Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Computer Graphics

Date: Tuesday 21st January 2014
Time: 14:00 - 16:00

Please answer any TWO Questions from the FOUR Questions provided.

Use a SEPARATE answer book for each SECTION.

This is a CLOSED book examination
The use of electronic calculators is NOT permitted
Section A

1. Illustrate your answers with diagrams and sketches throughout.

a) Describe the workflow of a 3D laser scanning project, and in your answer address the following issues:

   i) the geometry of the laser/camera system (4 marks)
   ii) why are multiple scans of a single object usually taken and how are they combined into a single representation? (3 marks)
   iii) what is Delaunay triangulation, and how is it used in processing point clouds? Illustrate your answer using some sample data of your own choosing. (5 marks)
   iv) describe a technique for filling holes in meshes (2 marks)

b) Describe a technique for simplifying polygonal meshes based on collapsing edges. (2 marks)

c) How can meshes with different levels of complexity be used in the real-time rendering process? (2 marks)

d) Describe an approach for providing local high-definition renders of remote secure laser-scanned datasets. (2 marks)
2. *Illustrate your answers with diagrams and sketches throughout.*

You have been commissioned to create an interactive 3D model of the University campus. The model will be used in two ways: first, ordinary users will be able to navigate the model in real-time, to ‘walk around’ the campus; second, privileged users will be able to interactively edit all features of the model, in order to continually improve and update it, as the campus changes.

You have a tight deadline for completion of the model, therefore it is essential that you use efficient modelling processes.

a) Explain how you would use video to capture the geometry of buildings on the campus. Your answer should discuss the following:

i) extrinsic camera parameters (2 marks)
ii) intrinsic camera parameters (2 marks)
iii) lens distortion (2 marks)
iv) camera and image calibration (4 marks)
v) feature detection and tracking (6 marks)

b) Describe a technique appropriate for modelling and rendering the trees on campus. (2 marks)

c) The overall model will be large. What issues need to be considered to allow walkthroughs at interactive frame rates? (2 marks)
3. a) Describe the process of Ray Tracing a scene that contains the following objects: a sphere made of a green matt material; a red transparent cylinder; a copper-tinted mirror; and a wooden table. The scene is lit only by a single spotlight, which emits a pure white light in the direction of the objects. In your description, explain the role of primary rays, secondary rays and shadow feelers, and describe how the various rays interact with each of the different objects in the scene. (7 marks)

b) In what way is Ray Tracing an embarrassingly parallel problem? Explain how this property can be used to accelerate the generation of ray-traced scenes, and describe one other approach to accelerating ray tracing. (3 marks)

c) Starting with a polygonal mesh, and ending with a set of suitably coloured polygons that could be rendered in OpenGL, describe the basic process of generating a radiosity solution for a model of a typical lecture theatre. (6 marks)

d) You have been asked to choose between Ray Tracing and Radiosity approaches to generating a 3D real-time interactive walkthrough of a new restaurant. The restaurant’s décor includes soft furnishings (curtains, upholstered sofas and chairs etc), real oak tables and soft lighting. The restaurant’s owners would like the tables to be populated with glassware, crockery and cutlery. Describe the pros and cons of these two approaches for this scenario, and suggest a compromise that would suit the client’s needs. (4 marks)
4. a) What is meant by Volume Rendering? Explain how its purpose differs from other rendering techniques, and give two distinct examples of its use. (4 marks)

b) Explain the process of Direct Volume Rendering using a suitable example. (4 marks)

c) Why might methods of indirect volume rendering be considered inappropriate for detecting medial issues such as the presence of a tumour? (2 marks)

d) Describe two distinct methods of Spatial Enumeration. In each case, describe the method and illustrate (with a diagram) a suitable data structure. Compare the pros and cons of each technique with respect to its initialisation and its response to changes in the position of objects, and explain how each technique could be used to answer the question ‘which object in the 3D space intersects with a given point (x,y,z)?’ (10 marks)