advanced computer graphics

friday 25th january 2008

time: 14:00 – 16:00

please answer three questions from the five questions provided - at least one question from each section

use a separate answer book for each section

the use of electronic calculators is not permitted.
Section A

Please answer at least one Question from each Section

1. Illustrate your answers with diagrams and sketches where appropriate.
   a) Discuss the problems of maintaining real-time performance when dealing with extremely complex polygonal models, addressing in your answer two different methods for facilitating real-time frame rates. (6 marks)
   b) Describe the principles of operation of a laser scanner, and state your opinions on its advantages and disadvantages. (4 marks)
   c) You are leading a small team to use laser scanning equipment to create digital models of some of the sculptures in the open-air Yorkshire Sculpture Park, an example of which is shown here:

You are required to create models capable of realistic rendering which:
   • are as accurate as possible to the source material
   • are as free as possible from geometric errors and inconsistencies
   • can be made digitally available to the general public in a secure way that keeps the full data set private

Describe how you would manage the project, and what techniques you would use in order to address these requirements. (10 marks)
2. **Illustrate your answers with diagrams and sketches where appropriate.**
   
   a) You have been commissioned by the famous (but fictitious) Japanese multimedia artist Hanabi Hoshiko to write a computer graphics system to help her create computer-generated real-time animations of traditional Japanese firework displays.

   You have decided to use methods based on particle systems. Write an email to her, explaining why you have chosen this method, bearing in mind that she has no previous knowledge of computer graphics, so is unlikely to understand any technical terms you might wish to use. (5 marks)

   b) Describe (in technical detail, this time) how your system will work, addressing the following issues in your answer:
      - firework trajectories, colours, and lifetimes
      - fireworks which, once launched, emit other fireworks
      - what user interface you will provide for the artist to use your system
      - suitable data structures for your implementation
      - issues to consider in order to ensure real-time performance (10 marks)

   c) As well as fireworks, Hanabi-san has subsequently decided she also wants to see the firework simulations set against mountain landscapes, again rendered using computer graphics. What approach would you take to modelling and rendering mountainous terrain? As part of your answer, discuss the ideas of “Hausdorff dimension” and “self-similarity”. (5 marks)

3. **Illustrate your answers with diagrams and sketches where appropriate.**
   
   a) Why is the acquisition of geometrical models from images and video sequences an important research area? (3 marks)

   b) What is meant by the following terms?
      - Intrinsic parameters of a camera
      - Extrinsic parameters of a camera
      - Camera calibration (6 marks)

   c) Why is it a hard problem for computers to automatically recognise “interesting” features in an image, such as “edges” or “corners”? As part of your answer, explain the principles of the Canny edge detection algorithm using an illustrated example. (5 marks)

   d) Explain how the identification of “features” in a video sequence can be used to calibrate the sequence, and how this information can be used to realistically augment the scene with synthetic objects. (6 marks)
Section B

Please answer at least one Question from each Section

4. a) Explain how light interacts with surfaces, paying particular attention to how, in computer graphics, effects such as the following can be modelled:

i) Diffuse materials.
ii) Shiny surfaces.
iii) Rough surfaces.
iv) Surfaces with coloured patterns (such as printed wallpaper).
v) Translucent and transparent surfaces.

Use diagrams to illustrate your answer where appropriate. (2 marks each)

b) Describe two alternative approaches to implementing these effects. Compare and contrast the approaches, paying particular attention to any assumptions they make and how these affect their facility to reproduce the effects. Is one approach better than the other and, if so, why? (10 marks)

5. a) Compare and contrast classical ray tracing and Monte Carlo ray tracing. Describe each of them in sufficient detail to give a clear explanation of their differences, strengths and weaknesses. Use diagrams to illustrate your discussion. (5 marks each)

b) Imagine that you are given the task of producing high-quality computer-generated images for an exciting new building. The building includes a large tinted-glass atrium with natural daylight, textured walls, marble floors, chrome fittings, and some carpeted areas. There is a fishpond in the centre of the atrium. The architects will provide you with a detailed geometric model of the building, details of the materials, and specifications of light fittings. Your images need to show the building both during the day (with natural lighting) and at night (artificial lighting).

What method would you choose to perform the rendering, and why? Describe the effects that would need to be modelled and explain how your chosen method would deal with these. (10 marks)

END OF EXAMINATION