Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Computer Graphics

Date:      Tuesday 17th January 2012
Time:     14:00 - 16:00

Please answer any THREE questions from the FOUR questions provided.
Use a SEPARATE answer book for each SECTION.

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 permitted provided they are
not programmable and do not store text.
Section A

1. Illustrate your answers with diagrams and sketches throughout.

To celebrate the 2012 centenary of Alan Turing’s birth, the University has commissioned an artist to design and build a large statue of Turing – over 50m tall – which will stand outside the Kilburn Building. You have been commissioned to create an interactive computer graphics model of the scene, which will be used for evaluating the impact of the sculpture on the environment, and planning its construction. You been provided with the following:

- a 1m tall clay scale-model of the statue
- a laser scanner
- a polygonal model of the Kilburn Building and the surrounding area

a) Describe the fundamental geometrical principles of laser scanning (4 marks)

b) In order to capture the full geometry of the statue, you will take several scans from different viewpoints. Explain what techniques you would use to

   i) Register the sets of polygons obtained from the different scans, in order to obtain a single coherent model (3 marks)
   ii) Fill any holes which result from missing scan data (3 marks)

c) Your interactive system needs to run smoothly in real-time. Discuss the issues of rendering very large numbers of polygons in real time, and approaches for maintaining a real-time frame-rate. (3 marks)

d) You will use the Stanford ScanView system for disseminating your model to clients. Explain how this system works from a technical point of view. (5 marks)

e) Comment on the practical advantages and disadvantages of using ScanView (2 marks)
2. *Illustrate your answers with diagrams and sketches throughout.*

a) Explain what is meant by the concept of the “pinhole camera”, and sketch its basic geometry. Why is this a useful concept? (4 marks)

b) Describe what is meant by each of the following.

   i) intrinsic camera parameters (2 marks)
   ii) camera calibration matrix (2 marks)
   iii) extrinsic camera parameters (2 marks)
   iv) calibrating an image (2 marks)

c) Given a video of a walkthrough of a scene, shot in an unbroken sequence by a single camera, explain the principles of a technique for analysing the video in order to calibrate it. (4 marks)

d) Once the video is calibrated, what techniques might you use for determining the 3D geometry of the scene, in order to reconstruct it as a 3D computer graphics model using OpenGL? (4 marks)
3. You are involved in the design of a new three-dimensional game, in which the player controls a space-craft as it travels though a series of large caverns, interconnected by narrow tunnels. The caverns are inhabited by various alien creatures, which attempt to destroy the player's ship, and also contain weapons and treasures that the player can collect.

a) Explain, in the context of such a game, the meaning and purpose of 'spatial enumeration'.

(2 marks)

b) Explain the following spatial enumeration techniques. For each one, describe its applicability (or otherwise) to this game, and comment on the space and time complexity of each. Illustrate each answer with a clear diagram.

   i) Gridcell (4 marks)
   ii) Hierarchical Bounding Volume (4 marks)
   iii) Polygon aligned BSP Tree (4 marks)

(c) The team involved in designing the game are debating whether to use Ray Tracing or Radiosity techniques to get high-quality results. Briefly describe the principles underlying each technique, and discuss how the technique could be applied in the context of this real-time game. (6 marks)
4. a) What is Volume Rendering? Give two distinct examples of its use  

b) Describe, using clear diagrams, the process of Direct Volume Rendering, referring to the following aspects:

   i) a suitable data structure for holding the source data  
   ii) the classification of voxels according to the source data  
   iii) calculating the composite value of a pixel  
   iv) illuminating the model

   (2 marks) 
   (2 marks) 
   (4 marks) 
   (4 marks)

c) Briefly describe a technique for Indirect Volume Rendering. Compare and contrast this technique with Direct Volume rendering, paying attention to the fidelity of the two techniques. Describe situations where the use of each technique would be appropriate. 

   (6 marks)