Exam in Advanced Computer Graphics and Visualization
1TD386; 1IT211

Time and place: 08:00–13:00 Friday June 2, 2006, Polacksbacken, Skrivsal

Instructions:

- Only paper, pen(cil), erasers, rulers, and dictionaries are allowed. No calculators allowed.
- Check that you have received the correct exam.
- The cover sheet shall always be filled in and returned, even if no exam questions have been answered.
- Write your name on all papers that you hand in. Do not use red ink.
- Start on a new paper for each question. Write only on one side of each paper.
- Sort the answer sheets in the order of the questions before you turn them in.

Grades: Pass (G): 20pts; Pass with distinction (VG): 30pts.
1 Scientific Visualization

Visualization is a necessary tool to make sense of information from various sources. The ways to present different data are limited only to your own imagination.

(a) A height field is a regular array of 2D points \( h = f(x, y) \), where \( h \) is an altitude above a point \((x, y)\). Height fields are often used to represent terrain data. How would you choose to visualize the height field? Motivate this choice and describe what properties of the data it would express. (3p)

(b) Interactivity is a keyword when dealing with visualization. Mention different types of interaction that would be useful to explore the height field in (a). (2p)

2 Contour Representation

(a) Imagine a discrete 2D image consisting of pixels being either object (1) or background (0). One way to represent the object is by its contour. One method for this is called marching squares. How does it work? What is the contour by marching squares of the shape on the last page? Hand this sheet in with the drawn contour. (2p)

(b) If we extend the marching squares argument to surfaces in three dimensions, then we get a method called marching cubes. Describe the six basic steps of this isosurface construction method. (3p)

3 Ray-tracing vs Splatting

In volume rendering, often two approaches are mentioned, ray-casting and splatting.

(a) Classify the two approaches into image-order or object-order rendering techniques. Describe their respective basic ideas. (2p)

(b) Why does a rendering produced by splatting appear smoothed compared to if the same scene is rendered using ray-casting? (2p)

(c) Discuss the aspect of computational times for ray-casting and splatting techniques. (1p)

4 MIP rendering

(a) Particularly in medical imaging, so called MIP rendering is used. What does the abbreviation stand for? How does the technique work? (3p)

(b) What type of images are suitable to display this way? (2p)
5 VTK

When using the Visualization Toolkit (VTK) you have become acquainted with a number of “friends”, some of them listed below. Describe their roles in the visualization pipeline.

(a) – vtkRenderWindow
   – vtkRenderer
   – vtkCamera
   – vtkActor
   – vtkMapper
   – vtkSource

(b) Please, draw a figure where the relationships between your “friends” are shown.

6 Advanced Visualization Techniques

(a) Hedgehogs and streamlines are techniques for visualization of 3D vector data over a 3D domain. Explain the techniques and discuss their potential usefulness in context of the given visualization problem.

(b) Which enhancements do stream ribbons offer compared to streamlines?

(c) How can implicit models and iso-contouring be combined for advanced geometric modeling? Briefly describe two techniques discussed during the lecture and in the book.

7 Shader Programming

Describe the differences in functionality between the vertex processors and fragment processors (as available today). How does this apply to their usefulness in high-performance general-purpose computation? Include both differences due to differing hardware and differences implied by the position in the rendering pipeline.

8 Human Factors

(a) Are purely chromatic differences between background and foreground in visualizations an efficient way of coding information intended for a human viewer? Why?

(b) Is the experience of a unique hue altered very much as a result of a change in overall luminance? What does this demonstrate?

No points awarded to answers without explanation.
Figure for Question 2