GX1339

NATIONAL UNIVERSITY OF IRELAND, GALWAY
OLLSCOIL NA hÉIREANN

SEMESTER II, SUMMER 2000 EXAMINATION

FOURTH YEAR SCIENCE (INFORMATION TECHNOLOGY)

CT404 GRAPHICS AND IMAGE PROCESSING

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Time allowed: THREE hours

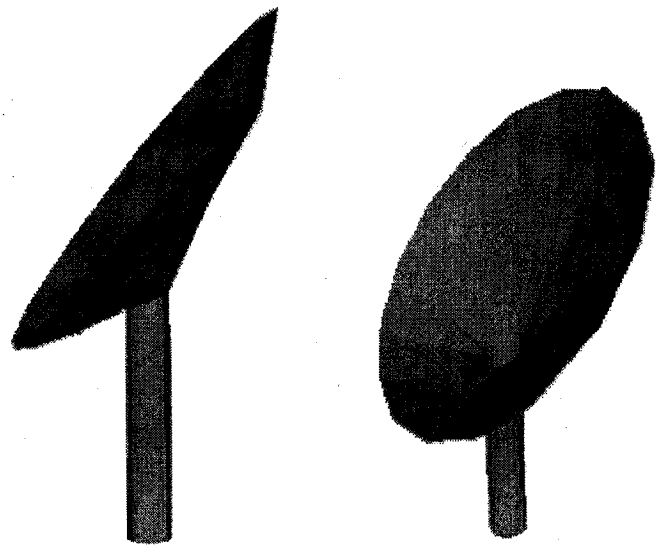
Answer TWO questions from section A and TWO questions from section B
All questions carry equal marks

Section A (COMPUTER GRAPHICS)

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

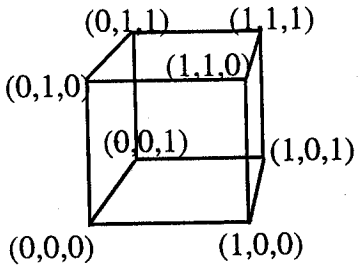
(b) Develop an algorithm for collision detection in a vector graphics environment. Would the same approach be equally useful in a raster environment? – state the reasoning behind your answer.

(c) The following 2 pictures show a model of an extruded satellite-dish shape created from a circular cross-section. Write Virtual Reality Modelling Language (VRML) code to create an object similar to this. Note that the most useful VRML nodes are summarised on the final page of this exam paper.

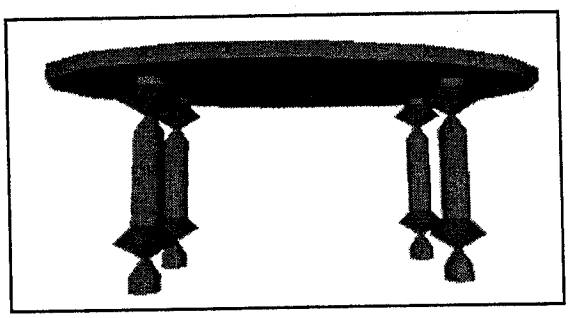


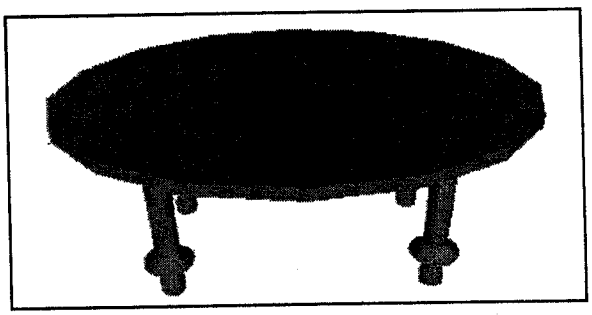
Q.2. (a) Explain, with the use of a diagram, the difference between planar projection and perspective projection.

(b) Presuming that the unit cube shown below is viewed using a 1-point perspective projection with the centre of projection located on the z axis at co-ordinate (0, 0, 30), calculate the (x, y) viewport (screen) co-ordinates of the 8 vertices,



(c) The table object pictured below was created by cloning an extruded leg shape, and then stretching a cylinder along one axis to make the elongated table-top. Write VRML code to create an object similar to this.

