UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2002/2003

September 2002

CCS543 – Data Visualisation

Duration : 3 hours

INSTRUCTION TO CANDIDATES:

- Please ensure that this examination paper contains **FOUR** questions in **SIX** printed pages before you start the examination.
- Answer all **ALL** questions.
- You can choose to answer either in Bahasa Malaysia or English.

ENGLISH VERSION OF THE QUESTION PAPER

1. (a) (i) In your own words, describe what it is meant by the term visualisation as introduced in this course.

(10/100)

(ii) After the introduction of computer, visualisation software have evolved in three phases. Describe software in each phase in term of features or functionalities they offered, their strength and weaknesses, and finally, give one example software for each phase.

(15/100)

(b) (i) Draw a block diagram of the generally accepted visualisation dataflow pipeline, clearly label it with dataflow direction. Briefly describe the main functions performed at each stage.

(15/100)

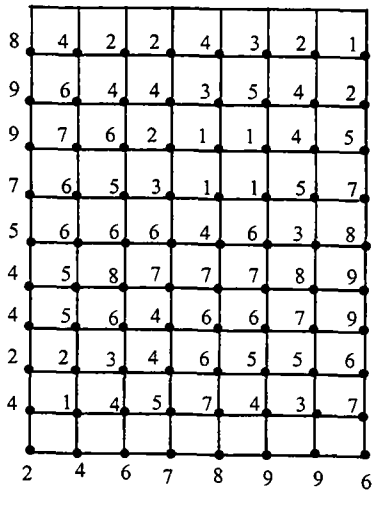
(ii) At least one of the blocks in the diagram you have drawn 1(b)(i) above is concerned with "modelling" the behaviour of the data to be visualised. How important is this process, and what is it trying to achieve? You may answer this question by giving suitable example to support your points.

(15/100)

(c) (i) Contour mapping is a technique for visualising 2D scalar data, briefly explain what features or characteristics of data it is trying to show. Give some examples where contouring method is useful.

(10/100)

(ii) Given the following 2D scalar data (gridded data), sketch the output of contour mapping for isovalues 2.5, 4.5, 6.5, and 7.5. Clearly label each isoline you have sketched above.



(20/100)

(iii) In contour algorithm, there are two cases in which ambiguities arises. Identify these two cases, and describe how contour algorithm resolves them.

(15/100)

2. (a) (i) Explain your understanding of volumetric data, contrast it with for example 1D or 2D data.

(10/100)

(ii) 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 (2)** 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.

(20/100)

(b) Illumination or shading is one of the important operations in a graphics pipeline. The following questions revolve around the illumination or shading operations.

(i) What extra values does this operation contribute to the graphics output? How crucial is this operation in the case of visualising volumetric data?

(10/100)

(ii) Briefly discuss the three common shading algorithms; Flat, Gouraud, and Phong shading. In your discussion, focus on the differences in the approach of intensity calculation, and also the quality of the output produced by each algorithm.

(15/100)

(iii) Normal vector plays a crucial role in shading operation, what is normal vector? How it is calculated/derived from the volumetric datasets?

(15/100)

(c) Visualising volumetric data is a time consuming operations, this is partly due to the shear size of the data. However, the blame has to be attributed to the contemporary techniques that are unable to produce visualisation of volumetric data in real time. Write a short descriptive note on the following techniques for accelerating visualisation of volumetric data.

(i) Maximum Intensity Projection (MIP)

(15/100)

(ii) Texture rendering technique

(15/100)

3. (a) (i) What is your understanding of vector quantity. Contrast this data classification with scalar quantity. It may be helpful to give some examples in justifying your answer.

(10/100)

(ii) Visualising vector quantity poses different set of challenges and difficulties to the ones found in scalar quantity. What are these challenges or difficulties? How are these difficulties handled or solved in existing flow visualisation techniques that you have encountered in the course?

(15/100)

(b) (i) A vector-field data can be visualised in a number of different ways. These methods fall into two broad categories. What are these categories? State a method for each.

(20/100)

(ii) 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? Describe how these assumptions lead to an incorrect trajectory for a particle advected by Euler's method.

(25/100)

(iii) In what ways does Runge-Kutta's method improves the deficiencies in Euler's method? Explain your answer.

(5/100)

(c) Similar to volume visualisation, the goal of achieving real-time and increase interactivity are pertinent to flow visualisation techniques. Select one techniques of speeding up flow visualisation below, and write a short descriptive note.

(i) Spot Noise

(ii) Line Integral Convolution (LIC)

(10/100)

(d) An alternative and interesting way to visualise flow is to be selective on what flow features we want to study or see. This approach is known as visualising flow topology. Describe what is meant by flow topology, what are they, what do they show, and why one wants to visualise them?

(15/100)

4. (a) The size of datasets visualisation techniques have to deal with are becoming increasingly large. Indicate a strategy an isosurface mapping algorithm could employ for dealing with large dataset.

(15/100)

(b) It is easy to overload an image with information. However, in some visualisations, mutiple dimensional data can be displayed without confusion.

(i) Give an example involving up to eight dimensions stating what each dimension might be. Eight dimensions are required for full credit.

(10/100)

(ii) Describe a technique to visualise your eight dimensional data above. State the advantages and disadvantages of your technique.

(10/100)

(c) Emerging technologies both open opportunities as well as creating problems to many areas including visualisation. Web's technology is so powerful and promising that it forces many applications to migrate to web-based services, visualisation is one example of application that joins this paradigm shift.

(i) As an expert in visualisation field, what would be your advise to the adoption of VRML as a tool for client interested to publish their results on the web. Focus your advise on the benefits offered by VRML, the limitations, the supporting tools needed by VRML, and ease of use/learning of the language. You can either agree or disagree with VRML as a good tool for presenting visualisation results over the web.

(20/100)

(ii) Compare and contrast the three category of architectures for web-based visualisation systems. In each case, provide a scenario of how visualisation are carried out. States benefits and limitations for each architecture.

(25/100)

(iii) A group of local doctors are about to perform a life treating operation to a brain's tumour patient. They have been planning this operation for months, and with the help from visualisation experts (that is you), they would like to establish a "collaborative" session with physicians from UK's top hospital. Your task is to propose a suitable setup/architecture for "collaborative" visualisation. Below are your constraints:

- the image/model of patient's brain is the "object" of sharing between local doctors and remote physicians. This image/model is located at local hospital.
- local hospital does not have powerful machine to run full blow graphics at the speed close to realtime - yet it crucial to have "interactive" session.
- local hospital has dedicated T1 line with the bandwidth of 1.5Mbits allocated for this session only.
- local hospital and the remote both have same visualisation software for them to collaborate.

Propose web-based visualisation architecture, justify your selection.

(20/100)

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