UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE FOUR

VISUALISATION

Friday 28 April 2000

2:00 to 3:30

Examiners:

Prof. K. Turner (External)

Prof. G. Brebner (Chairman)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) Within the context of visualisation, data are thought of as having structure and value. Using examples, state the meaning of each of these terms. How does data topology affects the choice of visualisation method? [*3 marks*]

   (b) The Marching squares algorithm is an algorithm which produces contour plots. Describe the operation of the algorithm and state the structure of data the algorithm operates on and the structure it produces. Indicate with a diagram all the different cases of contour intersection that the algorithm handles and show which cases are ambiguous. [*5 marks*]

   (c) Marching cubes is an extension to the Marching squares algorithm that operates on 3D data. Describe how the marching tetrahedra method resolves ambiguities which occur with the marching cubes algorithm and indicate why it is more important to resolve ambiguities which occur in 3D contour generation than it is with 2D contour generation. [*8 marks*]

   (d) The size of datasets visualisation systems have to deal with are becoming increasingly large. Indicate a strategy an application could employ for dealing with the following situations.

   - A terrain dataset too large to store locally.
   - A set of polygons produced by the marching cubes algorithm too numerous to be rendered at interactive rates.

   In both cases indicate the goal of data management. [*9 marks*]

2. (a) Describe the process of visualisation and state its aim. *[2 marks]*

(b) A surgeon is about to operate on a patient to remove a brain tumour. Before the operation a CT scan is performed of the patient's head which produces a regular 3D structured grid of density values. The tumour has a density value greater than that of the tissue that completely surrounds it, but much less than that of the skull. The surgeon requires a visualisation that shows the location of the tumour with respect to anatomical landmarks of the skull and brain that the surgeon is familiar with.

Describe two different methods of visualising these data from the CT scan. Indicate the advantages and disadvantages of each method with respect to the needs of the surgeon. *[8 marks]*

(c) Sketch the outline of a visualisation pipeline for each one of your chosen methods, indicating the type of data present at each stage and the transformations that are applied to those data. *[10 marks]*

(d) The process of volumetric illumination allows the shape of surfaces in a volume rendering to be seen more clearly. What do we mean by a surface in the context of diffuse volume rendering? When would the application of illumination be inappropriate? *[5 marks]*

3. (a) A vector-field that varies in time can be visualised in a number of different ways. These methods fall into two broad categories. What are these categories? State a method from each. [*2 marks*]

(b) Euler's method for calculating particle traces in a flow can be written $x(t_{i+1}) = x(t_i) + V(i).dt$ where $x(t_i)$ represents the position of the particle at step i and dt is the length of the timestep.

Show with the aid of a diagram what $V(i)$ represents. What assumptions does this method make about the vector field ? Show how these assumptions lead to an incorrect trajectory for a particle advected by Euler's method in a vector field consisting of pure rotation about the origin. [*8 marks*]

(c) Calculation of streamlines is expensive. Show how this process is simplified by the adaptive step Euler method. What assumptions does this algorithm make? [*5 marks*]

(d) Show how streamlines are used in the synthesis of textures by the LIC algorithm. How can animation of the filter kernel improve the visualisation? [*7 marks*]

(e) What advantages does the LIC method have over drawing flow glyphs? When might the LIC algorithm have disadvantages? [*3 marks*]