Closed Book Examination

Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

M.Sc. in Advanced Computer Science

Visualization for High Performance Computing

Thursday 29\textsuperscript{th} January 2009     Time: 09:45 – 11:45

Please answer any THREE Questions from the FIVE questions provided

The use of electronic calculators is permitted provided they are not programmable and do not store text
1. **Visualization Critic**

   a) Define each of the following terms with respect to graphical integrity (2 marks each):

   i) Lie Factor
   ii) Data Density
   iii) Data Ink Ratio
   iv) Chart Junk
   v) Data Context  

   (10 marks)

   b) The figure below comes from the Times newspaper last year. Describe, regarding graphical integrity, the key features picking out the good and bad points.  

   (6 marks)

   Consider how this information could be presented better.  

   (4 marks)
2. Perception Issues

Two major problems in visualization when using a 2D screen are a) accurate display of a specific colour on a particular screen; and b) perception issues when drawing 3D objects on a particular screen.

a) Briefly explain the CIE colour chart and then graphically show the relation and shape a screen Gamut has on this chart. (4 marks)

Explain the problem of colour Gamut matching when you have a particular display device and describe a possible solution. (5 marks)

b) Describe the key theoretical reason and problem for a user when 3D objects are drawn on to a 2D screen. (2 marks)

Give advantages and disadvantages of three ways in which the perception of 3D objects on 2D screens can be improved. (3 x 3 marks)
3. **Marching Cubes Algorithm**

a) Very briefly explain the following general terms:

i) Isocontour  
   (2 marks)  

ii) Isosurface  
   (2 marks)  

iii) Marching Cubes Algorithm  
   (3 marks)  

b) The Marching Squares Algorithm is a 2D version of the Marching Cubes algorithm.

We wish to apply the Marching Squares algorithm on the following (5x3) grid of points with known scalar values as specified with the numerical values on the vertices at the grid intersections, of the cells as shown.

Given a contour value of T, outline pseudo-code for the Marching Squares algorithm.  
(6 marks)  

c) Using a bisection method of your choice, for the following grid, apply the Marching Squares algorithm when T=2. Consider separately two cells in the grid in detail.  
(4 marks)  

d) Briefly describe the ambiguity that occurs with the following simple case and draw the two possibilities.  
(3 marks)
4. **Parallel Strategies**

   a) Describe what Load Balancing is in the context of data decomposition, discussing when and why it may be used. (2 marks)

   b) What are the implications for load-balancing if the decomposition uses equal sized blocks? (2 marks)

   c) Describe the three categories of granularity, how they are handled and provide simple examples. (3 marks)

   d) What is the impact of granularity on load-balancing and the decomposition/distribution of data? (3 marks)

   e) Using an arbitrary volume dataset and the marching cubes algorithm as an example, describe the issues for data coherency and load-balancing for the following two scenarios (as illustrated above):

   1. A volume decomposed into regular equal sized blocks.
   2. A volume decomposed into regular equal sized slabs. (5 marks)

   f) What are the advantages and disadvantages of using fine-grain parallelism in this scenario? (2 marks)

   g) Suggest a strategy for improving the load-balance and data coherency while using fine-grain parallelism. (3 marks)
5. **Flow Visualization**

a) A researcher wishes to visualize a flow field. Explain how the use of arrow glyphs can be mapped to the vector components. Then describe how this can cause visual clutter. (4 marks)

Describe with the aid of diagrams the following three alternatives (3 marks each):

i) Stream Lines
ii) Stream Ribbons
iii) Stream Surfaces (9 marks)

How might these basic methods be enhanced? (3 marks)

b) The researcher now wants to visualize symmetric tensors, each having six dimensions at any point in the 3D space. Describe two reasonable methods that this researcher could use – giving an advantage of each method over the other. (4 marks)