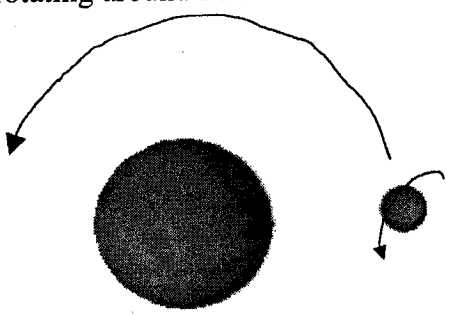




Q.3. (a) In the context of three-dimensional graphics, discuss 3 techniques used for each of the following: (i) hidden surface removal, (ii) surface shading.

(b) Describe the following concepts in computer animation: (i) nested co-ordinate systems; (ii) keyframe animation.

(c) The model depicted below is of two spheres. Write VRML code to create these spheres, and set up an animation in which the smaller sphere orbits the larger one, while also rotating around its own centre.



Section B (DIGITAL IMAGE PROCESSING)

Q.4. (a) What is meant by histogram manipulation? What is it used for? In your answer, refer to circumstances where two different types of histogram manipulation would be beneficial. Present an algorithm for histogram equalisation.

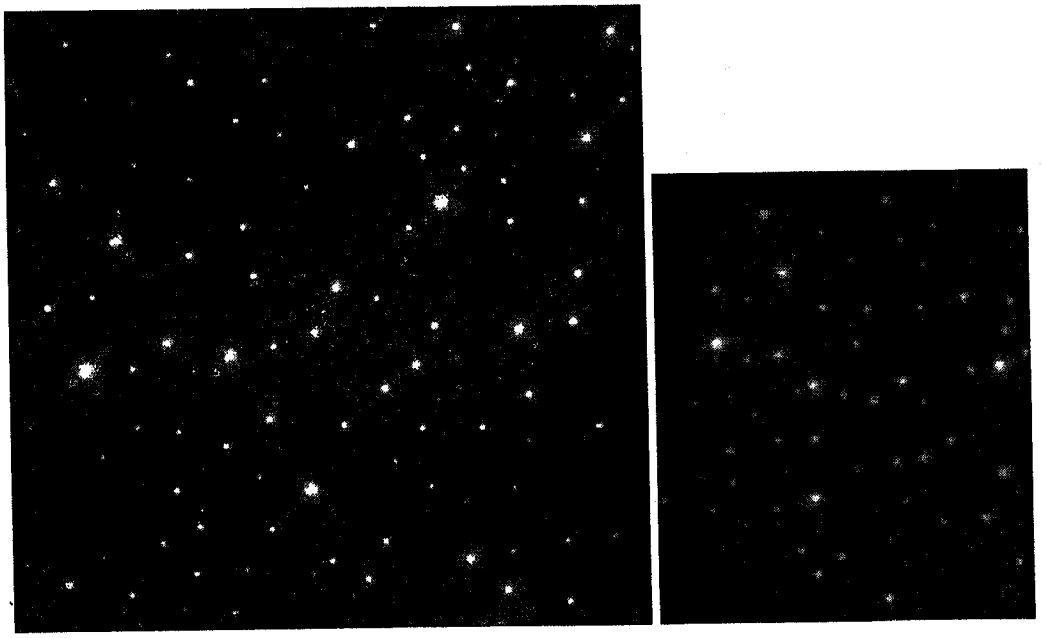
(b) Describe (with sketches and an algorithm) the process of image convolution and give three examples of its use. Compare and contrast Mean, Gaussian and Median filtering techniques, referring in your answer to their responses to noise and to edges. Give an example of a 5x5 Gaussian-style kernel (the coefficients need not be mathematically exact).

(c) What is meant by image deconvolution? Give two examples of its use in science and/or medicine. Name two deconvolution methods and the mathematical concepts upon which they are based. What are the dangers inherent in image deconvolution and how might they be reduced or avoided?

Q.5. (a) Are geometric operations *local* or *global* in nature? Why is interpolation used during many geometric operations? Describe two different interpolation approaches and present an algorithm for one of them.

