GX1338

NATIONAL UNIVERSITY OF IRELAND, GALWAY
OLLSCOIL NA hÉIREANN

SEMESTER II, SUMMER 1999 EXAMINATION

FOURTH YEAR SCIENCE (INFORMATION TECHNOLOGY)
HIGHER DIPLOMA IN APPLIED SCIENCE (SOFTWARE DESIGN & DEVELOPMENT)

CT404 GRAPHICS AND IMAGE PROCESSING

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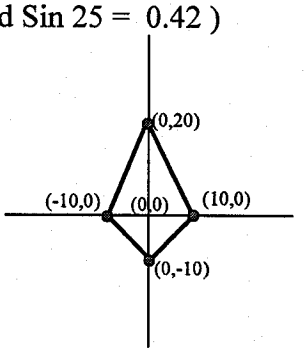
Time allowed: THREE hours

Answer any FOUR questions
All questions carry equal marks

Q.1. (a) Briefly explain the difference between vector graphics and raster graphics.

(b) Describe the following 3D graphics techniques: (i) hidden surface removal, (ii) surface shading, (iii) texture mapping, (iv) bump mapping.

(c) Calculate the co-ordinates of the vertices of the object shown below, following an anticlockwise rotation of 25 degrees about the origin.
(Note: Cos 25 = 0.91 and Sin 25 = 0.42)

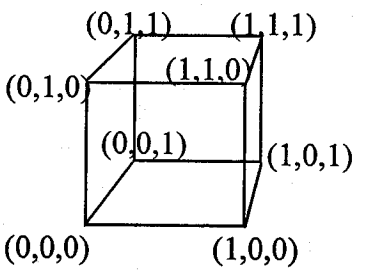


Matrix for 2D anticlockwise rotation by angle α about (0,0):

$$[x'\ y'] = [x\ y] \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix}$$

(d) Presuming that the unit cube shown on the next page is viewed using a 1-point perspective projection with the centre of projection located on the *z* axis at co-ordinate (0, 0, 50), *either*:

(i) calculate the *(x, y)* viewport (screen) co-ordinates of the 8 vertices,
or
(ii) write the necessary Visual Basic or C code to do these calculations.



1-point perspective projection where the centre of projection lies on the *z* axis at co-ordinate (0, 0, cp):

$$[M_{PERZ}]= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1/cp \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Q.2. (a) Describe the raster graphics technique of "antialiasing", referring to both weighted and unweighted area sampling in your answer.

(b) Provide a flood-fill algorithm for filling arbitrary shapes in a raster image.

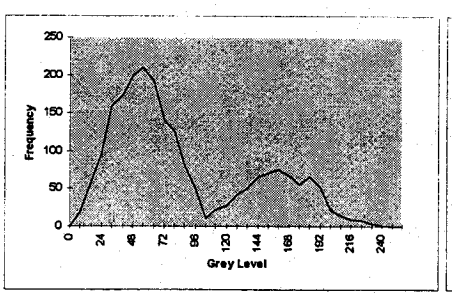
(c) Describe the typical functionality provided by graphics Application Programmers Interfaces (APIs) such as OpenGL, and by modern "hardware accelerated" graphics adapters.

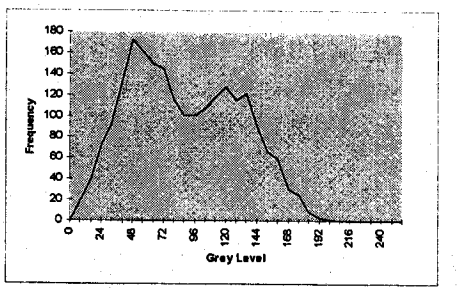
Q.3. (a) Briefly explain the difference between global (point) and local image processing operations.

(b) Describe greyscale histogram manipulation, referring in your answer to linear stretching, histogram-equalised stretching, and special stretching. In what circumstances would each of these stretches be of potential use? Provide an algorithm for histogram equalised stretching.

(c) What does the term "image convolution" refer to? Describe two important applications of image convolution, and provide an algorithm for convolution.

