THE UNIVERSITY OF WESTERN AUSTRALIA

FACULTY OF
Engineering, Computing
and Mathematics

School of Computer Science & Software Engineering

FIRST SEMESTER EXAMINATIONS 2003

COMPUTER VISION 412 (233.412)

This paper contains 1 section

This Paper Contains: 8 Pages
Time allowed: 2 hours
Reading time: 10 minutes
You may NOT write during reading time

Each question is worth 10 marks.
Marks for this paper total 50.
All candidates should attempt FIVE 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.

1.

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

(1)

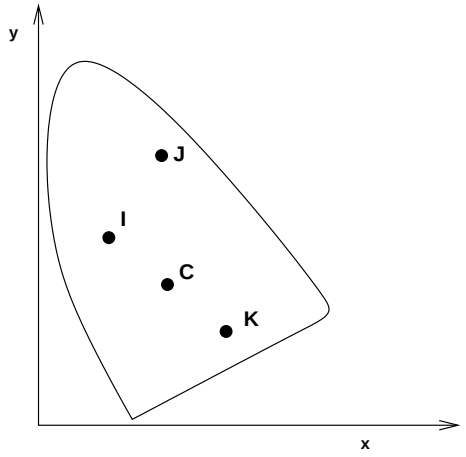
(b) What greyscale mapping function would you use to decrease image contrast?

(1)

(c) Would it be useful to apply histogram equalisation to an image of dark text on a light background? Explain your answer.

(2)

(d)



In the CIE diagram above, **C** is the point of equal energy where $x = y = z = \frac{1}{3}$.
(Note that conventionally the CIE diagram only shows the x and y axes).
What is the relationship between colours **I** and **K**?
How is the dominant wavelength of the colour **I** defined?
How is the dominant wavelength of the colour **K** defined?
If a display device uses the colours **I**, **J** and **K** as its primaries what will be the limitations on the colours that can be produced ?

(4)

(e) Given a green surface and a blue surface, both reflecting light with the same intensity, which will be perceived as brighter? Why?

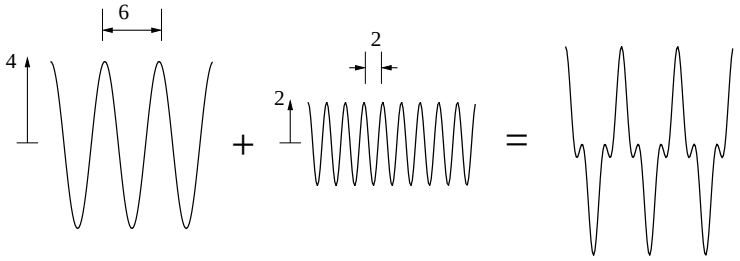
(1)

(f) Explain the differences between specular and diffuse reflection. Illustrate your answer with a diagram.

(1)

2.

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.

(2)

(b) Plot the form of a high-pass filter having a sharp cutoff frequency of 0.3 .

(1)

(c) Apply this high-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)

(d) What is the mathematical form of the Wiener filter?
Describe what each of the variables represent.
Explain how the filter works and describe its key features.

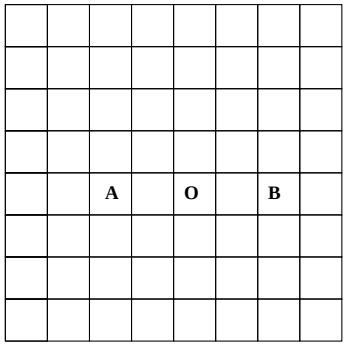
(3)

(e) What are the difficulties and inherent limitations that one faces in attempting to restore a blurred image?

(2)

3.

The diagram below represents an 8×8 2D Fourier transform of an image. The transform has been quadrant shifted to place the zero frequency point at the location marked **O**.



(a) If we know the value of the transform at the point marked **A** what is the value of the transform at point **B**?

(1)

(b) If all values in the Fourier transform were zero except for values of 1 at **A** and **B** we would have the Fourier transform of a basis function.
What will be the orientation and wavelength of this basis function?

(2)

(c) What is the basis function corresponding to a Fourier transform having a unit value at point **O** and being zero elsewhere?

(1)

(d) What are the basis functions used in the 1D Fourier transform?
Write out the mathematical equation and sketch the shape of the function.

(2)

(e) Explain the principles behind the Short-Time Fourier transform. Discuss the issues involved in the choice of the windowing function.

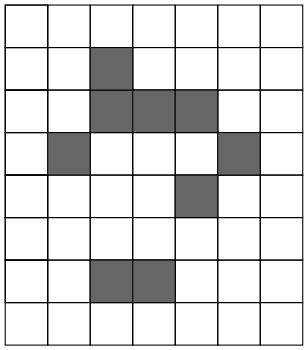
(2)

(f) Explain in words and illustrate with a diagram how a Gabor filter is constructed.
Explain how you can use these filters to calculate localised amplitude and phase information of a signal.

