Write Student ID Number Here:

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: Monday 7th June 2010  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.

Answer EACH SECTION in a new book.
Each Section is worth 20 marks

The use of electronic calculators is not permitted.

All question papers to be returned
SECTION A

Multiple choice section, not published.

All question papers to be returned
SECTION B

Answer ONE question from this section.

B1. Answer ALL parts

a) Explain the concept of an edge as it is used in image processing. Ensure that you define all the terms you use. (4 marks)

b) Use this definition to derive

i) a simple edge detecting algorithm using the Sobel kernel,

ii) a more sophisticated operator that incorporates the Gaussian kernel. (8 marks)

c) Use the following diagram to illustrate (the diagram is reproduced on a separate sheet to be attached to your answer book – see appendix at the end of examination):

i) where you think the simple edge detector will find edges,

ii) where you think the sophisticated edge detector will find edges.

iii) Why are these results different? (4 marks)

[PTO]
B2. Answer ALL parts

You have been contracted to specify and design an image processing system that will run on a mobile phone, will recognise emergency exit signs and will output an audible signal when one is recognised: three tones are required to indicate the direction of the arrow in the sign.

Signs are produced in a standard format. They have white text and symbols on a green background. The text, which is optional, is the word “exit” only, nothing else is used. The symbols, which are of a standard size, comprise:

- A man running to the left or right,
- An arrow pointing left or right towards the exit,
- The exit – symbolised by an opening.

For example:

![Image of an emergency exit sign]

Once an image is captured, the solution to the problem can be divided into two stages:

1. Identify whether there is a sign in the field of view
2. Identify the symbols present in the sign and sound the appropriate tone.

a) Identify the factors that

i) simplify and  
ii) complicate this problem (4 marks)

b) By making use of the factors you have identified in part a) i), describe how you would identify the presence of a sign in an image. (8 marks)

c) Describe how you would identify the three or four components in the sign. (7 marks)

d) Discuss the factors you should consider when setting a limit on how quickly the system should respond. (2 marks)
SECTION C

Answer ONE question from this section.

C1. Answer ALL parts

Note: You are expected to illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.

a) Explain what is meant by scan conversion and why it is necessary.
(2 marks)

b) Describe a method for solving the “hidden-surface problem” which can be integrated with polygon scan conversion. Give a worked example of the method.
(4 marks)

c) Under what circumstances does the method you described in part (b) give undesirable results? Suggest an approach for solving the problem.
(2 marks)

d) You have been commissioned by the British Museum to design a system for creating 3D models of their priceless objects. You have access to a laser scanner which enables you to easily collect large collections of triangles. Your system will enable an operator to take the triangle sets from the scanner, and interactively edit, transform, group and render them, in real time.

Propose a conceptual design for your system – at the level of data structures, algorithms, and flows of information. Your proposal should discuss at least the following issues, and should be illustrated with helpful diagrams:

i) creating structured collections of polygons
ii) being able to attach names to parts of models
iii) reading and writing your model to/from files
iv) maintaining interactive frame rates
v) transforming and viewing the models
vi) being able to manipulate vertices, edges and faces of polygons
(12 marks)
C2. Answer ALL parts

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 terms “local” and “global”, when applied to illumination models? (2 marks)

b) Derive a local illumination model which can determine pixel colours which take into account the following factors. Ensure that you define all the terms you use, and give their ranges of values.

i) Ambient illumination

ii) A single positional light source at a finite distance

iii) Diffuse reflection

iv) Specular reflection (8 marks)

c) Explain how you might take the method you described in (b) and apply it to a mesh of triangles, such that the mesh would be smoothly shaded to mimic the appearance of a solid illuminated object. (4 marks)

d) Explain the principles of (u,v) texture mapping. In your answer, address the following issues

i) Mismatch between texel and pixel sizes

ii) Seam discontinuities

iii) Blending (6 marks)
Appendix for question B1 follows.

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Appendix – question B1.

END OF EXAMINATION

All question papers to be returned