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

Examination for

IN4086 Data Visualization

Thursday, 20 August 2009, 9:00 – 12:00 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 and avoid verbose explanations, and 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 2008/2009, Reader IN4086, edition 2008/2009.

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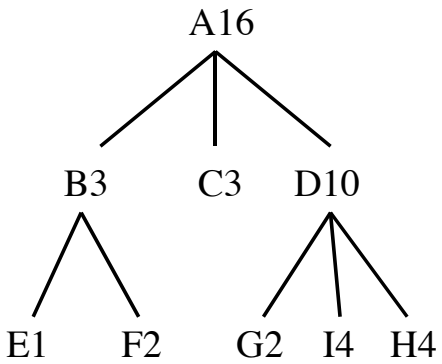
1. a. Briefly describe each of the four stages of the data visualization pipeline: data generation, pre-processing (filtering), mapping, and rendering. *(4)*



   b. In the above figure a hierarchical structure is shown as a tree diagram, in which the nodes are marked as capital letters, with an attached number (e.g. file size). Show how this structure can also be visualized as a *treemap*. *(3)*

   c. Given are data points P_1 … P_4, the corner points of a 2D rectangular grid cell. The corresponding data values are: $d_1 = 80$, $d_2 = 48$, $d_3 = 64$ and $d_4 = 32$. A point P lies inside the cell with relative coordinates $\alpha = \frac{1}{4}$, and $\beta = \frac{3}{4}$. Determine the data value d at P, using bilinear interpolation. *(3)*

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2. a. There are three types of cones on the retina of the eye. Make a drawing or describe how these three types of cones are distributed on the surface of the retina. Give two tips about the proper use of colors in computer images which result from this distribution. *(4)*
   b. The CIE XYZ color model uses the three primary colors X, Y and Z. In the CIE xy chromaticity diagram colors are drawn in a 2D xy coordinate system. How (with which formulas) can an XYZ color be transformed to xy in the chromaticity diagram? *(3)*
   c. xy CIE colors can be transformed to u'v' CIE 1976 UCS colors. What is the main property of the u'v' CIE 1976 UCS colors that makes them more suitable in certain applications than xy CIE colors? Describe the meaning of this property and give an example situation where we profit from this property. *(3)*

3. a. What is the essential difference between *surface fitting methods* (SF) and *direct volume rendering methods* (DVR) for visualization of a volume data set? Is the Splatting algorithm an SF or a DVR method? Is the Marching Cubes algorithm an SF or a DVR method? Is Volume Ray Casting a SF or a DVR method? *(4)*
   b. What is a *transfer function* in Volume Ray Casting? What is mapped on what? Which visual effects can be the result of changing the transfer function? *(3)*
   c. Describe the *color compositing* step in Volume Ray Casting. *(3)*

4. a. Briefly describe the procedure for virtual colonoscopy (the medical visualisation pipeline can be helpful in this explanation), and explain why it would be preferable over traditional optical colonoscopy. *(3)*
   b. The wall of the colon has many tissue folds, which makes it difficult to examine the complete inner surface during a virtual colonoscopy (parts are missed). Explain why this is a (medical) problem. Describe a (technical) solution to this problem: You have to correctly describe the solution and explain how it addresses the problem. *(3)*
   c. How is an image affected after it has been convolved with a Gaussian kernel with a standard deviation of 1 pixel? What would the difference be if the initial image were convolved with a Gaussian kernel with a standard deviation of 2 pixels? *(2)*
   d. Name one way of calculating the gradient image. *(2)*

5. a. What is the difference between a *stationary* (steady) and an *instationary* (unsteady) velocity field? How are unsteady velocity fields defined on a grid represented? *(3)*
   b. A stationary velocity field V is defined on a regular rectangular (Cartesian) grid. Briefly describe the three-step procedure for the calculation of a particle path in V, from a specified starting point P_0. Give a technique for each of the three steps. *(4)*
   c. Define the concept of a *streak line* in an unsteady velocity field. Describe how a streak line through a point P_0 is determined, using the procedure for particle path calculation. *(3)*

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6. a. What is the main characteristic of a *shock wave* in a flow field? Give a simple method for detection and visualization of shock waves. *(3)*
   b. What are *critical points* in a vector field? How can we classify different types of critical points? Give one example in a 2D vector field. *(3)*
   c. What is *tracking* in virtual reality (VR)? How can tracking of the head and the hand of the user be employed in a VR application? *(4)*

End of examination