images of a scene rather than just a stereo pair.

(3)

(c) Define the *focus of expansion* of a motion field and give an illustration. How is the focus of expansion related to stereo geometry?

(2)