UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE FOUR

VISUALISATION

Thursday 26 April 2001

09:30 to 11:00

Examiners:

Prof. K. Turner (External)

Prof. G. Plotkin (Chairman)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) A ray is cast through a regular 3D structured grid of semi-transparent cells towards the viewer. A cell i emits X_i units of light and has an opacity of α_i to light passing through the cell. There are L cells along the ray path. Outline an algorithm for determining the viewed brightness of the ray. [*5 marks*]

   (b) For certain applications front to back ray casting has an advantage. What is this advantage and what cost does this incur? [*2 marks*]

   (c) What is the practical advantage of all the cells emitting the same quantity of light? [*2 marks*]

   (d) Volume rendering can be used to display an iso-surface of constant scalar value within a volume. What transfer function is required to produce such an image? Compare the merits of this technique with the *marching cubes* algorithm in terms of accuracy, visual fidelity and computational requirements. [*8 marks*]

   (e) How might volume rendering techniques be used to visualise a vector field? [*8 marks*]

2. (a) Within the context of visualisation, data are thought of as having structure and value. Using examples, state the meaning of these two terms. Why is data topology important to the choice of visualisation algorithm? [*5 marks*]

   (b) For the following list of users and problems, state how visualisation may help to address the problem and state the desirable characteristics of a visualisation algorithm for the problem.

   - A surgeon needing to locate the position of a brain tumour from 3D Computed Tomography scan data.
   - An aerodynamic engineer wanting to understand the position and behaviour of vortices over an aircraft wing from an aerodynamic simulation.
   - A police officer looking for a fraudster in bank transaction records.
   - A consumer scientist wanting to understand patterns of consumer behaviour.

   Give an example of an appropriate visualisation method for each of the above. [*12 marks*]

   (c) Visualising multi-attribute data is a common problem in visualisation. Give two strategies for visualising multi-attribute data in the following applications:

   - Customer records in a client database containing information about company age, credit limit, account balance, account duration and number of employees.
   - A 3D regular grid of values of temperature, pressure and velocity magnitude in a gas.

   Briefly compare your chosen methods. [*8 marks*]

3. (a) What advantages does the line integral convolution (LIC) algorithm have over glyph plotting or streamline techniques for visualisation applications? Does the technique have any disadvantages? *[4 marks]*

(b) The following equation describes the LIC algorithm. Describe the operation of the algorithm stating the meaning of each term. What does $P(0)$ represent? *[11 marks]*

$$F'(p) = \frac{\int_{-L}^{L} F(P(s))k(s)ds}{\int_{-L}^{L} k(s)ds}$$

(c) Why is the denominator necessary? *[2 marks]*

(d) How is it possible to reduce the computational cost of evaluating this equation? *[8 marks]*