UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1998

MEng Honours Degrees in Computing Part IV
MEng Honours Degree in Information Systems Engineering Part IV
MSci Honours Degree in Mathematics and Computer Science Part IV
MSc Degree in Advanced Computing
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the
Diploma of Membership of Imperial College
Associateship of the City and Guilds of London Institute
Associateship of the Royal College of Science

PAPER 4.18 / I4.2

COMPUTER VISION

Thursday, May 14th 1998, 2.30 - 4.30

Answer THREE questions

For admin. only: paper contains 4 questions

1 The Hough Transform

A Hough transform is to be used to extract circles from an image. The image has a resolution of 256 by 256 and each of the circles have a radius of less than 64 pixels. Using a pseudocode of your choice, indicate how the implementation could be carried out in the following three cases:

a Using a three dimensional histogram array for xc, yc and r,

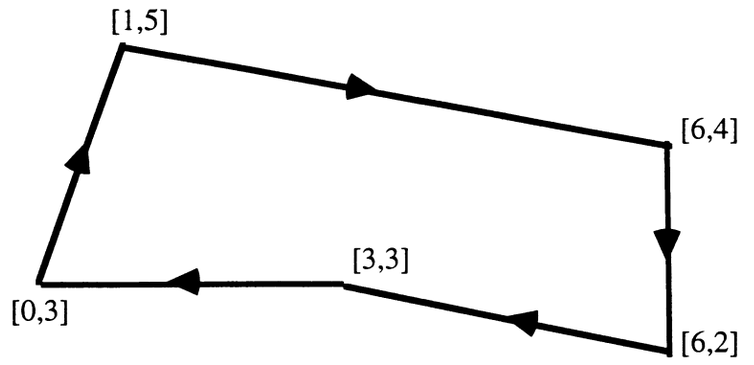
b Determining the centres with a two dimensional histogram first, using gradient information as well as position, and then finding the radii,

c Determining the centres with a two dimensional histogram first, using position information only, and then finding the radii.
(Hint: The centre of a circle is always mid-way between two edge points.)

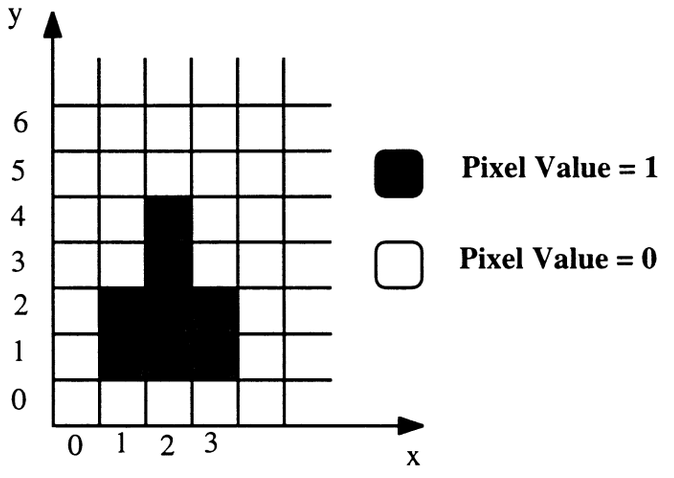
d Comment on the advantages and disadvantages of the three methods used in parts a, b and c.

2 Two Dimensional Object Recognition

a Explain how the area of an object could be computed from the edge vectors, illustrating your answer by computing it for the object shown below.



b Explain why the first moment cannot be used as an object discriminant. Compute the second moments ($M2_x$ and $M2_y$) for the object shown below assuming that all other image pixels are zero.



NB: $$M2_y = \sum_{x=0}^{xres} \sum_{y=0}^{yres} I(x,y)*(x-x_c)^2/\sum I(x,y)$$

c How could the two components of the second moment be used to find the orientation of an object?

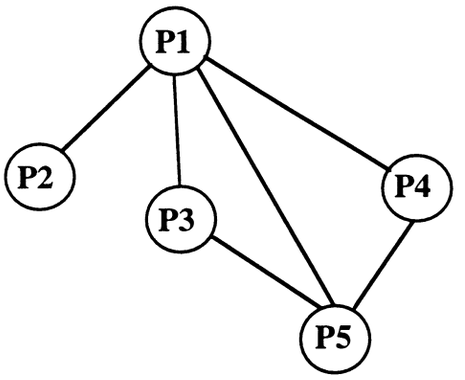
d Assuming that you are extracting the vertices of objects as the first stage of discrimination, suggest two further discriminants that could be computed simply in a factory environment.

e What advantages would the fourier descriptor have as a discriminant of shape over the use of area, perimeter and moments?

/Turn Over

3 Semantic Models

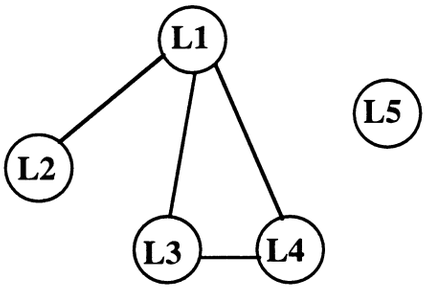
a A simple semantic model for a bicycle is shown in the following figure:



Node	Name	Type
P1	Frame	Quadrilateral
P2	Front Wheel	Large Circle
P3	Chain Wheel	Small Circle
P4	Rear Wheel	Large Circle
P5	Chain	Line Pair

The relations shown are all "connected"

When a number of primitives are extracted from an image the following relational structure is found:



Name	Type
L1	Large Quadrilateral
L2	Large Circle
L3	Small Circle
L4	Line Pair
L5	Large Circle

a. Construct an association graph between the semantic net and the extracted structure, noting that the association graph has a node for each possible matching node pair and arcs for matching node pairs where all relations agree or there are no relations.

b Indicate how you would interpret the graph.

c Suggest a way in which primitives extracted, but unmatched by the association graph method, could be interpreted.

d Briefly outline a method for measuring how good the match between image primitives and the semantic net might be.

4 Computational Stereo

Two cameras are set up to view a three dimensional scene. The left hand camera is placed at the origin and is facing in direction (0,0,1) (along the z axis). The right hand camera is at the point C = (cx,0,0) and also points in direction (0,0,1). Both cameras have focal length f.

a Find the equation of the plane through the centres of the two cameras and a pixel P = (xp,yp,f) belonging to the camera located at the origin. (The equation is in the form ax+by+cz=0 where (a,b,c) is a normal vector to the plane).

b Use the result of part a to derive an expression for the epipolar line corresponding to the pixel P.

c Given that the pixel P is in the centre of the image plane, and therefore has coordinate (0,0,f), sketch the epipolar line in the right hand camera. (assume both cameras are aligned vertically)

d Explain the purpose of an interest operator and explain how it can be used in conjuntion with the epipolar line.

e The Moravic operator is computed using the following three equations.

$$VL(\mathbf{p_i}) = \sum_{j \text{ neighbours } i} \{I(\mathbf{p_i}) - I(\mathbf{p_j})\}^2$$

$$IO(\mathbf{pi}) = \min_{j \text{ neighbours } i} \{VL(\mathbf{pi}), VL(\mathbf{pj})\}$$

$$IO(\mathbf{pi}) := 0 \text{ if } IO(\mathbf{pi}) < IO(\mathbf{pj}) \quad (j \text{ neighbours } i)$$

Explain briefly why it should determine points of interest.

End of Paper