Delft University of Technology
Faculty of Electrical Engineering, Mathematics,
and Computer Science

TU Delft

Examination for

IN4086 Data Visualization

Tuesday January 25, 2011, 14:00 – 17:00 h.

This examination has 6 open questions on 3 pages.
All questions have equal weight (10 points/question). Maximum score = 60 points.
Minimum score required for passing the exam: 33 points.

Use of notes, books and readers is *not* permitted;
The use of (graphical) calculators is permitted.

Write and draw clearly. Avoid verbose explanations; answers in the form of bulleted lists are preferred. Explain all your answers.

Please use a separate sheet for each question.
Write on each sheet: your name, study number, course code (IN4086), date, and question number. This is important because each question is graded separately.

The examination covers the following materials:
Course sheets fall 2010, Reader IN4086, edition 2009 or 2010.

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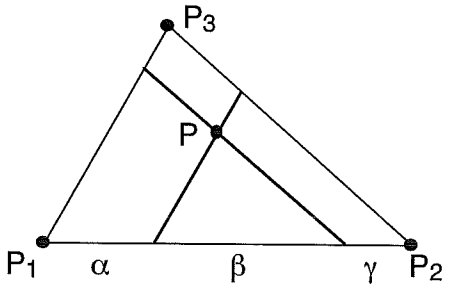
1. a. In data visualization a distinction is made between *scientific visualization* and *information visualization.* Discuss the main characteristics of these two categories. *(3)*

   b. Given are three data-points P_1, P_2 and P_3, the vertices of a triangular 2D grid cell, with corresponding scalar data values: $d_1 = 5$, $d_2 = 7$ and $d_3 = 6$. A point P lies inside the cell at local position $\alpha = 0.2$, $\beta = 0.6$, and $\gamma = 0.2$ ($\alpha+\beta+\gamma=1$). Determine the data value d_P at P using linear interpolation in the cell. *(3)*



   c. Point location in a tetrahedral grid can be done using an *incremental search* from a known position S to the unknown position P. Describe how this algorithm works. *(4)*

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2. a. What is accommodation of the eye? Does the eye need to accommodate when looking at a computer monitor? Does it make any difference which types of objects and which colors are displayed on the screen? *(3)*

   b. What is scotopic vision? What is photopic vision? Which types of light sensitive receptors play a role in scotopic vision and in photopic vision? *(4)*

   c. Describe a color matching experiment showing that all visible colors can be produced from three primary colors, assuming that negative amounts of one or more of the primaries are allowed. *(3)*

3. a. Direct volume rendering methods can be classified in *voxel projection* and *volume ray casting*. Give for both methods the global structure of the algorithm by means of a number of lines op pseudo code. *(4)*

   b. Which advantages of volume ray casting and voxel projection methods are combined in the *Shear Warp Factorization* algorithm to increase rendering speed? What is the most important disadvantage of Shear Warp Factorization? Explain your answer. *(3)*

   c. Describe how a histogram can be used in the classification step in a volume rendering pipeline. What is a transfer function? *(3)*

4. a. Briefly define three medical visualization application types and give an example of each type. You do not have to limit yourself to the examples discussed in class. *(3)*

   b. In virtual colonoscopy, CT data is acquired of the patient colon. The colon is primarily filled with air but also contains some stool. Due to tagging, the stool has the highest intensity.
   If one were to draw a straight line in the volume data starting in air, going through the tagged stool and ending in the soft tissue of the colonic wall, one could plot a graph of gradient magnitude over CT intensity, sampling values at regular intervals along the straight line. This graph has a very characteristic shape.
   i. Draw the graph and explain briefly what you see. You do not need to give exact values on any of the axes, only the general shape and relative positions of intersections with the axes are important. Label the intersections with the materials that they represent. *(2)*
   ii. How can this graph be used to eliminate the false border between stool and air caused by the partial volume effect? *(2)*

   c. Use any example of your choice, such as Computer Assisted Surgery for Shoulder Replacement, to describe the five stages of the medical visualization pipeline. *(3)*

5. a. Define the concepts of a streamline, streak line, and path line in a velocity field. Which of these are most suitable for visualization of time-dependent velocity fields, and why? *(3)*

   b. Spot Noise and Line Integral Convolution (LIC) are two types of texture-based flow visualization. Briefly describe the basic principle of each of these techniques. How can these techniques be extended for animated flow visualization? *(4)*

   c. Give at least two reasons why feature extraction and time tracking of features can be useful for visualization of very large time-dependent data sets. *(3)*

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6. a. Define both "multiple views" and "small multiples", making clear the difference between them. Explain when you would use the former and when the latter. *(3)*
   b. Draw a radar plot visualising your estimation of the difficulty of each of the six questions in this exam. Label each axis clearly, and represent difficulty with a number from 0 (extremely easy) to 5 (extremely difficult). *(2)*
   c. "*Active shuttering*" and "*passive polarization*" are two popular techniques for achieving stereoscopic display in a projection-based Virtual Reality system. Describe the differences between these two with respect to the technology used in the glasses and the projection screen. *(2)*
   d. When using a tracked interaction device in an immersive VR application, a user may freely manipulate objects in space. We sometimes want to restrict this free manipulation of certain objects, such as in the case of an aligned *slicing plane* in a data volume, which should only be moveable up and downwards. Explain how many spatial DOFs (degrees of freedom) a "free" object has. Which technique can be used to "restrict" manipulation in the case of the slicing plane, and how does it affect the DOFs ? *(3)*

End of examination