Two hours

EXAM PAPER MUST NOT BE REMOVED FROM
THE EXAM ROOM AND MUST BE RETURNED

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Graphics and Image Processing

Date: Wednesday 25th May 2016
Time: 09:45 - 11:45

Answer ALL Questions from Section A
Write your answers directly on the exam paper.
Only answers written in the boxes on the exam paper will be marked.

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
Section A contains Multiple Choice Questions and is therefore restricted
Section B

Answer one question from Section B.

1. **Note:** Illustrate all your answers with clearly-drawn diagrams and sketches.

   a) Consider this statement: “Synthetic images created using computer graphics techniques are always approximations”. Explain if you think this statement is true or not, and justify your explanation with examples. (3 marks)

   b) Explain, using suitable illustrated examples to accompany your answers, what is meant by the following:
      
      i. polygon normal vector (2 marks)
      ii. polygon soup (2 marks)
      iii. hierarchically structured objects (3 marks)
      iv. mesh data structure (4 marks)

   c) Explain the difference between object-space and image-space hidden-surface removal, and describe (with illustrations) a technique for implementing the latter. (4 marks)

   d) Your task is to create a 3D model of Kilburn Lecture Theatre 1.1 that will support an interactive walk-through. Suggest how you might go about collecting the data you need. (2 marks)
2. Note: Illustrate all your answers with clearly-drawn diagrams and sketches.

a) A sealed lightproof box contains a single partially shiny surface $S$, illuminated by a single monochromatic light source of intensity $I$. $I$ is located at a distance $D$ from the surface. In this context, explain what is meant by each of the following terms and for each derive a mathematical expression that enables its computation. Include definitions of all terms and their numerical ranges, and illustrate your answers with diagrams:

i) the light diffusely reflected from $S$ (4 marks)

ii) the light specularly reflected from $S$ (6 marks)

b) How would you modify your expressions if the light source $I$ was replaced by a coloured light source $C$? (2 marks)

c) You now have a triangular mesh $M$ made of the same material as $S$. $M$ is illuminated by $C$. Explain how to apply the expressions you derived above such that the resulting render looks smooth and has the correct shiny appearance. Illustrate your answer with a diagram. (4 marks)

d) You would like $M$ to appear to have an irregular, bumpy surface. Describe an image-based technique which could be applied during rendering to achieve this. (4 marks)
Section C

Answer ONE of the two questions.

3. a) Define an edge in the context of image processing. (2 marks)

b) Why are edges important in image processing systems? (2 marks)

c) Explain what is meant by the term scale in detecting edges. (2 marks)

d) Describe an algorithm that can be used to detect edges that takes their scale into account. (4 marks)

e) Design an algorithm that will detect box-like objects and uses edge detection. (8 marks)

f) Give an account of the effect of image noise on edge detection. (2 marks)

4. You have been contracted to devise a computer vision system to aid car drivers. It has three functions:

- to recognise lane boundaries and give a warning when the car drifts over them,
- to estimate the distance to the car in front and give a warning when this is too short,
- to recognise speed limit signs.

a) Outline the factors you will have to consider when deciding where to place the camera or cameras you will use, the number of pixels in the image or images you will capture and the field(s) of view of the cameras so that you can capture images with sufficient detail to solve these problems. (6 marks)

b) What features in the image(s) will you identify to solve the problem? Describe the image processing algorithms you would use to process the data and how you would use these results to recognise that a warning should be issued. (12 marks)

c) Discuss how bad weather and poor lighting will affect your solutions. (2 marks)