UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

M.Sc./DIPLOMA IN ARTIFICIAL INTELLIGENCE
M.Sc./DIPLOMA IN COGNITIVE SCIENCE
M.Sc./DIPLOMA IN COMPUTER SCIENCE
M.Sc./DIPLOMA IN INFORMATICS

VISUALISATION

Wednesday 24 April 2002

09:30 to 11:00

Examiners:
N. Chater (External)
N. Jennings (External)
E. Hancock (External)
K. Hawick (External)
R.N. Ibbett (Convener)
J. Oberlander (Co-Convener)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) A brain surgeon obtains a CT scan of a patient's head prior to performing an operation to remove a tumour. The data obtained are scalar values corresponding to density defined on regular grid of structured points 200x200x200. The surgeon wishes to know the position and size of the tumour with respect to anatomical landmarks such as the skull, blood vessels and nerves. Discuss the relative merits of the Marching Cubes algorithm and volume rendering by ray casting for this application. [*6 marks*]

   (b) How would illumination of gradient magnitudes improve the volume rendered images? Does it have any disadvantages? [*4 marks*]

   (c) The following equation is used in volume rendering by forward ray casting. Define the terms and state their significance for the computational complexity of the ray casting process. [*7 marks*]

   $\alpha_{new} = \alpha_{current} + (1 - \alpha_{current}) * \alpha_{accumulated}$.

   (d) Interaction is a very desirable characteristic of a visualisation algorithm. List and briefly compare the methods by which volume rendering can be accelerated such that it can be performed at interactive rates [*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 technique for the problem. Give an example of an appropriate visualisation method for each problem.

   - An aerodynamic engineer wanting to understand the position and behaviour of vortices over the surface of an aircraft wing from an aerodynamic simulation.
   - A police officer looking for a fraudster in bank transaction records.
   - An engineer studying vibration patterns in a steel beam from simulation data.
   - A home buyer searching for a suitable property in lists of properties for sale. [*12 marks*]

   (c) Visualising multi-attribute data is a common problem in visualisation. Give two strategies for visualising multi-attribute data in each of 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 velocity vectors and scalar values of temperature and pressure of a gas in a boiler.

   Briefly compare the methods you have chosen for each application. [*8 marks*]

3. (a) Visualisation of flow data can be a computationally intensive process. Outline the main tasks that have to be performed during the computation of a streamline in a regularly structured vector field and comment on how their computational complexity grows with increasing data size. [*7 marks*]

   (b) How does the variable step Euler method reduce these computational demands? [*4 marks*]

   (c) Why is this method well-suited to the line-integral convolution algorithm? [*2 marks*]

   (d) A museum has a unique set of carved stone tablets that it wants to digitally capture and make available to scholars to study at remote locations via a network. Explain the key ideas behind the following techniques and evaluate their suitability for this application.

   - Image based capture.
   - Accessibility shading.
   - Image based lighting.
   - Model based capture. [*12 marks*]