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

Examination for

IN4086 Data Visualization

Wednesday, 27 January 2010, 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.
Bonus points can be given up to a maximum total of 60 points.
Minimum score required for passing the exam: 35 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; 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 2009/2010, Reader IN4086, edition 2009/2010.

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1. a. A general model of the visualization process is a pipeline with four stages: data generation, pre-processing (filtering), mapping, and rendering. The user can interact with the visualization process at each of these stages. Indicate for each of the following input actions at which stage it will influence the process:
   - choosing a colour scale
   - selecting a part from a data set to be visualized
   - changing measurement parameters (e.g. MRI scanning protocol)
   - selecting an iso-value
   - specifying a viewpoint and lighting conditions

   (3)

   b. What are the three most important mappings for visualization of a 2D scalar field d(x,y)? Give for each mapping a *mapping function* which defines the relation between the data values and the visual parameters. *(3)*

   c. Explain the principle of linear interpolation along a line segment P_0P_1, when P_0 and P_1 are data points. Using diagrams, show how this principle can be extended to bi-linear interpolation in a square grid cell with vertices $P_0...P_3$, and to tri-linear interpolation in a cubic grid cell with vertices $P_0...P_7$. *(4)*

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2. a. What are *metameric colors*? Give an example. *(3)*
   b. i. Give some advice concerning the number of colors to be used for discrete color coding.
      ii. Give some advice concerning the number of colors to be used for a continuous color scale.
      iii. Give some advice about the use of a combination of a background color and a color for objects on top of it. *(3)*
   c. Can color X from the CIE 1931 XYZ color model be derived by combining amounts of R (red), G (green) and B (blue)? If yes, then give some information about the amounts of R, G and B to be combined. If no, then explain why it is not possible. *(2)*
   d. Can color R (red) from the RGB color model be derived by combining amounts of X, Y and Z from the CIE 1931 XYZ model? If yes, then give some information about the amounts of X, Y and Z to be combined. If no, then explain why it is not possible? *(2)*

3. a. How can most easily be checked whether an iso-surface intersects a cube shaped cell in a volume dataset or not? How does the *Cuberille method* use this information to create images of volume data? *(3)*
   b. What is *early ray termination* in volume ray casting? Can it be applied with front to back (FTB) or back to front (BTF) color compositing or with both? *(3)*
   c. Does Shear Warp Factorization use early ray termination? Explain why this is possible or why not. *(2)*
   d. Does Shear Warp Factorization need a time consuming voxel traversal algorithm? Explain your answer. *(2)*

4. a. In medical image data, one would ideally expect a clear step edge in intensity between two distinct materials, such as bone and soft tissue. However, in practice this is not the case. State what an edge usually does look like in medical image data (even this is an approximate model), and briefly explain why. *(3)*
   b. Explain the role of image processing techniques in medical visualization. Give one or more examples to illustrate your explanation. *(3)*
   c. You have been tasked with developing a software system for the planning of brain tumor resection surgery, that is, a brain tumor has to be removed surgically with as little as possible damage to both the function and the connectivity (you should know the relevant modality for this) of the surrounding healthy brain. Using the medical visualization pipeline and being as specific as you can, explain the system that you envision. To facilitate your answering, start by drawing a vertical version of the medical visualization pipeline and add the descriptions of the components of your solution to the right of the relevant pipeline stages. (*4* + max. *2* bonus points)

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5. a. Draw two example parallel coordinate plots: The first showing positive correlation and the second showing negative correlation. *(3)*
   b. Define linked multiple views and describe any example of your choice that clearly demonstrates the linking aspect. *(2)*

The potential benefits of using Virtual Reality for the visualization of 3D data are often attributed to the use of both stereoscopic display and 3D tracking of the head and hand-held input devices.

   c. For both stereoscopic display and head-tracking, briefly describe their main effect and the depth cues involved? *(3)*
   d. Describe which 3D interaction element (from the 3DUI taxonomy) could benefit from using a hand-held input device that is 3D tracked. *(2)*

6. a. Define the concept of a *stream surface*. Describe a simple method for the generation of a stream surface represented as a triangle mesh. *(3)*
   b. Briefly describe the basic principle of *Line Integral Convolution* (LIC) for vector field visualization. Which inputs are needed for applying LIC? Give an advantage and a disadvantage of the technique. *(4)*
   c. Discuss the meaning of *feature extraction* and *time tracking* of features. Give three examples of features in flow fields. *(3)*

End of examination