(b) What are the three basic steps (operations) involved in a generic linear image registration operation? As an example of such a linear registration, how might one align the two images of a star cluster shown below, taken with different astronomical imaging systems? (Hint: first identify the pattern of brightest stars common to both images).

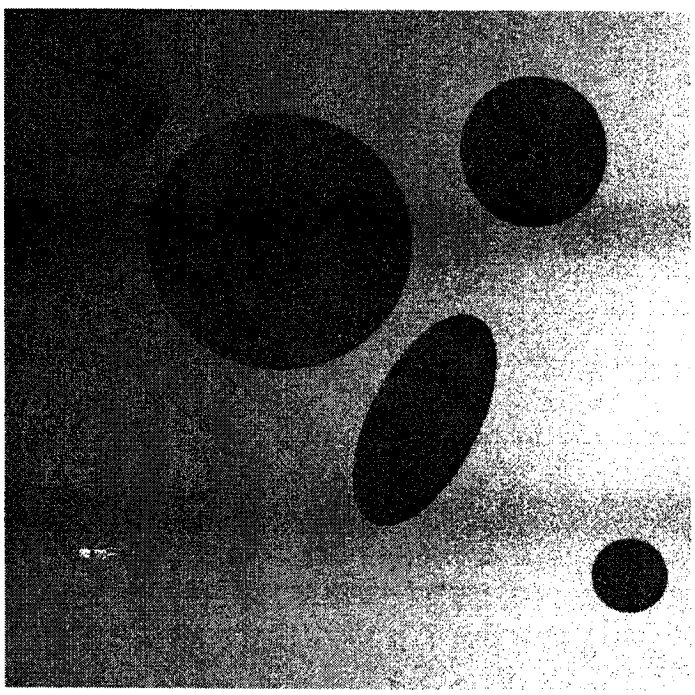
(c) If one of the astronomical imaging systems used to take the star cluster pictures suffered from spherical distortion, describe (with sketches) one way by which you could correct this effect.



Q.6. (a) Describe the processes of erosion and dilation, including their set-notation descriptions in your answer. Compare the four operations (i) opening, (ii) closing, (iii) thinning and (iv) thickening. When might each of these four operations be used?

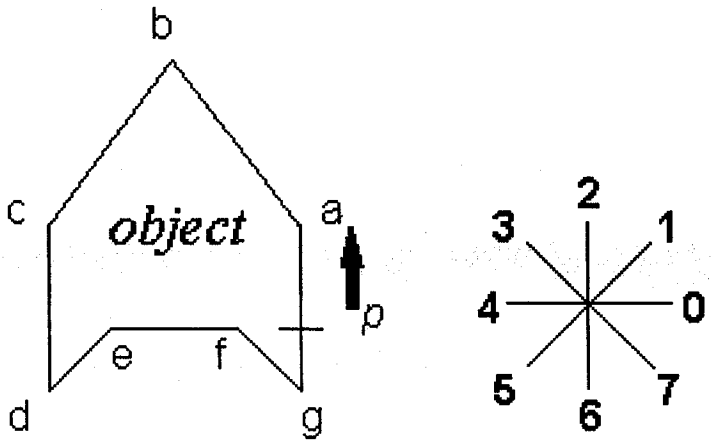
(b) Present a suitable and robust set of image processing algorithms to be used in an industrial vision system, for identifying, measuring and classifying apples and pears in images like the one shown below. The system should be able to fully automatically:

- Cope with a gradient in the image background and noise
- Identify and count apples (fairly circular objects)
- Identify and count pears (fairly elongated oval objects)
- Estimate their sizes (in pixels) as accurately as possible



