Two hours

QUESTION PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

UNIVERSITY OF MANCHESTER SCHOOL OF COMPUTER SCIENCE

Computer Graphics and Image Processing

Date: Thursday 30th May 2013

Time: 09:45 - 11:45

Please answer each of the 20 multiple-choice questions in SECTION A writing your answers directly on the question paper.

Also answer ONE Question from Section B
AND
also answer ONE Question from Section C

Use a SEPARATE answerbook for each of Section B and Section C

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text.

[PTO]

Section A is restricted and cannot be published

Section B

Answer *one* question from this Section.

Illustrate your answers with relevant and legible diagrams.

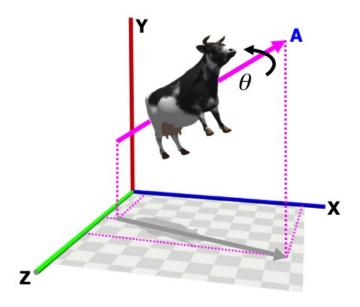
- 1. Note: You are expected to illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.
 - a) Explain the advantages of using 4×4 matrices to represent 3D coordinate transformations.

(2 marks)

b) Explain what is mean by "the duality of modelling and viewing", giving an example, with diagram, in 2D.

(2 marks)

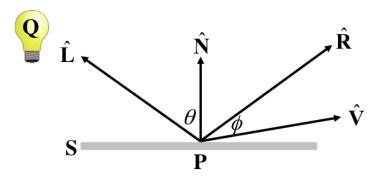
c) Referring to the figure below, describe the approach you would take, and the specific steps necessary to derive a single transformation matrix which rotates the cow by angle θ about the vector A. A does not pass through the origin, and is not embedded in any of the XY, XZ or YZ planes. For each transformation you use, you need only describe its effect. For example, you can write "matrix M_1 performs a scale by (a,b,c)", and you do not need to write down the actual values of the elements inside the matrix. (6 marks)



d) Explain what is meant by the following terms. For each of them, illustrate your answer with a clear diagram.

i)	parallel projection.	(3 marks)
ii)	perspective projection	(3 marks)
iii)	perspective division	(2 marks)
iv)	near and far clip planes	(2 marks)

- 2. Note: You are expected to illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.
 - a) What is meant by the term "scan conversion"? Illustrate your answer by describing a method to efficiently scan-convert a triangle. (4 marks)
 - b) Describe a pixel-space algorithm for removing hidden surfaces from rendered views of 3D models. (4 marks)
 - c) In what circumstances does the method you described in part (b) give incorrect results, and how can these effects be minimised? (2 marks)
 - d) The figure below represents a surface S, on which there is a point P, and the various quantities needed to compute the local illumination I at P, from a monochromatic light source Q of intensity I_Q . There is also ambient light in the scene, of intensity I_a .



Develop an expression for I, which incorporates the following features. In your answer, explain the function of the quantities on the diagram, and any other parameters, and their ranges of values, needed:

i) ambient illumination (2 marks)

ii) diffuse reflection (2 marks)

iii) specular reflection (2 marks) $I_{specular} = I_Q \times k_s \times (\hat{R} \cdot \hat{V})^N \ (1/2).$

iv) Explain how you would apply the local illumination model to a triangle mesh, such that it is smoothly shaded, and correctly takes into account specular reflection. Illustrate your answer with a diagram.

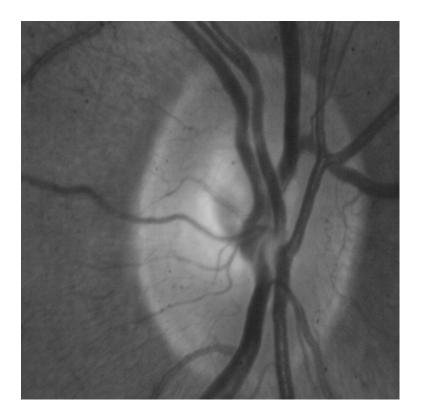
(4 marks)

Section C

Answer *one* question from this Section.

- 3. a) A greyscale image can be converted to a binary (two level) image by thresholding.

 Define the operation of thresholding. (2 marks)
 - b) The single variable involved in this operation is the threshold. Give three methods of calculating a value for the threshold from the image data. (6 marks)
 - c) What problems arise with this operation if the average brightness of the image varies across the image? How could these be corrected? (4 marks)
 - d) Below is an image of part of the retina called the optic disk.



Identifying the outline is important in diagnosing certain illnesses. Describe an algorithm that is able to identify the outline of the optic disk automatically, bearing in mind that the retina is not illuminated uniformly. You should consider the following in your answer:

(8 marks)

i) If you choose to use thresholding to identify the optic disk, how will you compute a sensible threshold value or values that is/are satisfactory for the whole image?

- ii) Once thresholding has been achieved, do you anticipate having a perfectly segmented image? If not, what operation(s) will you use to improve the result?
- iii) How will you go about convincing doctors that your method is as good or better that existing methods?

- 4. a) Give a brief account of how and why colour image data can be represented using three primitive colours, for example the CIE colour scheme. Why is this thought to be sufficient for most purposes? (4 marks)
 - b) Perceptually uniform colour spaces are often used when processing colour data. Using a suitable perceptual colour space, explain: (6 marks)
 - i) What is a perceptual colour space?
 - ii) How is colour represented in a perceptual colour space?
 - iii) What are perceptual colour spaces believed to give superior results compared to, for example, a CIE scheme?
 - c) It is believed that the number of car crashes could be reduced if a system could be developed to activate a car's brakes in response to the brake lights of the car in front, if the system responded more quickly than the driver. Design an algorithm that will:

 (10 marks)
 - i) Indicate that any of the brake lights of the car in front have lit.
 - ii) Respond if some of these brake lights have not worked, that is one or two of the lights have failed.
 - iii) Make an estimate of the distance to the car in front.