
THE UNIVERSITY OF WESTERN AUSTRALIA

FIRST SEMESTER EXAMINATIONS 2002

**DEPARTMENT OF COMPUTER SCIENCE & SOFTWARE ENGINEERING**

**COMPUTER VISION (233.412)**

This paper contains:
8 Pages
7 Questions

Time allowed: 2 hours
Reading time: 10 minutes

Each question is worth 10 marks.
Marks for this paper total 60.
All candidates should attempt SIX questions.

***PLEASE NOTE***

*Examination candidates may only bring authorised materials into the examination room. If a supervisor finds, during the examination, that you have unauthorised material, in whatever form, in the vicinity of your desk or on your person, whether in the examination room or the toilets or en route to/from the toilets, the matter will be reported to the head of school and disciplinary action will normally be taken against you. This action may result in your being deprived of any credit for this examination or even, in some cases, for the whole unit. This will apply regardless of whether the material has been used at the time it is found.*

*Therefore, any candidate who has brought any unauthorised material whatsoever into the examination room should declare it to the supervisor immediately. Candidates who are uncertain whether any material is authorised should ask the supervisor for clarification.*

SEE OVER

1.

(a) Explain in words and illustrate with a diagram the form of the greyscale function you would use to decrease image contrast.

(1)

(b) What greyscale mapping function would you use to increase contrast in the bright portions of an image, while decreasing contrast in the darker regions?

(1)

(c) How is the greyscale mapping function that performs histogram equalisation constructed?

(3)

(d) Explain the additive and subtractive models of colour. Illustrate the relationship between the two with a diagram. Which colour model is used by colour printers?

(3)

(e) Explain how you would increase the contrast of an RGB colour image.

(2)

---

2.

(a) In a discrete image what is the value of the Nyquist frequency?

(1)

(b) What limitation does the Nyquist frequency imply?

(1)

(c) Plot the form of a low pass filter having a perfectly sharp cutoff frequency of 0.25. What problems will arise from using such a filter?

(2)

(d) What does the 0 frequency component of a Fourier transform represent?

(1)

(e) If $F(\omega)$ is the Fourier transform of $f(x)$, $G(\omega)$ is the Fourier transform of $g(x)$, and $a$ and $b$ are constants

(i) What is the Fourier transform of $af(x) - \frac{1}{b}g(x)$ ?

(ii) What is the Fourier transform of $f(ax)$ ?

(2)

(f) For a real valued signal $f(x)$, having Fourier Transform $F(\omega)$, what is the relationship between $F(\omega)$ and $F(-\omega)$ ?

(1)

(g) Plot the amplitude spectrum of the Fourier transform of

$$2\cos(2\pi x) + 3 + \cos(4\pi x)$$

(2)

3.

(a) The shape of a binary object can be characterised by moments.
Define the $(p+q)^{th}$ moment of a binary object.

(1)

(b) Define the $(p+q)^{th}$ central moment of a binary object.
What invariant property(s) does the central moment have?

(2)

(c) Define the $(p+q)^{th}$ normalised central moment of a binary object.
What invariant property(s) does the normalised central moment have?

(2)

(d) Define the processes of neighbourhood averaging and median filtering for greyscale images.

Discuss the strengths and weaknesses of each method for the removal of noise.

(2)

(e) Consider a circle of radius $r$ and square of size $2r$ x $2r$.

(i) Sketch the morphological dilation of the circle and square using a circular structuring element of radius $0.99r$ having its origin at the centre.

(1)

(ii) Sketch the morphological erosion of the circle and square using the same structuring element.

(1)

(iii) Sketch the morphological opening of the circle and square using the same structuring element.

(1)

4.

(a) What are the intrinsic parameters of a camera calibration matrix?
What are the *solvable* intrinsic parameters?

(2)

(b) What are the extrinsic parameters of a camera calibration matrix?

(1)

(c) In a stereo pair of images what do the epipoles represent?
Illustrate your answer with a diagram.

(1)

(d) If the epipolar lines of a stereo pair of images are all horizontal what does this tell you about the stereo cameras?

(1)

(e) How is a 2D line represented in homogeneous coordinates? Use a diagram to illustrate your answer showing the line and its corresponding homogeneous coordinates.

(1)

(f) The projection of a plane into an image can be thought of as the composition of three transformations. What are these transformations?

(1)

(g) List the steps involved in rectifying an image of a planar region using perspective cues from the scene and knowledge of relative lengths and angles of features within the plane.

(3)

5.

(a) One measure of phase congruency is

$$PC(x) = \frac{|E(x)|}{\sum A_n(x)}$$

Under what conditions does this equation for phase congruency degenerate?

(1)

(b) Consider the signal

$$3\sin(2\pi x) + 4\sin(4\pi x + \frac{\pi}{2}) \ .$$

Draw a vector diagram indicating the amplitude and phase of the two components of the signal at $x = 1$. Show on this diagram the construction of $E(x)$ and determine the value of phase congruency at $x = 1$.

(4)

(c) What are the advantages of using phase congruency to detect features?

(2)

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

(3)

6.

(a) Explain in words and illustrate with a diagram how a Gabor filter is constructed.

(1)

(b) Explain how you use Gabor filters to obtain localised amplitude and phase information from a signal.

(2)

(c) Explain how you might use the Convolution Theorem to *deblur* an image.

What are the problems in trying to use this approach to deblur an image?

(3)

(d) Write out the Optical Flow Constraint equation.
Explain each of the terms in the equation.

(2)

(e) What is the relationship between the divergence of the motion field and the time to contact if an object is coming directly towards you?

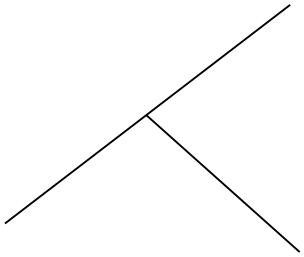
(1)

(f) How can the divergence of the motion field within a closed contour be calculated?

(1)

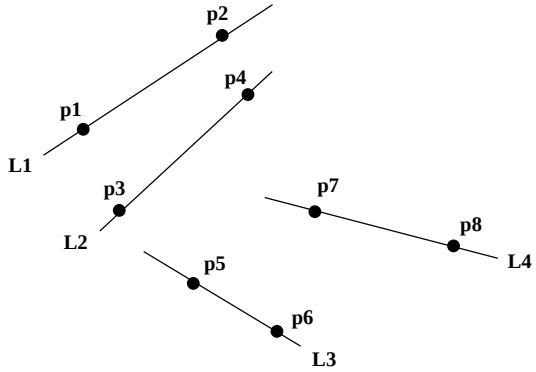
7.

(a) What are all the possible line labelings of the digram below?



(2)

(b) The diagram below is an image of a scene where lines $L_1$ and $L_2$ are parallel and lines $L_3$ and $L_4$ are parallel. In the scene these lines all lie within a plane.




Reproduce this diagram in your answer book and show graphically how you would construct the vanishing line of the plane.

Given the homogeneous coordinates $p_1$ to $p_8$ show how you would calculate the homogeneous coordinates of the vanishing line of the plane.

(3)

(c) 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?

(1)

(d) Describe in detail how you would use the Hough Transform to detect equilateral triangles in an image. Assume you have an edge map marking the outlines of the triangles. Also assume the triangles are of a fixed size with edge length 10 pixels, and can only appear in an 'upright' configuration with their base horizontal and the point at the top. (Hint: What are the parameters of the Hough space?)

(4)