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: Tuesday 31st May 2011

Time: 09:45 - 11:45

The Paper is in THREE Sections

Section A is Compulsory
Section A must be answered on the Question Paper
Only answers written in the boxes on the Question Paper will be marked.

You should also answer ONE question from Section B
and ONE question from Section C

Use a SEPARATE answerbook for each of Section B and Section C
Each Section is worth 20 marks

For full marks your answers should be concise as well as accurate.
Marks will be awarded for reasoning and method as well as being correct.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

Section A

Section A is a multiple choice section and is therefore restricted

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) What are the properties of a triangle that make it especially useful for creating 3D polygonal models? (2 marks)

   b) Describe, with a sketch, two mechanisms provided by OpenGL for efficiently specifying collections of linked triangles. (4 marks)

   c) What information does the surface normal give about a polygon? Give a practical example of the use of the polygon normal. (2 marks)

   d) Given a planar polygon with vertices A, B, C and D, describe how to compute the surface normal vector. (4 marks)

   e) You are part of a team designing an interactive polygonal modelling program. The program will allow an artist to interactively create arbitarily complex polygonal models from triangles. It will be possible to edit the model, to change vertices, change edges, add and delete triangles, and also attach names to different collections of triangles in the model. Suggest suitable data structures for storing the necessary information. Answer the following:

      i) What essential kinds of data do you need to manage? (2 marks)

      ii) A diagram showing the conceptual way the data structures fit together. (2 marks)

      iii) How you would code the data structures as C structs? (You will not be penalised for syntactic C errors). (4 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 do you understand by the terms "modelling" and "rendering"? Why is it useful to distinguish between these two activities? (2 marks)

   b) Consider the following statement, and answer the questions which follow it:

   "In the early days of computer graphics, the Hidden Surface Removal problem was the subject of much research, and robust solutions were difficult to achieve. In later years, a technique was developed which is now used in almost all applications".

      i) What is the fundamental difference between the early approaches and the modern approach? (2 marks)

      ii) Describe the modern approach to solving the Hidden Surface Removal Problem. (4 marks)

      iii) Discuss whether the modern approach gives perfect results in all situations, or not. (2 marks)

   c) Explain what is meant by each of the following terms, and give a mathematical expression for each, which will allow numerical values to be calculated. Be sure to clearly define any terms and vectors you use. Illustrate all your answers with clear and helpful diagrams.

      i) Diffuse reflection. (5 marks)

      ii) Specular reflection (5 marks)

Section C

Answer *one* question from this Section.

3. An upper-case letter 'H' has been scanned as the image shown below. White pixels have been recorded as 0s and black ones as 1s.

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0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0
0 0 0 1 1 1 0 0 0 0 1 1 0 1 0 0
0 0 0 1 1 1 0 0 0 0 1 1 1 1 0 0
0 0 1 1 1 1 0 0 0 0 1 0 1 1 0 0
0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 1 1 1 1 0 0 0 0 1 1 0 0 0 0
0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0
0 0 0 1 1 1 0 0 0 0 1 1 1 1 0 0
0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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a) Assuming that the letter, before it was scanned, was a perfect 'H' shape, how do you account for the observation that the letter does not look like the perfect 'H'? (2 marks)

b) What image processing operation(s) could you use to improve the appearance of the letter (i.e. to make it look more like the ideal 'H')? (5 marks)

c) If this processing has been performed, what technique(s) could be used to recognise that this is an image of the letter 'H'? Describe the techniques and discuss their advantages and disadvantages. (5 marks)

d) What factors do you think will affect the accuracy with which we can recognise letters using this algorithm? (4 marks)

e) It is possible to recognise characters using alternative information derived from the image. Would it be more reliable? (4 marks)

4. You have been contracted to build a computer vision system to check plastic moulded toys as they come off a production line. Two things must be checked: the toy is the correct shape with no extra or missing parts, and the design has been printed in the correct location with no smearing, warping or error in orientation.

   Your system will have components that control how the toys are handled, that is, how they are presented to the camera and how ones that pass or fail the inspection are sorted. These are not your responsibility.

   a) Outline possible solutions to the following:

      i) How the toys are to be illuminated (2 marks)
      ii) How many cameras are required to capture images of the toy? (2 marks)
      iii) How you will trigger the camera or cameras to capture data. (2 marks)
      iv) How you will compare the shape of the toy to the required shape. (2 marks)
      v) How you will decide that the printed design is correct. (2 marks)

   b) Outline image processing algorithms that will achieve the inspection of the toys'

      i) shapes (4 marks)
      ii) design (4 marks)

   c) How can you design the architecture of the software for parts (a) and (b) above, to make it flexible, i.e. easily updated to inspect a different type of toy? (2 marks)

END OF EXAMINATION