<u>Two hours</u>

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 3rd June 2015

Time: 14:00 - 16:00

**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

[PTO]

COMP27112

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) What is meant by "polygon soup" and why is it usually undesirable?   (2 marks)

   b) Suggest a suitable data structure for efficiently representing a complex triangle mesh, which will permit queries to be made on it such as identifying faces and edges. Illustrate your answer with diagrams of a sample piece of mesh and your suggested data structure.   (6 marks)

   c) Suggest the features of a suitable textual file format for writing out and reading in your data structure.   (2 marks)

   d) Explain what is meant by scan conversion and illustrate your answer by outlining a method for scan converting a triangle. Illustrate your answer with a diagram.
                                                                                  (4 marks)

   e) Explain how a technique for solving the hidden surface problem can be integrated with scan conversion. Illustrate your answer with a simple example involving two overlapping triangles.   (4 marks)

   f) What unwanted effects on the visual result can arise from numerical instabilities in scan conversion/hidden surface elimination, and how can they be solved?
                                                                                  (2 marks)

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

   a) What is the fundamental difference between local and global illumination models?
   (2 marks)

   b) Derive an mathematical expression which enables the computation of the colour of light reflected from a point on a surface which is illuminated by a coloured point light source. Your answer should include definitions of all terms and their numerical ranges, and cover the following:

      i) ambient illumination (2 marks)
      ii) diffuse effects (2 marks)
      iii) specular effects (2 marks)
      iv) treatment of coloured lights and coloured surfaces (2 marks)
      v) a supporting diagram (2 marks)

   c) Explain how intensity interpolation can be used to apply the expression you derived above in part (b) across a mesh of triangles. Illustrate your answer with a diagram.
   (4 marks)

   d) What is the major disadvantage of intensity interpolation and how can it be overcome?
   (4 marks)

Section C

Answer *one* question from Section C.

3. a) Describe the connected component labelling algorithm.   (4 marks)

   b) What property of a pixel is suitable for use in determining pixels' similarities in this algorithm? How is it realised for

      i) greyscale images
      ii) colour images

      Write the equations you would use.   (2 marks)

   c) Once you have found the connected components of an image, describe two algorithms you can use to derive a numerical description of them.
                    (8 marks)

   d) Assume you take this approach in designing a system to recognise a small number of hand gestures, such as pointing. How will you

      i) train the system?
      ii) evaluate its accuracy?   (6 marks)

4. You have been asked to design a machine vision system that will control a robotic arm that is equipped to write messages on the top of celebration cakes. Assume another colleague is responsible for the hardware that places a cake in a suitable position for your analysis to occur.

   Once a suitable image has been captured, the system must:

   • Identify the region of the image corresponding to the top surface of the cake.

   • Identify any decoration on the cake that should not be written over.

   • Estimate the dimensions of the region that can be written on.

   • Plan the layout of the text, this is, define the region of the cake that will be written on.

   • Convert the image co-ordinates of this region into world co-ordinates to be used by the drawing robot.

   a) Describe briefly the arrangement of camera and illumination you will require to allow good quality images to be captured. What principles do you apply in deciding on this arrangement?   (4 marks)

Name and describe the image processing operations will you use to identify the edge of the cake. Take care that your algorithm is robust against poor quality illumination and an ill-defined cake edge.

(6 marks)

Name and describe the operations to be performed to identify any decoration on the cake. (6 marks)

Describe the operations you will use to define the layout of the text. The output of this operation should be a data structure that describes the writable area.

(2 marks)

So far, you have been processing image data. Locations are specified in image co-ordinates. What information do you need to convert these co-ordinates into data suitable for controlling the robot? How will you do this conversion? (2 marks)