UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2004/2005

October 2004

CCS543 – Data Visualisation

Duration : 2 hours

INSTRUCTION TO CANDIDATES:

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

ENGLISH VERSION OF THE QUESTION PAPER

1. (a) (i) Visualization nowadays is a necessary tool across many disciplines. Why are there demands for visualization in these fields? List down the *factors* which spur the recent interest in visualization.

(20/100)

(ii) Modular Visualization Environment (MVE) is one of the styles in visualization system which provides visual programming interface. Briefly describe common *steps* an end-user needs to perform in order to visualize data in the MVE system. What are the main advantages of this paradigm compared to others styles of visualization system.

(20/100)

(b) The visualization reference model divided visualization processes into three logical modules: data enrichment, data mapping and rendering:

(i) One of the main tasks in the data enrichment module is to create the *model* that best estimate the underlying fields. This model is in general classified into either *interpolation* or *approximation*. Briefly describe *when* do we need to use interpolation (and vice versa approximation), and *why* do we choose one as opposed to the other (and vice versa)

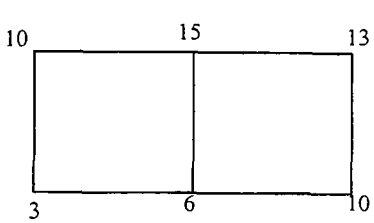
(15/100)

(ii) The mapping stage is where we decide which visualization technique to apply to our *enriched* data. Given there are many range of visualization techniques, we need to classify data into set and associate different techniques with different sets. For each of the data described below, provide the *classification scheme*, and suggest the *mapping technique(s)* to be applied to the scheme:

- Data of the height of individual in CCS543 class.
- A volumetric data that store velocity, temperature and pressure
- The water saturation and pressure on a horizontal cross-section of an oil reservoir.
- A medical data of human head consists of 109 slices of 256 x 256.

(15/100)

(c) Given the following 2D scalar data on the grid, *calculate* the intersection points with the edges of the cells and then *draw* the isoline for isovalue of 8. Assume that you are using linear interpolation method and the cell is a unit rectangle.



(30/100)

2. (a) (i) Compare and contrast two 3D scalar visualization techniques namely, *isosurface* and *volume rendering*. Highlight their main differences in approach, their limitations, and advantages over each other.

(30/100)

(ii) Marching Cube (MC) is the first 3D scalar data visualization technique to extract surface(s) from volumetric data. However, MC performs an *exhaustive* search for all cubes (voxels) in the data domain to extract the isosurface for a given isovalue. Discuss how you could *modify* MC algorithm so that only cubes containing the isosurface are searched and processed.

(20/100)

(b) Shading of graphics primitives such as point and triangle will give a realistic looking results, and this process is crucial for both isosurface outputs (set of triangles) and volume rendering (set of sample points). An important component in shading computation is the normal vector which tells us about the orientation of the graphics primitives. Explain how *normal vector* (for isosurface's triangle and volume rendering points) is *estimated* from 3D data defined on a regular voxels grid.

(20/100)

(c) (i) The compositing step in ray casting is performed either in *back-to-front* manner or in the opposite direction namely *front-to-back*. Describe the two compositing approaches (with supporting formula), and highlight why one would prefer one approach (you decide) over the other.

(15/100)

(ii) Maximum Intensity Projection (MIP) is a quick and dirty way to speed up the computational process of volume rendering at the expense of accuracy. Explain what *aspect* of accuracy is sacrificed by this method i.e. its limitations. Why is this method said best used with *angiography*?

(15/100)

3. (a) Flow properties can either be visualized directly (from raw vector data) or through some flow related quantities *derived* from the flow data.

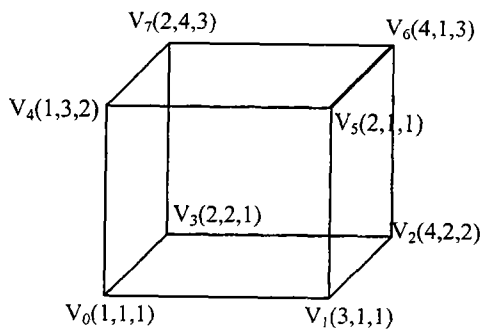
(i) List down these derived quantities, and suggest visualization technique(s) to visualize them.

(15/100)

(ii) What do we loose or gain by visualizing derived flow quantities? Justify your answer.

(15/100)

(b) Consider the following simple 3D flow visualization problem. You are given the velocity V(x,y,z) at the eight corners of the unit cube as shown in the diagram below:



The velocity is expressed as a vector of three components, the first giving the velocity component in x-direction, the second the velocity in y-direction, and the third the velocity in z-direction. Suppose a particle is released at time t = 0 from seed point (0.3,0.0,0.0). In the following calculation, you are requested to use Runge-Kutta's 2nd order method.

(i) Calculate an estimate of *where* the particle will travel to after a single time step of 0.1 seconds.

(15/100)

(ii) State the two major *sources* of error in this calculation, and explain how these arise.

(10/100)

(iii) Calculate an estimate of the *velocity* at the *new position* of the particle found in 3(b)(i) above.

(15/100)

(c) Line Integral Convolution (LIC) is a simple texture-based method to visualize 2D flow data.

(i) Describe how the texture is applied to flow data to create *texture* effect.

(20/100)

(ii) This method will generally show the *direction* of the flow but lacking in the *orientation* of the flow. Suggest an improvement over LIC method so that we can visualize both direction and orientation of the flow i.e. oriented-LIC.

(10/100)

4. (a) In Information Visualization, *'focus + context'* is an important concept:

(i) Explain what is meant by the term and describe the benefits it affords – use an application to illustrate your answer.

(15/100)

(ii) Describe briefly two practical implementations of the concept discussed in the course.

(15/100)

(b) School of Chemical Sciences in 2003 had carried out a study to monitor the levels of airborne chemicals in the science complex building (that is our building). In the course of this investigation, the scientists have collected samples of airborne acids and volatile organic compound (VOC), and their measurements are as shown in the table below:

Samples	**Chemicals**				
	Carbon Tetrachloride	**Chloroform**	**Dichloromethane**	**Methanol**	**Toluene**
Sample1	8	5	10	3	2
Sample2	2	4	15	8	5
Sample3	0	9	20	11	9
Sample4	3	6	12	15	11
Sample5	10	10	9	10	15

(i) Being the occupants of this building we are obviously concerned with the levels of these airborne chemicals that may be hazardous to our health. Create a visualization using *parallel coordinates* to visually show the relationships between these chemicals measurements.

(15/100)

(ii) Parallel coordinates technique work reasonably well for small number of variables (such as 5 in the above problem). However, the projection of lines can get very cluttered as the number of variables to visualize increases. Describe at least *two improvements* over original parallel coordinate to solve this problem

(15/100)

(c) A group of local doctors are about to perform a critical 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 a local hospital.
- local hospital does not have powerful machine to run full blown graphics at the speed close to real time – yet it is 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 visualization software for them to collaborate.

Propose web-based visualization architecture for this problem, and justify your choice of proposal.

(40/100)

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