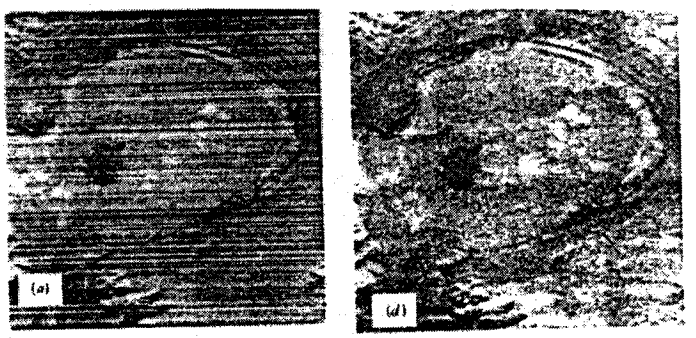
(d) Present an algorithm for segmenting the scene represented by the first greyscale histogram below, presuming that a bright object of interest lies on a dark background. Present a modified version of this algorithm for segmenting the scene represented by the second greyscale histogram below, in which the distinction between object and background is less well defined.



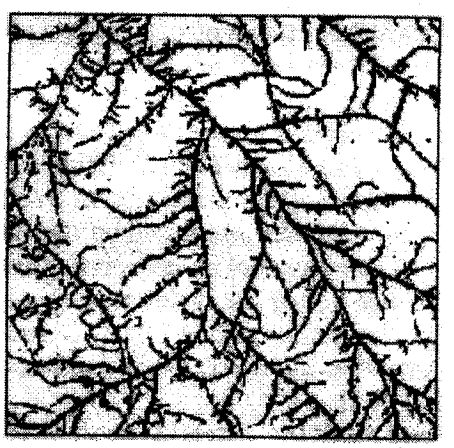


Q.4. (a) Discuss geometric image processing operations, and describe three different applications of this class of technique. Explain the term "interpolation" in your answer, and present an algorithm for bilinear interpolation.

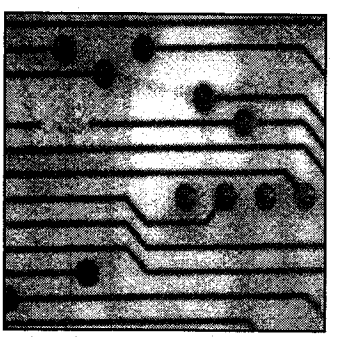
(b) Given the *before* and *after* images shown below, describe two digital methods by which the regular artefacts in the first image could be removed, resulting in the second image. What are the advantages and disadvantages of these methods, relative to each other?



Q.5. (a) The thresholded (i.e. binary) image below is of fungal growth in a laboratory. Presuming that the total length of growth is to be monitored over time via a series of such images, provide a suitable and robust set of algorithms for automating this task.



(b) The image below is of a printed circuit board (PCB), thousands of which are manufactured every hour in a particular factory. It is required as part of the quality control of this factory to produce an automatic machine vision system, which extracts the traces (straight bits), end points (places at which a trace terminates), and pads (circular bits) in the image. Present a suitable and robust set of image processing algorithms for this task.



Q.6. (a) A number of objects are to extracted from an image of reasonable signal-to-noise ratio (i.e. the objects of interest have edges of reasonable contrast). No morphological (shape) information can be presumed about the objects. Describe the algorithmic steps that could be carried out to segment this image in as robust a manner as possible.

(b) Presuming now that it is known that the objects of interest are approximately circular in shape and of radius 15 to 20 pixels, describe a modified list of steps.

(c) Presuming now the objects are not of any specific shape, but are however of fairly different tone and texture to the background (for example, the objects could be small islands and the background could be the ocean), describe a modified list of steps.

Q.7. (a) Describe approaches that could be taken to obtain 3D information from single images, using the following two visual clues: (i) shading, and (ii) prior knowledge of the geometric constraints of objects in the imaged scene.

(b) Present an algorithm for obtaining 3D information about a surface from stereo images of that surface. Discuss the problems that such an algorithm would face if the images were of a rural landscape seen from the air.

(c) Presuming that the objects of interest have been extracted from an image, describe the process of obtaining measurements, selecting relevant variables, and producing a pattern recognition system for automatic object classification.