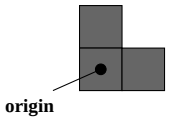
(2)

4.

The diagram below shows a binary image and a morphological structuring element. The dark pixels are the object pixels. Note the position of the origin of the structuring element.



Binary Image



Structuring Element

(a) Using 4-connectedness sketch the distinct objects that are in this binary image

(1)

(b) Using 8-connectedness sketch the distinct objects that are in this binary image

(1)

(c) Sketch the morphological erosion of the binary image using the structuring element.

(1)

(d) Sketch the morphological closing of the binary image using the structuring element.

(2)

(e) What is the centroid of all the object pixels in the binary image?
Assume the top left pixel has coordinates (0, 0).

(1)

(f) What is the second moment of the binary image above with respect to a vertical axis that passes though the third column of the image?

(2)

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

(2)

5.

(a) Explain the intrinsic parameters of a camera.
Write out the form of the camera calibration matrix in terms of the camera intrinsic parameters. Assume the world origin is at the projection centre.

(2)

(b) Draw a clear diagram showing the geometry of a structured light 3D measurement system. What are the advantages and disadvantages of a structured light system compared to a stereo system?

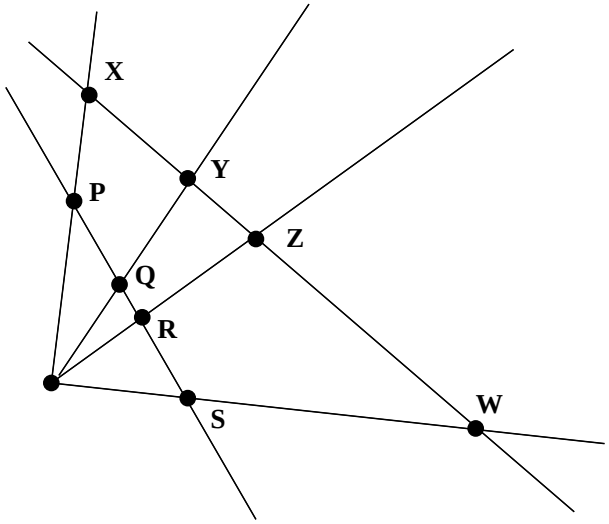
(4)

(c) Shown below are four points in a line. The distances of the points from point A are indicated below each point.

Construct a cross ratio from these points. You must clearly explain how you chose to construct your cross ratio. Do not evaluate the cross ratio, leave it expressed as a fraction.

(2)

(d)



In the diagram above what relationship exists between the points X, Y, Z, W, and the points P, Q, R, S?
Explain your answer.

(2)

6.

(a) Consider the signal

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

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 Local Energy, $E(x)$.

Using the measure of phase congruency given by

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

determine the value of phase congruency at $x = 1$.

(3)

(b) Consider the 5×5 image below. The pixel grey values are indicated by the values in the cells.

3	**2**	**1**	**2**	**4**
2	**1**	**3**	**200**	**3**
6	**7**	**8**	**7**	**9**
8	**100**	**6**	**6**	**7**
7	**9**	**6**	**8**	**8**

Apply a 3×3 median filter to the image. Note that to avoid problems at the edges of the image you only need to calculate the filtered values for the central 3×3 region.

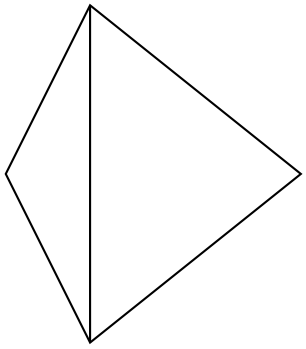
Apply the vertical edge filter used by the Sobel edge detector to the image above. Again, you only need to calculate the results for the central 3×3 region.

(4)

(c) Describe how the Marr-Hildreth edge detector works.

(1)

(d) What are all the possible line labellings of the line drawing below?
Describe the physical structure that would correspond to each of the labellings.



(2)

7.

(a) Explain the aperture problem in interpreting visual motion.
What strategy is usually adopted in machine vision systems to avoid the aperture problem?

(2)

(b) Define *the focus of expansion* of a motion field. Use a diagram to illustrate your answer.
How is the focus of expansion related to stereo geometry and the motion of the camera?

(2)

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

(1)

(d) Explain how the speed/scale ambiguity arises in the analysis of visual motion. Illustrate your answer with a diagram.

(2)

(e) What is the relationship between the vanishing line of a plane and the 3×3 homogeneous matrix describing the perspective projection of the plane into the image?

If the perspective projection of a plane is inverted what distortions of the planar surface may remain?

(3)
