Advanced Computer Graphics

Date: Friday 21st January 2011
Time: 09:45 - 11:45

Please answer TWO questions in total – answering ONE question from each section.

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 all your answers with clear diagrams and sketches.**
   
   a) Describe the trigonometrical principles of 2D laser scanning, illustrating your answer with an example. (5 marks)
   
   b) You have access to a commercial laser scanner which produces unstructured 3D range data – a set of points in 3D space. Your task is to design and implement a software system that takes multiple sets of this data as input, and produces as output one or more sets of triangle meshes. Describe how you would design and implement your system, and in your answer define and address the following issues, suggesting specific techniques where appropriate:

   i. System design and flow of data (3 marks)
   ii. Alignment (2 marks)
   iii. Delaunay triangulation (4 marks)
   iv. Occlusions and hole-filling (4 marks)
   v. Incorporating semantic structure into the meshes (2 marks)

2. **Illustrate all your answers with clear diagrams and sketches.**
   
   a) “We can model anything with polygons”. Discuss this statement. (2 marks)
   
   b) You have been commissioned to create a 3D computer model of the Kilburn building (the exterior only). You have been provided with video film of the building, shot from several different angles. Describe a technique for approximately extracting the 3D geometry from the video. (5 marks)
   
   c) You now wish to create realistic models of the trees at the front of the Kilburn building. Describe an algorithm for “growing” the shape of a tree, and rendering it. Illustrate your answer with diagrams showing the progression of the algorithm as it is executed. (4 marks)
   
   d) To make your Kilburn model appear realistic, you must incorporate rain. Suggest techniques for modelling and rendering rain, in real-time. (3 marks)
   
   e) How would you extend your rain simulation to include the following effects:

   i. Effects of wind (2 marks)
   ii. Impact on building (2 marks)
   iii. Formation of puddles and flows (2 marks)
Section B

3. **Illustrate all your answers with clear diagrams and sketches.**
   
a) Describe the process of ray tracing a scene that contains the following objects: a cube made of a matt blue material; a clear, colourless glass sphere; a copper-tinted mirror; a spotlight generating white light, and a marble statue. In your description, explain the role of primary rays, secondary rays and shadow feelers. (5 marks)

b) What is meant by the statement that ‘Raytracing is an embarrassingly parallel problem’? Describe three other mechanisms by which the performance of a raytracer can be improved. (4 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. (4 marks)

d) Describe one technique that could be used to accelerate the solving of a radiosity problem, and one technique that could be used to improve the rendering performance (4 marks)

e) Compare and contrast the outputs generated by a raytracer and a radiosity solver (3 marks)

4. **Illustrate all your answers with clear diagrams and sketches.**

a) What is the purpose of volume rendering? Explain the process of Direct Volume Rendering an image based on data from an MR scan of a human hand. Describe in your answer a suitable data structure for holding the MR data, a technique for assigning colour and opacity to the data points, and a mechanism for compositing the final pixel colour as rendered in the image. (5 marks)

b) Describe a process for indirect volume rendering. What are its pros and cons with respect to Direct Volume Rendering? (5 marks)

c) What is meant by ‘Spatial Enumeration’? Include in your answer a concrete and practical example of its use. (2 marks)

d) Describe four distinct methods of spatial enumeration. Explain in each case their pros and cons, and state their space and time complexity. (8 marks)

END OF EXAMINATION

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