Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Computer Graphics

Date: Monday 12th January 2015
Time: 09:45 - 11:45

Please answer ONE Question from Section A
and ONE Question from Section B

Use a SEPARATE answer book for each SECTION.

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

[PTO]
1. *Illustrate your answers with diagrams and sketches throughout.*

   a) What are the limitations of using polygons to model entities in the real world? (2 marks)

   b) Describe, with illustrated examples, a technique suitable for creating a geometrical model of a tree. In your answer explain how your technique would include the following features:

      i) the overall shape of the tree (4 marks)
      ii) the density of the branches (2 marks)
      iii) the distinction between branches and leaves (2 marks)

   c) Suggest suitable techniques for rendering realistic-looking images of your tree model, including differentiating branches and leaves. (4 marks)

   d) Your tree will be placed in a mountainous landscape. It is raining and there is lightning. Suggest suitable techniques for modelling and rendering:

      i) the mountainous landscape (2 marks)
      ii) the rain (animated) (2 marks)
      iii) the lightning (animated) (2 marks)
2. *Illustrate your answers with diagrams and sketches throughout.*

a) What are the benefits of methods which enable geometrical models of the real world to be extracted semi-automatically from images/videos? (2 marks)

b) What is meant by the following characteristics of a camera?
   
   i) extrinsic parameters (2 marks)
   ii) intrinsic parameters (2 marks)
   iii) lens distortion (2 marks)

c) Explain the principle of calibrating a camera using each of the following methods:
   
   i) a single static image, and why this is not always possible (2 marks)
   ii) a pair of static images, and what conditions must be met (2 marks)
   iii) a video sequence (5 marks)

d) Compare and contrast the extraction of geometry from images/video with the use of laser scanning. (3 marks)
3. a) With reference to the Rendering Equation:

\[ L_o(x, \omega, \lambda, t) = L_e(x, \omega, \lambda, t) + \int_{\Omega} f_r(x, \omega', \omega, \lambda, t) L_i(x, \omega', \lambda, t) (-\omega' \cdot n) \delta \omega' \]

Define each of the following components in sufficient detail to explain how the equation underpins computational approaches to photorealistic rendering.

i. \( \lambda \)

ii. \( t \)

iii. \( L_o(x, \omega, \lambda, t) \)

iv. \( L_e(x, \omega, \lambda, t) \)

v. \( \int_{\Omega} f_r(x, \omega', \omega, \lambda, t) L_i(x, \omega', \lambda, t) (-\omega' \cdot n) \delta \omega' \)

vi. \( f_r(x, \omega', \omega, \lambda, t) \)

vii. \( L_i(x, \omega', \lambda, t) \)

viii. \( -\omega' \cdot n \)

[1 mark for each component]

b) Briefly describe each of the following rendering techniques, explaining their strengths and weaknesses. For each technique, comment on the extent to which it approximates solving the rendering equation.

- Ray Tracing
- Radiosity
- Volume Rendering

[4 marks each]
4. Describe, using clear diagrams, the following spatial enumeration structures in the context of developing an architectural walkthrough of a building. Discuss the pros and cons of each approach and comment on their space and time complexity. In each case, explain how the data structure can be used to identify an object selected by clicking a mouse pointer on the 2D viewplane, and explain how the structures are affected when objects in the environment they represent move or change shape.

- Gridcell
- Octree
- Hierarchical Bounding Volume
- Axis aligned BSP tree

[5 marks each]