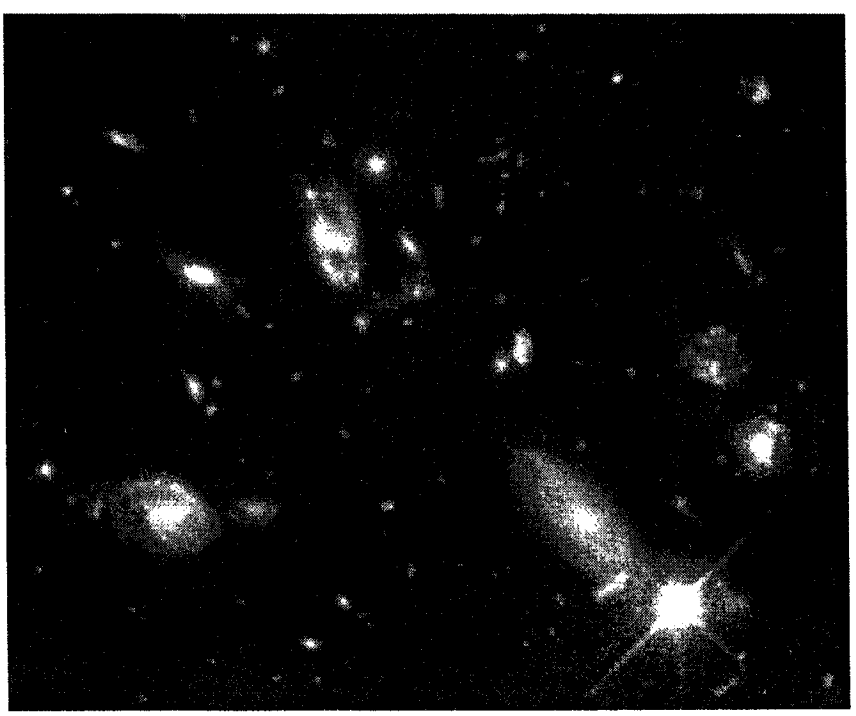
Q.7. (a) What is meant by Feature Extraction? Describe fourcharacteristics which are desirable in a selected feature.

(b) What is the purpose of the boundary chain code? For the object boundary shown below (left) and the code template shown beside it (right), graph the output of (i) the boundary chain code, (ii) the differential boundary chain code.



(c) What is the purpose of the Canny technique? Summarise the execution steps of the Canny technique by providing an algorithm.

(d) Describe how one would automatically distinguish between 2 classes of astronomical object - stars and galaxies - which populate the Hubble Deep Field image (extract shown below) in their thousands. What standard statistical measure would you use? You may assume that all stars have the shape of a Gaussian point-spread function (PSF), whereas all galaxies have a range of resolved shapes, more extended than the PSF; but note that the faintest stars and galaxies are more difficult to measure accurately because of noise.



Some useful VRML node information:

```
Shape
{
        geometry
        appearance
}

Transform
{
  children    [ ]
  translation 0.0   0.0   0.0
  rotation    0.0   0.0   1.0   0.0
  scale       1.0   1.0   1.0
  center      0.0   0.0   0.0
}

TimeSensor
{
  enabled             TRUE
  startTime           0.0
  stopTime            0.0
  cycleInterval       1.0
  loop                FALSE
  isActive            # eventOut
  time                # eventOut
  cycleTime           # eventOut
  fraction_changed    # eventOut
}

PositionInterpolator
{
  key    [  ]
  keyValue [  ]
  set_fraction    # eventIn
  value_changed   # eventOut
}

OrientationInterpolator
{
  key    [  ]
  keyValue [  ]
  set_fraction       # eventIn
  value_changed      # eventOut
}

Extrusion
{
  crossSection [ ]
  spine        [ ]
  scale        [ ]
  orientation  [ ]
  beginCap
  endCap
  creaseAngle
}
```

Co-ordinates for a circle-shaped cross section, suitable for extrusion:

```
1.00 0.00,    0.92 -0.38,
0.71 -0.71,   0.38 -0.92,
0.00 -1.00,   -0.38 -0.92,
-0.71 -0.71,  -0.92 -0.38,
-1.00 0.00,   -0.92 0.38,
-0.71 0.71,   -0.38 0.92,
0.00 1.00,    0.38 0.92,
0.71 0.71,    0.92 0.38,
1.00 0.00
```

```
Box
{
        size 2.0 2.0 2.0
}


Sphere
{
        radius                  1.0
}

Cylinder
{
        radius                  1.0
        height                  2.0
        side                    TRUE
        top                     TRUE
        bottom                  TRUE
}

Group
{
  children    [ ]

}
```